ESAP Proceedings

Commercialization of Livestock Agriculture in Ethiopia

Proceedings of the 16th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, October 8 to 10, 2008

Part II: Technical Session

Ethiopian Society of Animal Production
P.O. Box 80019, Addis Ababa, Ethiopia

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Welcome Address

Dr. Tadelle Dessie (ESAP President)

H.E.Dr. Solomon Asefa, Director General, EIAR
H.E. Mr Mafa Chipeta, FAO Sub-regional office and AU and EU Rep.
Distinguished invited Guests,
Development practitioners,
Entrepreneurs,
Think-thanks,
Conference Participants, and ESAP members,

Ladies and Gentlemen:

On behalf of the executive committee of the Ethiopian Society of Animal Production (ESAP) in particular and the ESAP family in general, I feel deeply honored and overwhelmingly pleased when I welcome each and every one of you to this robust gathering of the 16th Annual Conference of our Society.

Ladies and Gentlemen:

Ethiopia is endowed not only with large but diverse livestock resources. However, Ethiopia is using its rich endowment to little advantage. For many years' livestock production in Ethiopian-and indeed agriculture more generally was seen as a poor investment for development. But after years of being ignored, livestock issues are beginning to be put back on Ethiopia's development agenda. Livestock are being recognized as essential assets for livelihoods; as key to moving out of poverty; as a way into lucrative markets; as a source of foreign exchange; as well as it serves as an important cultural resources, social safety nets and means of saving.

Distinguished Guests and Participants

In the past, the debate on the type of appropriate interventions for the improvement of livestock in Ethiopia was limited to technical innovations and local adoption to enhance production and productivity. But very little attention was given to the policy and institutional issues that play a pivotal role in determining the overall success or failure of the sector.

Today, we recognize that building effective policies and institutions are the indispensable first steps aimed at strengthening innovation processes, tapping new commercial opportunities, and tackling the challenges facing the poor. This implies the need for closer examination of how existing policies, institutions and stakeholders interactions influence the development of the livestock sector.

This issue is urgent because of Ethiopia's pressing need to increase production and value-addition to meet both domestic and global demand in a rapidly changing and highly competitive world. Currently, local demand for foods of livestock origin (e.g. milk, chevron, beef, mutton, egg etc) is increasing in urban centres, while new, global opportunities are expanding for similar products (e.g., beef, dairy, skin, and hides, honey, wax). These trends and several initiatives undertaken in response to these, present real opportunities for livestock producers, traders, processors, exporters and all others involved in the sector.

Ladies and gentlemen,

Given the fact that real opportunities are their to benefit from this sector development at national and individual level the number of entrepreneurs involved are limited and the sector is not commercialized enough. Understanding the intellectual power and national responsibility vested on this gathering allow me to pose some pertinent questions for all of us:

1. Why commercialization of livestock agriculture is not happening in Ethiopia at least to the same level to other sectors?
2. What policy and institutional supports we have for a person who needs to engage in livestock and livestock product commercialization?
3. Is livestock and livestock products from Ethiopia competitive in the international market? In both quality and price???
4. Is the private sector responsive and pro active in responding to and in understanding the needs of the importing countries?
5. Will the production system followed by our small holder and pastoral farmers/systems and their produce remain competitive in the international market?
6. What are the effects of other areas of development and their positive or negative effects in livestock development?
7. What about the direct and indirect effects of the global food crises to the livestock sector in Ethiopia? And what are the short and long term remedies given the fact animals are food converters not producers?
8. How can the country supply the growing national and international demand for livestock while maintaining its resource base?
9. How will growth in the livestock sector affect poor livestock producers, or poor rural and urban consumers?
10. Which new policies and modifications are needed to enhance livestock commercialization from farm to fork, and
11. How will poor stakeholders in the sector realize, understand and benefit from new developments in the national and international markets?

Distinguished Guests and Participants

In answering the above questions and many more, and with the intension of helping to address some of these questions in light of experiences from the national and global environment that this years' conference theme has been committed to the "Commercialization of livestock Agriculture in Ethiopia: challenges and opportunities"

Ladies and gentlemen,

More than 12 papers on the theme of the conference will be presented today and tomorrow morning and discussed by carefully identified discussants which will be followed by presentations and discussions of more than 30 technical papers in the courses of the conference. At the end of this three days of meeting policy recommendations and proceedings of the conference will be published and distributed to all concerned.

Ladies and Gentlemen:

Last but by no means not least, I would like to thank all organizations and individuals that in one way or another contributed to the success of this conference organization and help us to undertake our mission as a professional society. Special thanks go to the management of EIAR for allowing us to use this hall with its facilities.

I thank you

Feed and Nutrition

Policy Considerations on Feed Supplementation in Pastoral Areas of Ethiopia

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Abstract

Feed supplementation during emergencies in the pastoral areas of Ethiopia aims to protect the assets of the affected households until the natural resource base can recover and normal management practices can be resuming. During emergency phase of drought survival feeding is the approach most commonly used. Strategic feed supplementation has not been widely used during emergences due largely to a lack of knowledge regarding the implementation of this intervention. In common with other complementary livestock services (such as- provision of animal health services, provision of water, destocking and marketing of livestock and livestock products) future strategies for supplementary feeding need to take account of long term development polices consideration in improving animal nutrition in normal periods and increasing the supply of feed during drought.

Key: feed supplementation, pastoral area of Ethiopia, drought, emergency, policy consideration,

Introduction

Pastoralism is the oldest socio-economic systems in Ethiopia where husbandry in open grazing areas represents the major means of subsistence for the pastoralist. At present, the vulnerability of the pastoral community to droughts has reached a serious stage claiming the lives of both humans and livestock every four to five years.

Any development interventions during drought in line with feed, water, health and market depend on appropriate polices of government, local administration, donors, NGOs, and development agencies.this is because interventions can be effective only if the policy environment is right. Efforts to develop feed, for example, need to cope with the fluctuation in forage yield resulting from climate variability. In line with this, training of community animal health workers will allow them to treat well fed animals; also efforts to build market infrastructure, will succeed only if policies promote livestock trade.

Key Issues and Limitation

Policy key issues include the followings, among others:

a. The lack of information on feed supplementation in pastoral areas.
b. Feed development designed with in the situation in high potential areas where the majority of the people live. They ignore the very different-needs to lowland, dry, pastoralist areas,
c. They assume a sedentary way of life the norm in the highlands, but the exception in pastoralist areas. They see decentralization as an ideal and encourage people to adopt it.
d. Polices are often based on inadequate understanding of the technical context of pastoralism. For example, they may be based on an out dated notion that pastoralist over exploit their environment and cause overgrazing and land degradation. In fact pastoralism is almost the only viable method of using dry land resources (feed, water and other natural resources). Pastoralist practices different coping strategies. These strategies are sustainable and efficient given the rationale and uncertainty of climate and cyclical nature of drought.
e. A frequent lack of government capacity to respond and coordinate feed supplementation in pastoral areas.

f. Feed development services in pastoral areas (in terms of resource and development) are poor, giving pastoralist little opportunity to improve their livelihoods.
g. Pastoralists are prone to drought making it difficult for government to mobilize aid and investment by the government, NGOs, donors and private investors.
h. Education curricular in almost higher learning institutes neglect pastoralism, meaning that few in coming generations will understand pastoralist issues.
i. The fact that many external interventions aim at addressing the symptoms "rather than solving the problems"
j. The lack of implementation and initiative on primary production improvement in pastoralist areas.

Policy Support

Fodder/Feed supplementation during stress periods is a traditional coping mechanism among many pastoral societies. Women can often be seen walking long distance or climbing steep cliffs to obtain grass, pods, leaves or roots etc with which to feed young calves, milking animals or breeding stock. Lopping or cutting tree branches, is another form of fodder supplementation. In recent years, it has also become common to see women selling this natural fodder supplementation on the market.

The trend towards agro pastoralism has also resulted in more crop residues being transported over long distances to markets. Government and non-governmental organizations have been relatively slow at adapting the idea of supplying feed/fodder supplements in emergencies. This is probably due to the low availability of local feed/fodder supplements, the large distance and high cost of transporting feed/fodder from production to stress areas. Another problem is the difficulty to anticipate the required duration of feed supplementation and the number of animals to feed.

In 1993 The National Policy for Disaster Prevention, Preparedness and Management applied "livestock preservation" directories. Plans exist for some contingency planning for emergencies at regional level, but polices as to what interventions can or can not be made are lacking.

Feed Supplementation

Where non-governmental organizations and governments have started providing feed supplements, an intervention that is popular in some places and in other places unknown or not exercised. Lessons learned from the intervention from areas where it has been tried suggest the need for policy support in the following areas:

- Early warning system must be simple and target the user's communities.
- Early warning system must include contingency plans backed up with the capacity to respond. A need for donors; governments and implementers to have an immediate contingency fund; in this case fund to be allocated not only for grain, drugs and vaccines etc but also for feed supplementation.
- Early warning focus too much on food distribution and lacks indication for alternative interventions; and needs to be improved.
- Feed supplementation should be executed with the community participation, establishing their own cooperative's food shops. Government and non-government organizations can assist them with provision of funds for purchases, transport, storage and sale during emergency.
- Feed supplementation can be integrated into destocking programmes, where animals are purchased in exchange for feed.

- Core breeding stock should be selected for supplementary feeding and be further supported with receive veterinary inputs and sufficient water (supplementary feeds additives such as molasses/urea, and grain concentrates makes animals thirsty).
- Feed supplements should also be made available for sale for non-breeding animals.
- Livestock feed can be expensive to transport especially hay and other roughages and difficult to obtain (the intervention must be prepared early).
- The use of pellets or block results in less wastage than meal and powder forms.
- The number of animals to be fed and the duration of feeding should be agree upon with beneficiary communities before implementation.
- Feed supplementation can also focus on animal trade routes to keep the market system open and prices stable. This could mean subsidizing the cost of feed for trade.
- The food for stock (as opposed to food-for work) approach should be tested on a pilot scale before large scale feeding is done.
- Other approaches such as purchase or exchange of animals for a combination of cash and animal feed (or fodder); the cash is then used to buy food for human and the animal fodder used to feed a portion of the remaining herd (as supplementary feed).
- Important complimentary services for livestock feed supplementation should be included (such as- Provision of animal health services, provision of clean water and destoking etc)
- Follow up and update monitoring and evaluation process is vital (see the following warning indicators: inline with feed supplementation).

Warning Indicators

The following warring indicators are good guidelines for further emergency response:

People migrating with livestock away from conflict points

- Conflicts in closed grazing areas or water points.
- Declining in crop residues and other feed sources.
- A shift to lopping (cutting) branches of trees or digging for water bearing roots.
- Decreasing herd size and high mortality.
- Livestock condition starts declining from fair to poor
- Milking animals dry up livestock traders stop buying
- Owners slaughter their own animals.
- Hikes in price of feed and decreased availability.
- Coping strategies change to survival strategies
- Resumption of feed supplementation programme.

Alterative Feed Interventions

Seasonal or protracted periods or insufficient livestock nutrition is a key problem. Interventions are required to address pre-crisis, chronic crises and post crisis settings. The following alternative feed development interventions should therefore be included for supporting the feed supplementation programme.

- ***Policies to Support Strategies Involving Persistence***: Where the herds forage demand in adjusted to the variation in forage supply, include:
  a. Maximizing herd size
  b. Adjusting herd composition

c. Keeping multiple /mixed of herd species.

- ***Policies to Support Strategies of Mobility:*** provides large scope for counteracting large fluctuations in forage supply that result form drought, include:
  a. Tracking rain fall by moving herds
  b. Movement to key resources
  c. Movement between different agro-ecological zones.
- ***Policies to Support Crop-Livestock links***: for the large seasonal and annual variation in rainfall and forage yield, livestock husbandry is hardly possible with out links to cropping areas, include:
  a. Food links
  b. Forage links
  c. Draught links
  d. Manure links
  e. Investment/employment links etc.
- ***Policies concerning Pasture and forage Production/Development*** :
  a. Strategies of sowing forage under irrigation is highly preferred and recommended for emergency/survival feeding. Particular dual- purpose of crops and forages for both food and feed deserve attention. "Pastoralist friendly" irrigation scheme should be encouraged, where access to water and forage/fodder crops or crop residues for pastoralist use are integrated in to the planning and use of feed supplement.
  b. Range enclosure to reserve forage (fodder banks) will help to even out seasonal variations in forage supply.
  c. Storage of hay, crop residues and sown forage, is worth promoting as strategic feeding of particular classes of animals.
- ***Policies concerning Feed Supplement (import/subsidy)***:

This is proposed to alleviate the impact of drought. It has a potential for ensuring survival during a limited critical period. The feed supplementation programme should be supported by the above mentioned polices for ensuring the continuous use of feed. Otherwise feed supplementation through subsidy/import may become a permanent feature of the pastoralist economy. Importing feed supplement form wetter areas can also compensate fluctuation in forage supply.

At this end, there is a need of policy support for further research for development on key pastoralist issues, such as

a. Most studies into the cost and feasibility of supplementing livestock feed.
b. Research on the improvement of rangeland productivity and other alternative feed sources.

Integration with Concerned Institutions

Feed supplementation and development interventions in pastoralist areas have also suffered form institutional problems. Some efforts duplicate each other, while some agencies retain a monopoly of interventions in their sector-leading to inflexibility and a lack of innovation. Administration is complex, with a large number of institutions at various levels involved in approving, funding and implementing emergency programs like feed supplementation etc. This leads to slow decision making, blurred accountability and wastage.

The policy outlook may be improving as he federal government increasingly recognizes the importance of Ethiopia's pastoralist areas. The government and international organizations are devoting special attention to managing pastoralist feed supplementation and development issues.

These organizations operate at both the federal (e.g., the Ministry of Federal Affairs, the Pastoralist permanent standard Committee in the parliament) or/and Regional levels. Moreover, Higher Learning Institutions are also recognizing the importance of pastoralist resource, and new ones are being established in these regions; hopefully they will appreciate the concern and act accordingly.

Advocacy

Nevertheless, much still needs to be done. In order to change policies, it is first necessary to bring about other changes. For example, to change policies on feed supplementation, it is necessary for policy makers' first to understand to pastoralist way of life. Only then will they be able to revise polices accordingly. Pro-pastoralist advocacy efforts for feed supplementation should aim to help key policy makers achieve this understanding.

The main audiences of institutional networking and policy advocacy threat for feed supplementation include:

- Policymakers: Parliamentarians, Cabinet Members, Regional Councils, Regional Pastoralist Coordination Offices, Federal and Regional Ministry of Agriculture offices and other concerned ministries.
- Donors
- The General Public
- Mass media

Advocacy methods for feed supplementation include:

- Workshops, seminars
- Informal discussions, visits by members of parliament
- Newspaper columns
- Press releases, interviews
- Exhibits
- Strategy papers
- Field visits for decision makers

A Way For ward

Lessons learned from livestock relate interventions during natural disaster in pastoral areas of Ethiopia suggest the need for policy considerations on feed supplementation, such as:

In common with other types of emergency livestock interventions, like-destocking market support, provision of water, animal health services, and restocking –future strategies for supplementary feeding need to take account of long-term development polices consideration in improving animal nutrition in normal periods and increasing of feeds during droughts. The over all supply of livestock feed at a national level need to be planned and supported, because sudden large scale demand in pastoral areas during drought has implication for both livestock systems in other parts of the country and the export of livestock feeds. The survival feeding approach most commonly used in Ethiopia need to be modified with more strategic feed supplementation to encourage production.

Natural livestock feed polices need to be developed together with livestock production/husbandry/marketing and natural resources management and environment policies. Impacts of a supplementary feeding programme need to be monitored and evaluated to learn lessons for future implementation. Financial indicators such as cost of feed purchase and transport, storage and other distri-

bution costs need to be include in the monitoring system. Policy support to awareness-raising may be needed to ensure that professionals in academic, research and development areas are better equipped to integrate the feed supplementation program into their efforts to support postural communities.

References

Alemayehu Mengistu (2002), Forage Production In Ethiopia. A Case Study with Implication for Livestock Production. Ethiopian Society of Animal Production. Berahene Selam Printing Press. Addis Ababa, Ethiopia.

Alemayehu Manegistu (1998), The Borena and the 1990 -1992 Drought. Rangeland and Livestock Resource Study. Institute of Sustainable Development. Berahene Selam Printing Press. Addis Ababa, Ethiopia.

Coppick D.L. (1994) The Borena platean of Southern Ethiopia Synthesis of Pastoral Research Development and Change, 1981-1991 ILCA Systems Study 5 ILCA, Addis Ababa, Ethiopia.

Leng, R.A. (1992). Drought Feeding Strategies. Theory and Practice. University of New England, UK.

Ministry of Agriculture and Rural Development (2004). Pastoral Area Development Study: Main Report, MOARD, Addis Ababa, Ethiopia

Ministry of Agriculture and Rural Development (2008) Natural Guidelines for livestock relief interventions in pastoral areas of Ethiopia, MOARD, Addis Ababa, Ethiopia.

Preston, T.R. And long, R.A (1987). Mating Ruminant Production Systems to Available Resources in the Tropics and Sub-tropics Penambal Books, Armidale, Australia.

Plant height, herbage yield, grain yield, straw yield and their interrelationships in selected oats (Avena sativa L.) varieties

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Abstract

This paper presents variations in plant height at different growth stages, herbage yield, grain and straw related performances and interrelationships of the measured parameters in 20 oats varieties evaluated at Holetta, central highlands of Ethiopia. Analysis of variance showed the presence of significant differences ($p<0.05$) among the varieties in all the parameters measured indicating the availability of a wide opportunity to exploit varietal differences for efficient utilization of oats. On average, there was a difference of 6 t DM/ha between the lowest and highest herbage yielding varieties and a height of 60 cm between the shortest and tallest varieties when forage was harvested at a physiological maturity of soft dough stage. Similarly, there was a difference in grain yield of 6.7t/ha between lowest and highest grain-producing varieties, a thousand-grain weight of 14g between fine and bold seeded varieties, straw yield of 5t DM/ha, a harvest index of 21% and straw to grain ratio of 2.26 between the two extreme varieties. Moreover, there were various degrees of correlations among the measured parameters suggesting the possibility of making indirect selections for relatively complex parameters using those associated parameters that could be measured easily. In general, the outcome of the present study could be of great practical significance for oats growing farmers in choosing the right variety based on the intended use and nature of the prevailing farming system.

Keywords: Oats; Variety; Growth stage; Herbage yield; Grain yield; Straw yield

Introduction

The use of sown forage crops has received considerable attention for complementing the conventional feed resources especially in areas where high producing crossbred dairy cows are owned in the Ethiopian highlands (Daniel, 1990). The very nature of the integrated crop-livestock production systems in the Ethiopian highlands requires multipurpose forage species suitable for feed and food or feed and natural resource conservation thereby to address the multi-faceted problems of the farming community. Due to its multipurpose use as feed and food, short life cycle, suitability in crop rotations and better performance on marginal lands, oats is the most important species for integration into the existing farming system. Oats appears to be the only feasible forage crop grown at very high altitudes (up to 3000 m) or on heavy soils (vertisols) where temperate grasses such as ryegrass, cocksfoot or tall fescue are difficult to establish (Lulseged, 1981). The species owes its reputation to its versatility as it can be grown for grain, hay, silage or direct grazing and is being used as feed for dairy cattle, young stock, sheep and hogs (Kipps, 1970; Boonman, 1993). Moreover, it has superior recovery after grazing and is highly useful for overcoming critical periods of feed shortage or for finishing animals for market when permanent pastures are of poor quality (Lovett and Scott, 1997).

Besides its chief use as livestock feed, oats grain can also be processed and used for human consumption in the form of porridge, oats cake and other foods (Purseglove, 1972). Oats as a food grain has rapidly gained increasing popularity in recent years, as a result of its serum cholesterol lowering properties (Anderson *et al.*, 1990) which is mainly attributed to the water-soluble fiber (β-glucan) content in the grain and partly due to other components including saponins (Price *et*

al., 1987). The nutritional composition of oats grain is also reported to be superior to most cereal grains (Frey and Hammond, 1975; Kellems and church, 1998; Robbins *et al.,* 1971; Schipper and Frey, 1991).

In Ethiopia, conventional research on oats begun in the early 1970`s following introductions of a number of lines collected from different parts of the world (Astatke, 1976). Of the previous introductions, some seven varieties were selected based on their adaptability and forage yield and recommended for forage production in the mid 1970`s. In the mid 1980`s additional grain type varieties were introduced from CIMMYT and evaluated for their adaptability to the Ethiopian highlands. All together about 20 selected varieties have been maintained for further evaluation considering more parameters assumed useful to outline wide ranges of specific recommendations in using oats cognizant to the features and felt needs of the different farming systems. The major parameters of interest for integrating oats varieties in the farming system are maturity, plant height, herbage yield, grain and grain related performances and their interrelationships. Therefore, this study was aimed at assessing differences in plant height, herbage yield, grain and straw related performances and their interrelationships in 20 selected oats varieties.

Materials and Methods

Experimental site

The experiment was conducted at Holetta Agricultural Research Center (HARC) in the central highlands of Ethiopia. The center is located at 38° 30`E, 9° 3`N and 45 km west of Addis Ababa and lies at an elevation of 2400 m above sea level. Based on an average meteorological data of 34 years (1969 – 2003) of the HARC, the annual rainfall of the area is 1066 mm with bimodal distribution, over 70% of which occurs during the main rainy season (June to September) and 30% during the small rainy season (February to April). The average annual minimum and maximum temperatures of the area are 6° to 22°C. The area is also characterized by occasional frost that occurs in the months of October to December, where temperatures below zero are recorded for few days during these months.

The major soil type of the area is a red-brown clay loam nitosol, and analysis of composite soil sample taken from the upper 20 – 30 cm soil horizon of the specific experimental plot in this study indicated that the soil had a pH (1:1 H_2O) of 5.1, total N content of 0.2%, P content of 12.4 ppm, OM content of 2.2% and cation exchange capacity (CEC) of 17.0 meq/100 g soil. Similarly, values for the major climatic variables during the course of the experimental period (June – December, 2003) were: total rainfall (686 mm), average minimum and maximum temperatures (6.5° and 21.2°C) and relative humidity of 60.6% (HARC meteorological data).

Oats varieties

Twenty oats varieties that were selected on the basis of their adaptation to the highlands of Ethiopia from previous introduction and screening works were used for the experiment. The varieties and their respective origins are shown in Table 1.

Sowing, data collection and measurements

The oats varieties were sown on 24th of June 2003 in a Randomized Complete Block Design (RCBD) arrangement with four replications. Sowing was made by drilling the seeds in rows of 0.2 m wide on 4m x 3m plots spaced 0.5 m apart. A starter dose of fertilizer at the rate of 18/46 N/P_2O_5 kg/ha (100 kg DAP/ha) was applied across all plots during sowing. A uniform seeding rate of 100 kg/ha was used for all the varieties as per previous recommendation for pure stands of oats in the highlands of Ethiopia (Astatke Haile, 1979). All the plots were hand weeded once a month after sowing and thereafter as required based on occurrence of weeds.

The varieties were closely examined beginning from the early vegetative growth and a reliable record of the different growth stages (boot, heading, milk, soft dough and grain maturity stages) was taken. Plant height was determined as an average height of five randomly selected plants measured from ground level during each growth stage.

For the determination of herbage yields of the oats varieties, half of each plot was harvested whenever the varieties reached the recommended harvesting stage for forage of the soft dough stage. At harvest, the total fresh biomass was recorded in the field and about 350 g sample was collected in a paper bag and dried at 65°C for 72 h in a forced drat oven to determine the DM percentage. Herbage DM yield per ha was then determined as percent DM multiplied by fresh biomass per ha divided by 100. The remaining half plot of each variety was harvested at grain maturity to assess grain related performances of the varieties. In order to isolate the grain from the remaining biomass, the panicle portion was first cut apart and air-dried on a clean canvas to facilitate threshing and separation of the grain using manual operations. The aftermath left after grain was harvested from ground level and its fresh biomass was measured and recorded in the field. Representative samples of the aftermath were then taken and oven dried at 65°C for 72 h to determine straw DM yield. Grain yield was estimated at an adjusted moisture content of 12.5% which is established to be the optimum moisture content that is safe for handling and storage of cereals. The residue remaining after grain threshing (chaff) was oven dried at 100°C overnight and added to the aftermath DM for estimation of straw DM yield on ha basis. Harvest index, thousand-grain weight and straw: grain ratios were also determined. Harvest index was calculated as the ratio of grain yield to total above ground biomass yield multiplied by 100.

Statistical analysis

Analysis of variance was performed using the statistical analysis system (SAS) software (SAS, 2001) and mean separation was carried out using the Duncans new multiple range test. Correlations of days to maturity, plant height, herbage yield, grain yield, straw yield, thousand grain weight and harvest index were determined by simple correlation analysis procedure of SAS (SAS, 2001)

Results and Discussion

Plant height at different growth stages

Height of the 20 oats varieties at different growth stages is shown in Table 2. Plant height ranged from 61.40 to 130.63 cm, 80.86 to 140.75 cm, 109.13 to 172.00 cm, 120.38 to 179.88 cm and 120.00 to 179.50 cm at boot, heading, milk, soft dough and grain maturity stages, respectively. Both variety and growth stage significantly affected plant height ($P<0.05$). The general trend indicated that height of all the varieties significantly increased ($P<0.05$) from boot to soft dough stages. However, plant height did not change much after the soft dough stage and the difference was not significant between soft dough and grain maturity stages for all the varieties ($P>0.05$). This shows that soft dough stage is the physiological maturity stage after which oats varieties do not grow in height but may accumulate more starch and nutrients in the kernel. The 20 oats varieties evaluated in this study could be classified as short, intermediate and tall varieties in height. Varieties such as CI – 8251, Lampton, CI – 8237, PI – 244475, PI – 244480 and CI – 8235 were significantly taller ($P<0.05$) than most of the other varieties during all the growth stages. On the other hand, varieties such as SRCP X 80 Ab 2767, 79 Ab 382 (TX) (80 SA 94), Clintland 60 MN 16016, Ky to 78394 Canada and SRCP X 80 Ab 2764 were significantly shorter ($P<0.05$) than most of the other varieties at all stages of growth. All the remaining varieties were intermediate in height. Most of the taller varieties such as PI-244480, CI-8237 and lampton were observed to be comparatively susceptible to lodging. Early grazing, cut-and-carry feeding in the middle of their growth and other agronomic and management practices like manipulation of sowing date, seeding rate and soil

fertility may help to reduce lodging risks. Preservation as silage could be another remedy for better utilization of the varieties that are susceptible to lodging. On the other hand, most of the short and intermediate varieties were resistant to lodging except the heavy grain bearing varieties like Coker SR res 80 SA 130, SRCP X 80 Ab 2291 and 79 Ab 384 (TX) (80 SA 95) which were slightly susceptible to lodging in the later stages, especially under conditions of strong wind storm.

The variation in height among the oats varieties has got practical significance as it could be associated to other parameters of importance for forage and grain production or in dictating the reaction of different varieties to lodging. Nelson *et al* (1995) attested that height is genetically determined, but is subjected to environmental influence such that certain growth regulators reduce plant height and increase lodging resistance. Most of the taller varieties in this study such as PI-244480, CI-8237 and lampton were observed to be comparatively susceptible to lodging. Early grazing, cut-and-carry feeding in the middle of their growth and other agronomic and management practices like manipulation of sowing date, seeding rate and soil fertility may help to reduce lodging risks. Preservation as silage could be another remedy for better utilization of the varieties that are susceptible to lodging. On the other hand, most of the short and intermediate varieties were resistant to lodging except the heavy grain bearing varieties like Coker SR res 80 SA 130, SRCP X 80 Ab 2291 and 79 Ab 384 (TX) (80 SA 95) which were slightly susceptible to lodging in the later stages, especially under conditions of strong wind storm.

Herbage yield of the oats varieties

Whole forage DM and estimated yields of the different morphological fractions of the 20 oats varieties are presented in Table 3. Herbage DM yield from whole forage ranged from 11.94 to 17.04 t/ha. Similarly, the estimated yields of the morphological fractions ranged from 1.74 to 3.53 t/ha for leaf blade, 1.93 to 3.48 t/ha for leaf sheath, 4.26 to 6.76 t/ha for stem and 2.65 to 5.16 t/ha for panicle components. The oats varieties Grayalgeris, CI – 8235 and SRCP X 80 Ab 2291 gave relatively more herbage yield than all the other varieties but significantly higher ($P<0.05$) than Clintland 60 MN 16016 and Ky to 78394 Canada. Moreover, varieties such as Coker SR res 80 SA 130, SRCP X 80 Ab 2252, SRCP X 80 Ab 2291, 79 Ab 384 (TX) (80 SA 95), SRCP X 80 Ab 2806 and 79 Ab 382 (TX) (80 SA 94) which were relatively early to attain the physiological maturity of soft dough stage gave reasonably high herbage yield. These varieties can thus be potentially recommended for cut-and-carry feeding or direct grazing in situations where a considerable area of land remains fallow until the intended crop is being planted such as the case of chickpea and lathyrus growing areas of the Ethiopian highlands. In these areas, chickpea and lathyrus are grown using residual moisture from mid-September to early October and the farmers can obtain a substantial quantity of green feed by growing early maturing oats varieties. Moreover, as feed shortage is critical during this period in most of the highlands, there will be a wide opportunity to extend such varieties.

On the other hand, medium and late maturing varieties may preferably be used for hay or silage making depending on their morphological characteristics. Varieties such as Grayalgeris, PI-5800, CI-8251, PI-244475, PI-338517 and Clintland 60 MN 16016 gave comparatively higher leaf yield (leaf blade + leaf sheath) than stem and therefore could be useful for haymaking. These varieties reach physiological maturity for harvest when weather conditions are favorable for curing the hay. Most of the previously recommended varieties like Lampton, SRCP X 80 Ab 2252, CI-8235, CI-8237, SRCP X 2806 and SRCP X Ab 2291 were found to give more stem yield than leaf and could be more useful for silage making or cut-and-carry feeding in the middle of their growth while their stem is succulent. The complaint of farmers on poor palatability of the hay made of these varieties can be justified by the more stemmy nature of the varieties as found through morphological fractionation in this study. This in turn also proves that forage yield alone as a variety evaluation criterion will not be adequate for recommending a given variety for forage production.

Although there was considerable variation among the different oats varieties in herbage yield, all the varieties were by far productive than the yields reported for conventionally available feed resources and other adaptable forage crops in the highlands of Ethiopia (Lulseged and Alemu, 1985). Herbage yield obtained from oats varieties in this study was generally in the range of the values previously reported for few varieties in the same area (Astatke, 1976; Lulseged, 1981 and Getnet *et al.*, 2004) despite slight seasonal variations. Intermediate to late maturing varieties gave comparatively higher forage yield than the early maturing varieties. This could be explained in terms of the longer growth duration which probably allowed the late maturing varieties to take full advantage of the better growing conditions (Ciha, 1983). Herbage yield in combination with other characteristics like maturity, proportions of morphological fractions and nutritive value of the herbage are useful considerations in selecting the best variety for forage production (Arelovich *et al.*, 1995). Varieties such as Coker SR res 80 SA 130, SRCP X 80 Ab 2252, SRCP X 80 Ab 2291, 79 Ab 384 (TX) (80 SA 95), SRCP X 80 Ab 2806 and 79 Ab 382 (TX) (80 SA 94) were relatively early to attain the physiological maturity of soft dough stage, and moreover, gave reasonably high herbage yield. These varieties can thus be potentially recommended for cut-and-carry feeding or direct grazing in highland areas where a considerable area of land remains fallow until the intended crop is being planted such as the case of chickpea and lathyrus growing areas of the Ethiopian highlands. Alemayehu and Lazier, (1989) suggested oversowing of improved forage crops such as oats for cut-and-carry feeding on degraded areas and establishment of the same on farms as strategies for forage production. In addition to these approaches, the promotion of early maturing varieties as preceding forage crops to chickpea/lathyrus will be a sound strategy as it enables the smallholder to get additional benefit from the same plot of land within a season without disturbing the normal farming practice.

Straw and grain related performance of the oats varieties

Table 4 indicates grain yield, thousand grain weight, straw yield, harvest index and straw to grain ratio of the 20 oats varieties. Grain yield ranged widely from 3.83 to 10.56 t/ha, thousand-grain weight from 19.48 g to 33.58 g, straw DM yield from 9.86 to 14.58 t/ha, harvest index from 22% to 43.50% and straw to grain ratio from 1.30 to 3.56 units. There was wide variation among the oats varieties in most of the grain related parameters. The oats varieties Coker SR res 80 SA 130, SRCP X 80 Ab 2767, SRCP X 80 Ab 2291and SRCP X 80 Ab 2806 gave significantly higher ($P<0.05$) grain yield than most other varieties whereas grain yield was significantly lower ($P<0.05$) in CI-8251, PI-244480 and PI-5800. Coker SR res 80 SA 130 gave exceptionally higher grain yield (10.56 t/ha) and this figure appears to be greater than the grain yield reported for improved barley and wheat varieties in the highlands of Ethiopia. This variety could thus be a potential candidate to be promoted for grain production in areas where oats is grown for human food. Varieties like SRCP X 80 Ab 2252, 79 Ab 384 (TX) (80 SA 95), Ky to 78394 Canada and 79 Ab 382 (TX) (80 SA 94) also gave considerably higher grain yield (over 7 t/ha). Such considerable grain yield combined with the inherent qualities of oats to be grown on poorly fertile soils without much fertilizer input is highly important from the context of resource poor farmers.

Alike the trend in grain yield, there was wide variation in thousand-grain weight among the 20 oats varieties. The oats varieties with higher grain yield also tended to have higher thousand-grain weight and vice versa. Accordingly, the highest grain producing variety (Coker SR res 80 SA 130) had significantly higher ($P<0.05$) thousand-grain weight than most of the other varieties whereas lower grain yielding varieties (PI-244480 and CI-8251) had significantly lower ($P<0.05$) thousand-grain weight. Moreover, varieties such as SRCP X 80 Ab 2252, SRCP X 80 Ab 2806, 79 Ab 384 (TX) (80 SA 95) and SRCP X 80 Ab 2291 had comparatively higher thousand-grain weight than the other varieties such as Clintland 60 MN 16016, Grayalgeris, PI-244475 and PI-338517.

On average, over 12-t/ha straw was obtained from the 20 oats varieties and this figure was lower only by 2 t than the overall mean herbage yield of the varieties. The oats varieties such as PI-

244475, PI-244480, CI-8235, Coker SR res 80 SA 130 and SRCP X 80 Ab 2291 had comparatively higher straw yield, whereas PI-338517, SRCP X 80 Ab 2764, 79 Ab 382 (TX) (80 SA 94) and Ky to 78394 Canada had relatively lower straw yield than the other varieties. The two varieties, Coker SR res 80 SA 130 and SRCP X 80 Ab 2291 combined both high grain and straw yields, while the other high grain producing varieties were intermediate in their straw yield. The second lower grain producing variety (PI-244480) had the highest straw yield than the rest varieties.

Harvest index of the 20 oats varieties ranged widely from 22% to 43.50%. The high grain producing varieties such as SRCP X 80 Ab 2767 and Coker SR res 80 SA 130 had significantly higher ($P<0.05$) harvest index than most of the other varieties. Moreover, shorter varieties such as Ky to 78394 Canada, 79 Ab 382 (TX) (80 SA 94) and SRCP X 80 Ab 2764 had comparatively high harvest index. On the contrary, the poor grain producing varieties like CI-8251, PI-244480 and PI-5800 had significantly lower ($P<0.05$) harvest index than most other varieties. Generally, there was a clear distinction among the varieties in their harvest index and the trend indicated that high grain producing or shorter oats varieties had higher harvest index than low grain producing or taller varieties. The straw: grain ratio of the oats varieties also ranged from 1.30 to 3.56 units with a mean of 1.94 units. Unlike the case of harvest index, poor grain producing varieties (CI-8251, PI-244480 and PI-5800) had significantly higher ($P<0.05$) straw: grain ratio whereas high grain producing or shorter varieties (SRCP X 80 Ab 2767, Coker SR res 80 SA 130 and Ky to 78394 Canada) had significantly lower ($P<0.05$) straw: grain ratios than most of the other varieties.

In general, the evaluated oats varieties demonstrated remarkable and widely variable grain and straw related performances and this shows the multipurpose use potential of oats. The oats variety Coker SR res 80 SA 130 gave exceptionally higher grain yield (10.56 t/ha) and this figure appears to be greater than the grain yield reported for improved barley and wheat varieties in the highlands of Ethiopia. This variety could thus be a potential candidate to be promoted for grain production in areas where oats are grown for human food. Varieties like SRCP X 80 Ab 2252, 79 Ab 384 (TX) (80 SA 95), Ky to 78394 Canada and 79 Ab 382 (TX) (80 SA 94) also gave considerably higher grain yield (over 7 t/ha). Grain yield of the oats varieties in this study was by far better than the figures previously reported for some of them in the area (Astatke, 1976; Lulseged, 1981; Getnet *et al*., 2004). This may be attributed to seasonal influences. Such high grain yield along with the anticipated beneficial nutritional value in human diet (Hurt *et al*., 1988; Anderson *et al*., 1990) and the fact that oats is preferred by farmers due to its ability to grow on poorly fertile soils could indicate prospective future for expanding grain type oats varieties in the highlands of Ethiopia. Oats varieties with higher grain yield also tended to have higher thousand-grain weight and vice versa. Zhou *et al* (1998) reported that variety is the main cause of the difference in grain size and thousand-grain weight which in turn affect quality of the oats grain. This shows that thousand-grain weight is a useful parameter for the indirect assessment of oats grain quality. Moreover, thousand-grain weight has got practical significance in estimating seeding rate for each variety in order to ensure that equal number of seeds could be sown per unit area.

The two oats varieties, Coker SR res 80 SA 130 and SRCP X 80 Ab 2291 combined both high grain and straw yields, while the other high grain yielding varieties were intermediate in their straw yield. In general, all the oats varieties included in this study gave higher straw yield than the values reported for different cultivars of barley in the central highlands of Ethiopia (Seyoum *et al*., 1998) and for maize in mid-altitude areas of southern Ethiopia (Adugna *et al*., 1999). Stem accounted for the major portion of the straw followed by leaf sheath and leaf blade in all the varieties. This could explain the poor quality of the straw, as an increase in fiber and lignin is related to a lower proportion of leaves and a higher proportion of stems in plant DM that usually occurs at advanced physiological maturity. However, Prasad *et al* (1993) reported higher CP and lower NDF values for oats straw than barley and wheat straws. White *et al.* (1981) also reported that oats straw is more digestible than barley straw, and barley straw is more digestible than wheat straw. This may be attributed to less shattering loss of leaf material in oats straw compared to

other cereals. There was a clear distinction among the oats varieties in their harvest index and the general trend indicated that high grain producing or shorter oats varieties had higher harvest index than low grain producing or taller varieties. Varietal differences in harvest index were also reported in maize (Adugna *et al*., 1999), in tef (Seyoum *et al*., 1996) and in barley (Seyoum and Zinash, 1995). The straw: grain ratio is used as a multiplier to convert cereal grain yields into crop residue yield and the value reported for oats in Africa was 1.5 (Kossila, 1988). However, most of the oats varieties in this study had higher straw: grain ratio than the reported value, while only 4 varieties had a value below 1.5. The straw: grain ratios of SRCP X 80 Ab 2764, SRCP X 80 Ab 2252, 79 Ab 384 (TX) (80 SA 95) and SRCP X 80 Ab 2806 were comparable to the reported value. The overall average straw: grain ratio in this study was higher than the reported value and this may be attributed to selection for taller varieties as height is positively correlated with both forage yield and straw yield, but negatively correlated with grain yield. This could obviously be the case as forage yield was the major selection criteria for oats varieties in Ethiopia.

Correlations of the measured parameters

Correlations of days to maturity, plant height, herbage yield, grain yield, straw yield, thousand-grain weight and harvest index of the studied oats varieties is shown in Table 5. Days to maturity at forage harvest was significantly negatively correlated with grain yield ($P<0.01$), thousand-grain weight and harvest index ($P<0.05$) and had positive but non-significant correlation with plant height and herbage yield. Plant height was significantly positively correlated with both herbage yield and straw yield, but was significantly negatively correlated with harvest index ($P<0.05$). Herbage yield was positively correlated with straw yield but had no considerable correlation with grain yield suggesting the possibility of improving forage yield without adversely affecting grain production and vice versa in oats. Similarly, there was no considerable association between grain yield and straw yield, but grain yield had highly significant positive correlation with thousand-grain weight and harvest index ($P<0.001$).

The absence of strong correlation between herbage yield and grain yield in this study was consistent with the works of Stuthman and Marten (1972) who reported that forage yield and grain yield were not associated in their study of 30 oats cultivars. This may indicate the possibility of improving herbage yield without adversely affecting grain production and vice versa. Moreover, the positive correlation between herbage yield and straw yield magnifies the multipurpose use of oats. The negative correlation between maturity and grain related parameters also shows the need to promote early maturing oats varieties for grain production.

Conclusions

The 20 oats varieties manifested clear and meaningful differences in most of the parameters measured and the observed variations are of great practical significance for better utilization of oats through exploitation of desirable varietal features. All the oats varieties gave reasonably better herbage yield and straw yield particularly in view of the overall livestock feed situation in the Ethiopian highlands. Moreover, oats varieties with prospective potential for grain production were identified. In general, the information generated in the present study would help oats growing farmers to choose the right variety based on the intended purpose of production and the nature of the farming system.

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References

Adugna Tolera, Berg T., and Sundstøl, F. 1999. The effect of variety on maize grain and crop residue yield and nutritive value of the stover. Anim. Feed Sci. Technol. **79**: 165-177.

Alemayehu Mengistu and Lazier, J.R. 1989. Recommended forages for Ethiopian environments and current strategies for utilization. In: proceedings of the XVI International Grassland Congress, 4 – 11 October 1989, Volume II, pp 1597-1598, Nice, France.

Anderson, J.W., Deakins, P.A. and Bridges, S.R. 1990. Soluble fiber hypocholesterolemic effects and proposed mechanisms. In: Kritchevsky, D., Bonfield, C. and Anderson, J.W. (eds.). Dietary Fiber Chemistry, Physiology and Health Effects. Plenum, New York, pp. 339-363.

Arelovich, H.M., Miranda, R., Horn, G.W., Meiller, C. and Torrea, M.B. 1995. Oats varieties: Forage production, nutritive value and grain yield. Agr. Exp. Sta. Tech. Bull. No. 109, pp 3-27, Cabildo, Argentina.

Astatke Haile. 1976. Results of experiments in forage crops and pasture management in the highlands of Ethiopia (1971 – 1976), Forage and Range Bulletin No. 1: IAR (Institute of Agricultural Research), Addis Ababa, Ethiopia.

Astatke Haile. 1979. Forage Crops and Pasture Management in the Highlands of Ethiopia. Forage and Range Bulletin No. 2: IAR (Institute of Agricultural Research), Addis Ababa, Ethiopia.

Boonman, J.G. 1993. East Africa's Grasses and Fodders: Their Ecology and Husbandry. Kluwer Academic Publisher, The Netherlands.

Ciha, A.J. 1983. Forage production of triticale relative to other spring grains. Agron. J. **75**: 610 – 613.

Daniel Keftasa. 1990. Effect of management practices on Rhodes grass and lucerne pastures with special references to developmental stages at cutting and associated changes in nutritional quality. Proceedings of the first workshop on utilization of research results on forage and agricultural by-product materials as animal feed resources in Africa, held in Lilongwe, Malawi, 5-9 December 1988.

Frey, K.J. and Hammond, E.G. 1975. Genetic characteristics and utilization of oil in caryopses of oats species. Journal of the American Oil Chemistry Society **52**: 358 – 362.

Getnet Assefa, Fekede Feyissa, Abreham Gebeyehu and Muluneh Minta. 2004. Characterization of selected oats varieties for their important production traits in the highlands of Ethiopia. In: proceedings of the 11th annual conference of the Ethiopian Society of Animal Production. August 28-30, 2003, Addis Ababa, Ethiopia, pp. 305-314.

Hurt, H. D., Mathews, R., and Ink, S.I. 1988. Biomedical considerations of oats dietary fiber and β-glucans. In: Mattson, B., and Lyhagen, R. (eds.). The Third International Oats Conference. pp. 205 – 222.

Kellems, R.O. and Church, D.C. 1998. Livestock feeds and feeding. Fourth ed., Prentice Hall, Upper Saddle River, New Jersey, USA.

Kipps, M.S. 1970. Production of field crops. Tata Mc Graw-Hill Publishing Company Ltd., New York.

Kossila, V. 1988. The availability of crop residues in developing countries in relation to livestock population. In: Reed, J.D., Capper, B.S., Neate, P.J.H. (Eds.). Plant Breeding and the Nutritive value of Crop Residues. Proc. Workshop held at ILCA, Addis Ababa, Ethiopia, 7 – 10 December 1987, ILCA, Addis Ababa, pp. 29 – 39.

Lovett, J.V. and Scott J.M. 1997. Pasture production and management. Inkata Press, Melbourne, Australia.

Lulseged G/Hiwot. 1981. Summary of fodder oats research undertaken by IAR. Pasture and fodder forage bulletin no. 2, IAR, Addis Ababa.

Lulseged Gebrehiwot and Alemu Tadesse. 1985. Pasture Research and Development in Ethiopia. In kategile, J.A. (ed.). Pasture Improvement Research in Eastern and Southern Africa, Proceedings of a workshop held in Harare, Zimbabwe, 17-21 Sept.1984. Ottwa Ont, IDRC.

Nelson, J.E., Bauer, A. and Connor, J.F. 1995. Growth staging of wheat, barley and wild oat. A strategic step to timing of field operation. Montana Agricultural Experiment Station Capsule Information Series No. 30. (http://Growth Staging of Wheat, Barley and Wild Oat. htm)

Prasad, C.S., Sampath, K.T., Rai, S.N. and Joshi, A.L. 1993. Physical, chemical and morphological characteristics of slender and coarse straws and response to urea treatment. A review. In: Singh, K. and Schiere, J.B. (Eds.). Feeding of Ruminants on Fibrous Crop residues: Aspects of treatment, feeding, nutrient evaluation, research and extension. Indian Council of Agri. Research, Krishi Bhavan, New Delhi, India. Pp. 320-335.

Price, K.R., Johnson, I.T. and Fenwick, G.R. 1987. The chemistry and biological significance of saponins in foods and feeding stuffs. CRC Crit. Rev.Food Sci. Nutr, **26**: 27 – 135.

Purseglove, J.W. 1972. Tropical crops. Monocotyledons, Longman Group Limited, U.K.

Robbins, G.S., Pomeranz, Y. and Briggle, L.W. 1971. Amino acid composition of oats groats. Journal of Agricultural and Food Chemistry **19**: 536 – 539.

Schipper, H. and Frey, K.J. 1991. Observed grains from three recurrent selection regimes for increased groats-oil content of oats. Crop Science **31**: 1505 – 1510.

Seyoum Bediye and Zinash Sileshi. 1995. The influence of variety and location on feeding value of barley straw. In: proceedings of the third annual conference of the Ethiopian Society of Animal Production, 27 – 29 April 1995, Addis Ababa, Ethiopia.

Seyoum Bediye, Zinash Sileshi and Tesfaye Mengiste. 1996. Tef (Eragrostis tef) straw quality as influenced by variety and locations. In: proceedings of the 4th annual conference of the Ethiopian Society of Animal Production. April 18-19, 1996, Addis Ababa, Ethiopia, pp. 145-152.

Seyoum Bediye, Zinash Sileshi, Getnet Assefa and Hailu Gebre. 1998. Effect of cultivar and fertilizer application on yield and quality of barley straw. In proceedings of sixth annual conference of Ethiopian Society of Animal Production, 14-15 May 1998, Addis Ababa, Ethiopia, pp 279 – 285.

Statistical Analytical Systems (SAS). 2001. SAS/STAT user's guide release 8.1. Statistical Analysis Systems Institute, Inc, Cary, NC, USA.

Stuthman, D.D. and Marten, G.C. 1972. Genetic variation in yield and quality of oats forage. Crop Sci. **12**: 831 – 833.

White, L.M., Hartman, G.P. and Bergman, J.W. 1981. In vitro digestibility, crude protein and phosphorous content of winter wheat, spring wheat, barley and oat cultivars in eastern Montana. Agron. J. **23**: 117 – 121.

Zhou, M.X., Roberts, G.L., Robards, K. and Holmes, M.G. 1998. Effects of sowing date, nitrogen application and sowing rate on oat quality. Aust. J. Agric. Res., **49**: 845 – 852.

Table 1. Varieties of oats used in the study

Serial No	Variety	Origin
1	79 Ab 382 (TX) (80 SA 94)	CIMMYT
2	79 Ab 384 (TX) (80 SA 95)	CIMMYT
3	CI – 8251	Yugoslavia
4	Jasari	Kenya
5	SRCP X 80 Ab 2806	CIMMYT
6	Lampton	Ethiopia
7	SRCP X 80 Ab 2252	CIMMYT
8	CI – 8235	USA
9	CI – 8237	USA
10	Grayalgeris	Algeria
11	SRCP X 80 Ab 2291	CIMMYT
12	Coker SR res 80 SA 130	CIMMYT
13	SRCP X 80 Ab 2764	CIMMYT
14	SRCP X 80 Ab 2767	CIMMYT
15	Clintland 60 MN 16016	CIMMYT
16	PI – 338517	Not specified
17	PI – 244475	Not specified
18	PI – 5800	Not specified
19	PI – 244480	Not specified
20	Ky to 78394 Canada	CIMMYT

Table 2. Plant height (cm) in 20 oats varieties at different growth stages

Variety	Growth stage				
	Boot	Head	Milk	Soft dough	Grain maturity
79 Ab 382 (TX) (80 SA 94)	63.78h	86.13hij	109.63hi	120.38j	120.00h
79 Ab 384 (TX) (80 SA 95)	76.08gh	101.13fg	130.63efg	151.25cdef	151.13d
CI – 8251	130.63a	138.63a	160.88abc	169.38ab	166.75b
Jasari	99.13de	116.88cde	137.63de	145.50efg	146.00de
SRCP X 80 Ab 2806	72.38gh	100.88fgh	140.00de	152.50cde	153.88cd
Lampton	117.80ab	130.75abc	162.63ab	179.88a	179.38a
SRCP X 80 Ab 2252	70.13gh	96.63fghi	134.13ef	151.50cdef	153.38cd
CI – 8235	108.45bcd	130.13abc	155.00bc	161.00bc	163.63bc
CI – 8237	119.78ab	140.75a	172.00a	179.25a	179.50a
Grayalgeris	97.13de	120.50bcd	133.25efg	146.13efg	145.00de
SRCP X 80 Ab 2291	80.28fg	103.25ef	128.50efg	145.75efg	148.25de
Coker SR res 80 SA 130	70.25gh	100.50fgh	138.03de	147.50def	149.50de
SRCP X 80 Ab 2764	70.13gh	84.88ij	122.25fgh	133.88ghi	138.50ef
SRCP X 80 Ab 2767	61.40h	80.88j	109.13i	131.50hij	133.50fg
Clintland 60 MN 16016	66.80gh	95.50fghij	121.25ghi	139.38fgh	146.13de
PI – 338517	92.00ef	109.25def	129.15efg	143.38efgh	146.75de
PI – 244475	116.98abc	128.50abc	149.50cd	160.25bcd	162.75bc
PI - 5800	105.25bcde	122.13bcd	141.13de	155.50cde	162.50bc
PI – 244480	102.00cde	133.38ab	157.50bc	170.88ab	173.50ab
Ky to 78394 Canada	69.75gh	86.75ghij	114.00hi	123.75ij	127.00gh
Mean	89.50	110.37	137.31	150.43	152.35
SE	5.41	5.27	4.46	4.58	3.94

[abc] means with different letters within a column are significantly different ($P<0.05$)

Table 3. Herbage dry matter (t/ha) yields of whole forage and estimated yields of morphological fractions in 20 oats varieties harvested at the soft dough stage

Variety	**Component**				
	Whole forage	**Leaf blade**	**Leaf sheath**	**Stem**	**Panicle**
79 Ab 382 (TX) (80 SA 94)	13.03abc	2.04de	2.14cd	4.78bcd	4.07abcdefgh
79 Ab 384 (TX) (80 SA 95)	14.05abc	1.88de	2.26cd	5.54abcd	4.37abcde
CI – 8251	14.26abc	3.06abc	2.75abcd	5.50abcd	2.96fgh
Jasari	13.27abc	2.31cde	2.11cd	5.06abcd	3.80bcdefgh
SRCP X 80 Ab 2806	15.85ab	2.43bcde	2.56bcd	6.32ab	4.54abcd
Lampton	14.20abc	2.11de	2.18cd	5.12abcd	4.79abc
SRCP X 80 Ab 2252	14.19abc	2.54bcde	2.67abcd	5.20abcd	3.78bcdefgh
CI – 8235	16.13a	2.70abcd	3.48a	6.23abc	3.72bcdefgh
CI – 8237	15.17abc	1.87de	2.57bcd	5.57abcd	5.16a
Grayalgeris	17.04a	3.53a	2.79abcd	6.26abc	4.46abcd
SRCP X 80 Ab 2291	16.12a	2.61bcde	2.46cd	6.76a	4.30abcdef
Coker SR res 80 SA 130	14.34abc	2.07de	2.79abcd	5.39abcd	4.11abcdef
SRCP X 80 Ab 2764	13.36abc	1.74e	2.09cd	5.06abcd	4.47abcd
SRCP X 80 Ab 2767	12.98abc	1.86de	1.93d	4.36cd	4.83ab
Clintland 60 MN 16016	11.26c	1.87de	2.48bcd	4.26d	2.65h
PI – 338517	14.04abc	2.70abcd	2.40cd	4.95abcd	3.99abcdefgh
PI – 244475	15.44ab	3.02abc	3.34ab	5.69abcd	3.39defgh
PI - 5800	14.06abc	3.22ab	2.87abc	4.92abcd	3.05efgh
PI – 244480	13.83abc	2.11de	2.86abc	6.11abcd	2.76gh
Ky to 78394 Canada	11.94bc	1.87de	2.17cd	4.44bcd	3.46cdefgh
Mean	14.23	2.38	2.54	5.38	3.93
SE	1.46	0.32	0.30	0.67	0.47

[abc] means with different letters within a column are significantly different (P<0.05)

Table 4. Straw dry matter and grain yields (t/ha), thousand grain weight (g), harvest index (%) and straw : grain ratio in 20 oats varieties

Variety	Straw yield	Grain yield	1000-grain wt	Harvest index	Straw: grain ratio
79 Ab 382 (TX) (80 SA 94)	9.95e	7.20bcde	25.70f	41.80ab	1.41f
79 Ab 384 (TX) (80 SA 95)	10.98cde	7.33bcde	30.48bcd	39.85ab	1.52ef
CI – 8251	13.80abc	3.83i	21.10gh	22.00f	3.56a
Jasari	12.85abcde	6.57defg	29.50cd	33.88cd	1.97cd
SRCP X 80 Ab 2806	13.18abcd	8.60bc	31.53abc	39.69ab	1.52ef
Lampton	12.74abcde	6.52defg	29.28d	33.66cd	2.00cd
SRCP X 80 Ab 2252	11.17cde	7.71bcd	32.53ab	40.86ab	1.45f
CI – 8235	14.12abc	6.68def	25.73f	32.18de	2.21c
CI – 8237	12.67abcde	6.84def	29.38d	34.91cd	1.87cde
Grayalgeris	10.26de	5.22fghi	24.98f	33.83cd	1.96cd
SRCP X 80 Ab 2291	14.05abc	8.64b	30.25cd	37.93bc	1.66def
Coker SR res 80 SA 130	14.09abc	10.56a	33.58a	42.89a	1.37f
SRCP X 80 Ab 2764	9.90e	6.86cdef	28.75de	41.03ab	1.45f
SRCP X 80 Ab 2767	11.22bcde	8.67b	28.55de	43.49a	1.30f
Clintland 60 MN 16016	11.02cde	5.80efgh	22.70g	34.41cd	1.94cd
PI – 338517	9.86e	5.13fghi	25.48f	34.16cd	1.93cd
PI – 244475	14.58a	6.72def	25.23f	31.56de	2.17c
PI - 5800	12.69abcde	4.87ghi	26.33f	27.76e	2.64b
PI – 244480	14.38ab	4.28hi	19.48h	23.00f	3.39a
Ky to 78394 Canada	9.98e	7.22bcde	26.70ef	41.88ab	1.39f
Mean	12.17	6.76	27.36	35.54	1.94
SE	1.13	0.62	0.75	1.59	0.14

[abc] means with different letters within a column are significantly different (P<0.05)

Table 5. Correlation of days to maturity, plant height, herbage yield, grain yield, straw yield, thousand grain weight and harvest index in 20 oats varieties

	Days to maturity a	**Plant height**	**Herbage yield**	**Grain yield**	**Straw yield**	**Thousand grain weight**
Days to maturity						
Plant height	0.16					
Herbage yield	0.34	0.46*				
Grain yield	-0.65**	-0.33	0.07			
Straw yield	-0.17	0.66*	0.44	0.06		
Thousand grain weight	-0.49*	-0.12	0.18	0.83***	-0.04	
Harvest index	-0.49*	-0.65*	-0.18	0.83***	-0.50*	0.74***

* *p<0.05. ** p<0.01. *** p<0.001.*

[a] *Duration at forage harvest*

Availability of livestock feed resources in Alaba *Woreda*, Southern Ethiopia

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Abstract

This study was undertaken in Alaba, Southern Ethiopia with the objective of quantifying the major feed resources. General linear model (GLM) was fitted for dry matter yield of private grazing lands of the household in tone over covariates household grazing land size and number of households' livestock in TLU for each type of livestock's. Models were fitted for crop residues dry matter yield and aftermaths of the households. Mean holdings of total lands did not vary between the two farming systems significantly ($P > 0.05$) but land use systems varied between the two study sites significantly ($P < 0.05$) with Pepper / Wheat /Livestock farming system having higher values than Teff / Haricot bean /Livestock system. Similarly, livestock holding in tropical livestock unit (TLU) and total dry matter (DM) productions of feed resources were significantly different between the two study sites ($P < 0.05$) and the major sources of feeds for livestock near to 78 % are obtained from crop residues followed by grazing lands. Significant differences of crop residues yield was observed between the two study sites ($P<0.05$) due to high rate of cultivation in Teff / Haricot Bean /Livestock system. Results are based on 114 sample households' surveyed in the two great strata of the Woreda at two seasons. The results of the models showed that the following variables with the corresponding P-value in the bracket were found to have a significant effect over the dependent variable dry matter yield of grazing land, household grazing land size in hectare (< 0.0001), numbers of household livestock in TLU for horse (0.03), mature female donkey (0.04), and for dairy cows (0.07). Livestock feed balance in terms of dry matter yield showed that a total of 1,224.6 tone of dry matter are produced for total TLU values of 1,128.2 but in actuality 3,178 tone of dry matter is required for the surveyed existing stocks. Quantification estimate clearly showed that the time of abundant feeds availability in the Woreda is only five months.

Key words: *Farming systems, Livestock unit, Dry matter, Utilization Efficiency and Feed balance.*

Introduction

Livestock production is an integral part of the farming systems in Ethiopia and plays a vital role in the livelihood of the majority of people. In spite of this, the productivity is low mainly due to several factors such as genetic make up, poor nutrition and poor veterinary care. But poor nutrition is the major limiting factor. Livestock feed resources are classified as natural pasture, crop residue, improved pasture and forage, agro-industrial by-products, other by-products like food and vegetable refusal, of which the first two contribute the largest feed type (Alemayehu, 2003). Animals depend mainly on natural pastures for their feed requirements because they provide more than 90% of the livestock feed and yet the natural pastures are generally very poorly managed due to overstocking and others resulting in severe land degradation, loss of valuable species and dominance by unpalatable species (Alemu, 1998). The total livestock density of the *Woreda*[1] is about 255, 467 heads which is quite considerable to poverty eradication and food security if feed, the greatest component of productivity, is resolved not to be a problem. Comprehensive survey of the types, quantity, quality, availability, alternative uses of the different feed resources is importantly identified to facilitate the decision making process in livestock feed resource development under small holder Ethiopian conditions. The results provide firm understanding of the prevailing situation and enable specific interventions to be introduced. Most of the research works conducted

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only indicated the shortage of feeds without quantifying the amount of dry matter (DM) obtained in each feed resource type and whether this is adequate to the total number of livestock available to that particular area. Therefore, it is very much imperative to assess the already existing feed resources in terms of quantity and quality in relation to the requirements of livestock annual basis so that it would be very easy to suggest either improving the existing feed resources, introduce another feed alternatives or suggest development and policy interventions for each agro-ecology.

Material and methods

Description of Alaba woreda and its farming systems

Alaba is found in the southern Nations and Nationalities region 310 km south of Addis Ababa and about 85 km south west of the Regional capital, Awassa in the Great Rift Valley. There are two farming systems in Alaba that are classified based on the crop commodities they produce and species of livestock they rear since use of altitudinal, vegetation and soil variability were difficult to be used to identify due to similarities of these factors. Accordingly an area where crop commodities of *Teff* and Haricot bean are abundantly produced and where sheep is the predominant species from livestock is called *Teff* / Haricot bean / Livestock (Farming system I). An area where crop commodities of Wheat and Pepper are abundantly produced and where goat is predominant species from livestock is called Pepper / Wheat / Livestock (Framing system II). Therefore, livestock species abundance is one of the strata formation criteria in this case. Intensification of cultivation is higher in *Teff* / Haricot bean / Livestock farming system and due to this reasons lands are covered with crops leaving very small plots for grazing land. In *Alaba,* there are 38,699 ha total land out which 32,896 ha cultivated and 204 ha are grazing lands (CSA, 2007).

Stratification and Sampling Methods

The two farming systems have respectively 43 and 30 peasant associations. Therefore, these two were taken as strata to categorize PA's in the *Woreda* and in each strata or farming system two further stages were formed depending upon the variation in the level of management of livestock, availability of feeds, systems of feed preservation and usage of the feed resources. Five peasant associations in each stage were selected and household surveys were conducted. Stratified two stages random sampling technique was employed to select farm households in each farming system and a total of 114 farm households were randomly visited once for the interview (Figure 1).

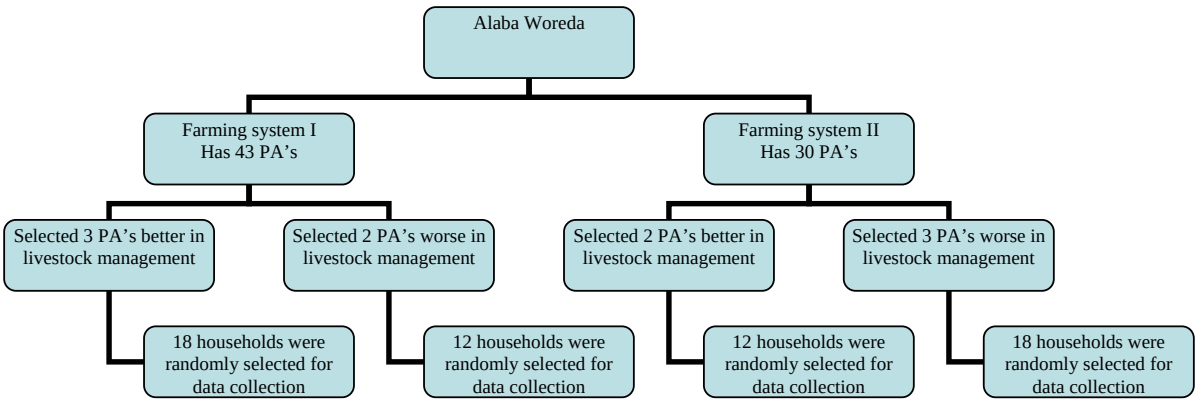

Figure 1. A chart showing stratifications and staging for livestock feed resource efficiency utilization research in Alaba

Study design and types of data collection

The first phase of the data collection used a combination of rapid rural appraisal techniques and standard questionnaire. Then designing the questionnaire was carried out based on the results

of the checklists of discussion with focused groups. Then after, a well structured questionnaire was prepared in a way it can address the interests of all the key informants commonly, pre-tested, changed into Amharic with five days consecutive training. This was followed by the actual survey that had taken place in two phases from December 06-19, 2007 and June 24-July 07, 2007 for fourteen days each in ten peasant associations from the two strata of the *Woreda* and in each strata and at each stage, five peasant associations from which six households were randomly selected have been properly administered the questionnaires.

Estimation of crop residues yield

Areas of land cultivated and yield of crops obtained were surveyed by using the questionnaires at the visited households. In this respect, all cereals, pulses, vegetables and cash crops produced by each farm household were all incorporated regardless of their nutritional quality so that the yield of crop residues is calculated based on the biomass harvest index ratio of 1: 2 (Seyoum and Zinash, 1991). From this then is obtained the total crop residues biomass yield of all crops sawn by the farmer in tone so that a conversion of the dry matter yield of every crop residue is obtained as per the chemical analysis result for a Sub-Saharan country (SSA), Ethiopia to get the dry matter yield ratio of crop residues produced by each household and that of each farming system and the *Woreda* overall. General linear model (GLM) was fitted for dry matter yield of each crop residues in tone over the areas of cropped land of the households, number of oxen holding of the household in tropical livestock units and the amounts of fertilizers used as covariates by each household.

Estimation of the productivity of natural pasture

A range of biotic and abiotic factors influences the productivity of grassland like herbage species, ground cover, edaphic factors including the type and texture of the soil and its fertility, climatic factors particularly temperature, rainfall and its distribution, and presence of undesirable plant species. The utilization of herbage either directly by animals or under cut and carries system also affects grassland production. Both private and communal grazing land sizes of the entire visited farm household were surveyed in the questionnaire where normally in farming system I the later was not at all found but is to a certain extent available in farming system II of the *Woreda's* area. What was obtained as a proportion of the communal land was shared amongst farm households herding their livestock to obtain the share proportion of each farm household land size. General linear model (GLM) was fitted for Dry matter yield of private grazing land of the household in tone over household grazing land size and number of households' livestock in TLU for each type of livestock's used as covariates. Then after, using (FAO, 1987) dry matter yield production yield conversion factor of 2 t/ha, the total yield of the grazing land of each household was obtained.

Determination of biomass yield from trees and shrubs

Samples of trees were collected to make specimens of their leaves, thorns, pods and seeds for species like acacia where it was later taken to Alage Agricultural Technical and Vocational Training College's Natural Resource Department Herbarium for identification. Two species from each trees and shrubs were sampled from the households but unfortunately enough it was not possible to find shrubs of feed values except tree forages within farm households' vicinity; indeed, there are a lot within the grazing land and forests. Trees forages found in the territory of the farmers were considered in spite of high potential availability in the *Woreda* as inaccessible land and forest. Trunk diameter was measured at 30 cm height for shrubs and 120 cm height for trees using measuring tape and leaf yield per annum was determined using the allometrric equation of log w = 2.24 log dt-1.5 (Petmak, 1983) to calculate for its potential biomass yield using the existing equation. Then, dry matter yield portion of these tree species was directly obtained from the Sub Saharan Africa (SSA) feeds chemical analysis result data.

Estimation of aftermath and fallow grazing

Total lands after cropping was considered at each household with potential fallow lands; to obtain the dry matter yield contribution of the households as per annual conversion of (FAO, 1987) which is 0.5 tone/ha and 1.9 tone/ha, respectively to get the total dry matter production for which balance estimate with livestock unit ratio is to be computed with evaluation of efficiency of utilization using the model. General linear model (GLM) was fitted for total dry matter yield obtained from aftermath of the household over household total cropped land size and areas of land of the household covered by different crops to infer about the estimates of changes of the aftermath that would arise because of 1 unit changes of the covariates.

Feed utilization efficiency, estimation of nutrient supply and requirement

Dry matter production from all feed resources was used to evaluate utilization efficiency of the feed resources at household level. General Linear model was fitted based on parameters that affect utilization of livestock feed resources of grazing land and others. Grazing systems, feeding calendar and storage of crop residues, quality upgrading were the efficiency measuring parameters. Nutrient requirement of a given animal species is calculated based on 2.6 kg of DM/100 kg of live weight in the surveyed households (Greyseels and Anderson, 1993). Database of Sub-Saharan African feeds was exhaustively utilized by for samples results that range up to thousands especially for a Sub-Saharan Africa country, Ethiopia and the values were entered as a data for analysis to get the results. Total dry matter yield obtained from the analysis result was compared against the total livestock holding of each farm household, farming system and the *Woreda* and the feed resources were summed together to estimate the total dry matter of the feed resources and to compare it versus the total ruminant feed requirement after converting them into the appropriate livestock units.

Statistical models used for data analysis

The main uses of models 1-3 is to give dry matters estimates of each feed resource change because of one unit change of the independent variables(covariates).

$X_{ijk} = \mu + F_i + C_j + G_k + e_{ijk}$, Where Xijk is the dry matter yield obtained by the household from grazing land

F_i is the effect of i th location (Farming system), i = 1 and 2

C_j is the effect of j th household grazing land size, j = 1, 2…114

G_k is the effect of k th household size in tropical livestock unit (TLU), k = 1, 2…114

e_{ijk} is the random error

$Yijk = \mu + F_i + H_j + I_k + e_{ijk}$, Where Y_{ijk} is dry matter content obtained from crop residues production of the household

F_i is the effect of ith location (Farming system), i = 1 and 2

H_j is the effect of j th household oxen holding in tropical livestock unit (TLU), j = 1, 2…114

I_k is the effect of k th household fertilizer use in tone per annum, k = 1, 2…114

e_{ijk} is the random error

$Z_{ijk} = \mu + F_i + J_j + K_k + e_{ijk,}$ Where $Z_{ijk\ is}$ total dry matter yield obtained from aftermath of the household

F_i is the effect of i th location (Farming system), i = 1 and 2

J_j is the effect of j th household cropped land total

K_k is the effect of k th each crop area in hectare

e_{ij} is the random error

Data analysis and interpretation

Data of the survey results and relevant secondary data were organized, summarized and analyzed using SAS, 1987 (Version 8.2) statistical package. Descriptive, regression and two ways independent mean comparison between a given parameter of the two study sites were employed in data analysis. Mean and percentage values of various parameters were compared between the two study sites of the *Woreda* (farming system I and II). Accordingly, values of parameters that differed significantly among the two studied areas were separately presented. The general linear model of univariate and multivariate was used to fit models, observe their significances and estimate the effect of covariates on a single dependent variable and the effect on many dependent variables, respectively. The model estimated the possible change values that might come because of one unit change of the covariates clearly.

Results and discussion

Land holdings and land use systems in the study area

Land is the most important limiting production factor in the study area and the quality and quantity of land available greatly determines the amount of production. However, as opposed to family size, the land holding per household is decreasing from time to time posing the integration of crop and livestock systems with no fallacy. Rate of land allocation for cultivation was 80% in *teff* / haricot bean / livestock farming system with mean value of 1.84 per household and communal grazing land per household was 0.02±0.01 which implies that lands allotted for communal grazing are rarely found. Private grazing lands of the surveyed households showed a value of 0.35±0.035 in this farming system. Total land holding per household of 2.96±0.01 ha in farming system of Pepper / Wheat /livestock out of which 74.3% was cultivated and mean value of 2.14 in *teff* / haricot bean /livestock were not significantly different ($P > 0.05$). Areas of communal and private grazing lands of the households between the two farming systems were, however, significantly different at ($P < 0.05$). This is so because farmers relatively allot more plots of their lands in pepper / wheat /livestock area of the *Woreda* where this in turn will influence the total feed resources to be obtained for their livestock in total dry matter regardless of the ratios with the livestock density. The average land holding of the overall study sites per household was 2.55±0.086 ha.

Livestock holding and composition

This study focuses on the individual as well as the total holdings of the study areas based on the sampled households. Individual farm house holdings of each livestock species and structures were converted into appropriate tropical livestock unit conversions to get the TLU values. Total TLU in the *Woreda* was found to be 9.87 per household as per the survey result of which cattle, sheep, goats and equines take a proportions of 7.38, 0.27, 0.42 and 1.8 TLU where as poultry took 4.01±0.42 TLU. Comparison of means of almost all livestock showed significantly higher difference between the two farming systems ($P < 0.05$) where more densities in TLU were found in farming system II but sheep and horses were abundantly found in more stocking rates in farming system I (Fig. 2). Oxen, dairy cattle and poultry holdings were not significantly different ($P > 0.05$) between the two farming systems the reasons of impressions are because oxen are the main traction components for cultivating the lands and dairy cattle are the main sources of fresh milk for both children and the families. The total TLU value of the *Woreda* based on the surveyed data were found to be 1,128.2 for all species of livestock where the peak value is held by dairy cattle followed by oxen, heifer and female calves respectively which clearly imply their high use value within the farmers. The total TLU values of Farming system I of all livestock was calculated as 498.7 where the household share was 9.5 TLU per household and the value for Farming system II was 629.6 in total and 10.15 for household share. In general, cattle were the predominant livestock of the total sum of the herd composition holding of the farm households by 837.8 TLU where equines, goats

and sheep ranked values of 114.8, 40.9 and 33.6 TLU; however, takng the two farming systems sheep predominate the composition of shoats by 18.3 TLU in *Teff* / haricot bean /livestock farming system compared to 15.9 TLU of goats and goats predominate by 24.5 TLU in farming system II sheep of 15.3 TLU (Fig. 2).

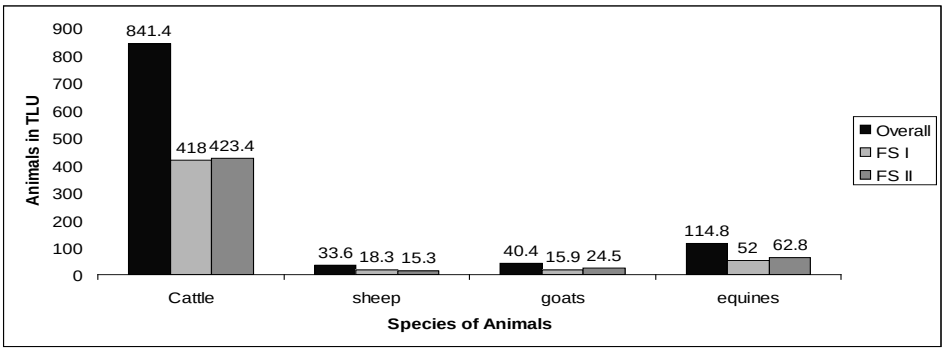

Figure 2.Total livestock holding and structure in the *Woreda* (Based on the survey data)

Dry matter productions of the different feed resources

Feed resources in the *Woreda* are obtained from grazing land, fodder crops, fodder trees, crop residues and a locally available mineral *'bole*[2]*'*. A total of 1,224.6 tone of dry matter from all feed resources are produced in 114 surveyed households which make the ratio of dry matter to livestock holding of the *Woreda* to be 1.09 of which the greatest proportion is obtained from maize and sorghum crop residues and considerably low amount of feeds are obtained from the grazing lands of the *Woreda* when compared to the total livestock holdings available. In this study each feed resource produced at each household was computed on dry matter basis and mean and sum totals were all arrived at where the following results were obtained (Fig. 3).

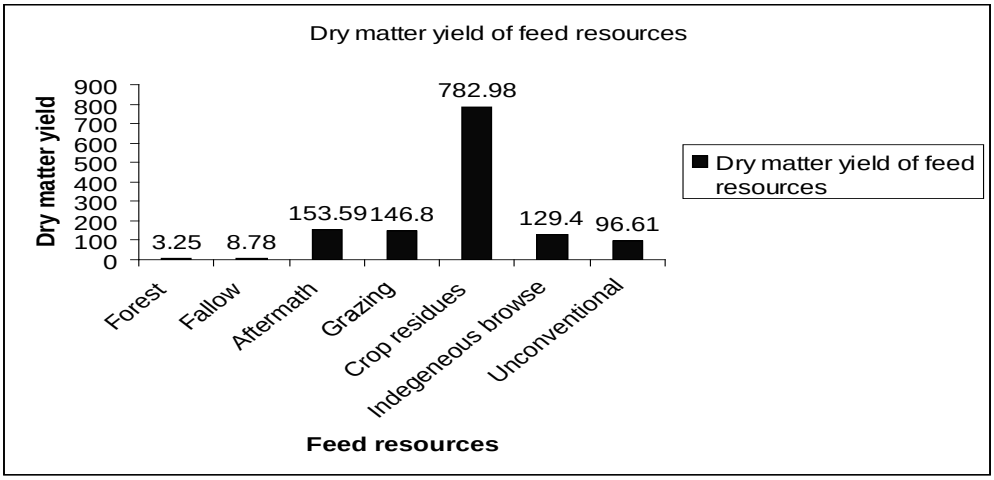

Figure 3. Dry matter production shares of different feeds of the Woreda in tone (Based on survey data).

Livestock feed balance

According to the analysis of the surveyed results data farmers in Farming system I need nearly 1,196.2 t DM/yr where as the actual production is only 524.67 t /DM/yr (Fig. 10) which is only 43.8% of what is required and able to support the existing stocks only for 5.4 months while in Farming system II a total of 1,370.3 t DM/yr is required for the surveyed livestock against the actual yield of 679.53 t /DM/yr which is 49.5% of the sites requirement and able to support the total

2 *'Bole' is local name given to salt licks of animal by many kushitic languages.*

livestock for only six months. In general 3,178 t /DM/yr is required against the actual production per annum of 1,224.6 that is only 38.5% and supporting the total *Woreda* animals for only five months (Fig.11). The availability of dry matter and tropical livestock units' ratio for *Wolayita* district which is adjacent to Alaba is computed to be 1.37 and 1.24 for the year 1982/83 and 1983/84 respectively (Adugna, 1992) and this value is quite comparable with the survey results of this study 1.09. This variation of higher values in *Wolayita* may be attributed to high degree in the use of multi purpose trees, efficient land use and systems of farming difference.

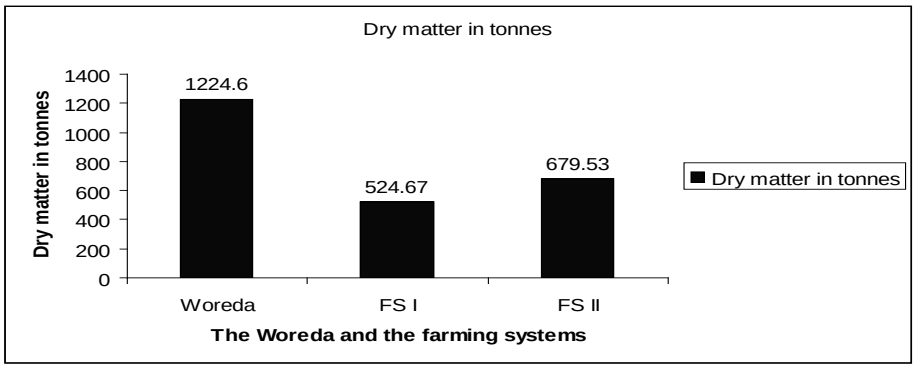

Figure 5 Total dry matter yields of the *Woreda* and the two farming systems.

Proportions and shares of the feed resources from all-possible sources in the *Woreda* showed that a total of dry matter of 8.5 t/hh/yr is produced for a total TLU of about 8.13 in *teff* haricot bean and 10.65 t DM/hh/yr for 10.107 TLU for Pepper / wheat /livestock. This value is comparable with over all annual crop reside availability of 9.01 tone per household in Sinana (Solomon, 2004) and 9.35 tone per household in the highlands of Arsi (Abdinasir, 2000). This means the ratio of dry matter to livestock units is 1.045 and 1.054, respectively in the two farming systems where as this ratio is 1.09 for the overall *Woreda*. This ratio is quite low and clearly shows the gap that exists between feed balance and livestock number at any rate and it is incomparable with many of other results.

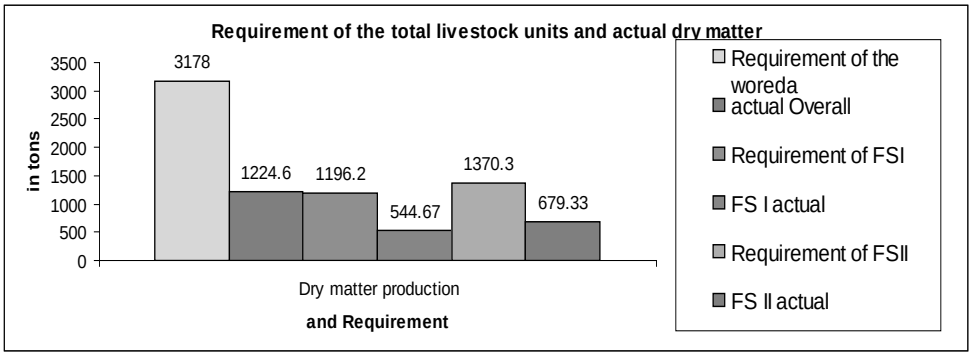

Figure 6 Dry matter requirements against yield in Alaba (Feed Balance based on survey data).

Dry matter of grazing lands against the existing livestock density

Results of analysis of the fitted model for grazing land showed the following variables with the corresponding P-value in the bracket have a significant effect over the dependent variable Dry matter yield of private grazing land. Household grazing land size in hectare (<0.0001), Number of household livestock in TLU for horse (0.03), mature female donkey (0.04), and for dairy cows (0.07). The fitted model can be written as: Dry matter yield of grazing land = 0.53 + 1.94 Household grazing land size in hector + 0.40 TLU for horse -0.53 TLU for mature female donkeys + 0.14 TLU for cows. The sign for the estimated coefficients is positive for the three parameters and this

is an indication that they have positive impact on the amount of dry matter yield obtained from grazing land except mature female donkeys. These coefficients estimate the dry matter obtained per household as influenced by a unit change of the significant variables. This clearly showed that dairy cows are the important livestock structures prioritized by farmers mainly because they are the sources of children milk, butter for generating cash and pulls for replacement stock. Female donkeys were the second herd structures that had significant linear effect but inversely on dry matter productions of grazing lands of the households and this imply that they are the main sources of transportations to load marketable goods from the farm to the market and bringing back forth farmers domestic consumptions. It has been also observed in Alaba that either a single donkey pulls an animal wheel cart or pairs of donkeys have been observed to give transportation services for the farmers as a chariot in the deep local *kebeles* and for most cases Alaba is an area where dense donkey population was found relatively. Horses were also linearly related as per the model result to dry matter production of grazing land of the households because they are farmers' local vehicles and have good income from sale to urban areas to be used as "*Gari*". This finding is in agreement with donkeys are mainly used for transporting goods from site to the market in Sinana and in Dinsho due to cool temperature horses substitute the role of the donkeys (Solomon, 2004). All the rest of livestock had insignificant linear effect on dry matter production of grazing lands of the households, which clearly showed that the rest of livestock species and structure exist and increase at the cost of the reserved households' dry matter from grazing lands of the three significant linear animal species. This is why only one-third of the total feed was available in Alaba. The crop residues contribute to rest of species and structure of animals in spite of being low in nutritive value. Other interventions for the rest of the livestock must therefore be assessed to meet their feed requirement. Grazing is continuous throughout the year for all these animals with out control.

Dry matter production of private grazing land

Total private grazing land dry matter yield obtained on average from the surveyed households was found to be 0.93± 0.10 and 1.58± 0.19 in *Teff* / Haricot bean /Livestock and Pepper / Wheat / Livestock farming system respectively and this significantly higher value of the dry matter ($P < 0.05$) is attributed to more plots of land owned by the farmers in the latter system which will go to support the more denser livestock holdings per household and (Fig. 4). The over all dry matter yield production per household was 1.22± 0.09 from an average grazing land holdings of 0.44± 0.04 according to yield estimate of FAO (1987).

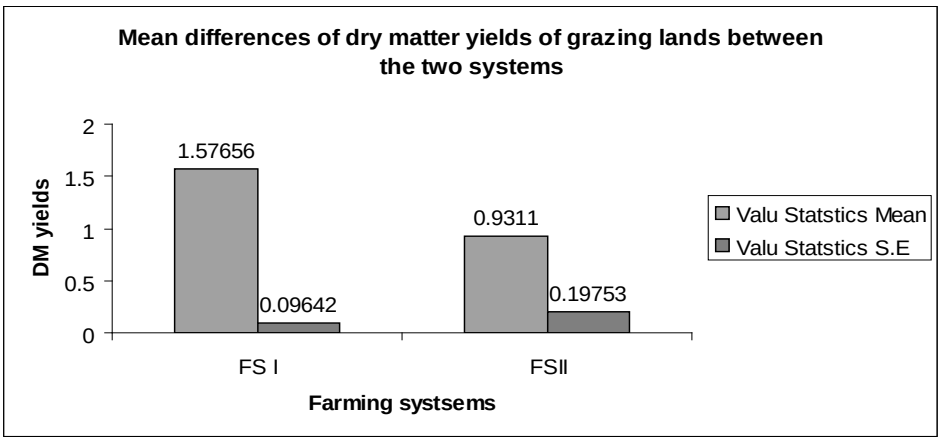

Figure 4. Mean difference of dry matter yield of grazing land between the two farming systems

Dry matter production from crop residues

Crop residues are abundantly produced in almost throughout the world where there is integration of crop-livestock and different thoughts exist as to their complement and contrast. Of all feed resources produced in the *Woreda* crop residues produced in terms of dry matter alone were 65.3, 57.73, and 78.72% in *teff* / haricot bean /livestock, Pepper / wheat livestock farming systems as well as the *Woreda*, respectively. Farmers understand the fact that crop residue is one of the major feed resources to rely on but very few of them store in a separate cottage to cope up the long period of unavailability of six months as a result most of the crop residues are hipped up out side in the field or discarded to be wasted by trampling. Higher mean value records were observed in terms of crop residues dry matter production in Farming system of *Teff* / haricot bean / livestock for commodities of, millet, potato and haricot bean and therefore there is significant difference ($P< 0.05$) in the production of dry matter crop residue yields of these crops between the two study sites where it is more for this farming system. In a similar manner, Pepper /Wheat/ livestock producing farming system produced more amounts of dry matter crop residues for maize, wheat, pepper, sorghum and barley where it was significantly different between the two farming systems ($P < 0.05$). The major uses of crop residues in the *Woreda* is of course as a feed value but considerable households surveyed alternatively use crop residues for fuel, roof shatter, fences and any of their combinations as the need arises and this puts maximum pressure on the dry matter yield obtained from crop residues besides of failure to collect, store, treat and conserve it properly. The results of the dry matter of crop residues fitted model estimated the change that would be obtained because of one unit changes of the covariates of total cropped land in hectare, number of oxen holding and amounts of fertilizers in quintals used by each household and the effect over the dry matter yield from crop residues is given for all crop residues produced per household of a given farmer as influenced by the covariates. Area of cropped land of the household had significant linear effect on the crop residues dry matter yield of the household at P (0.0001) with the model. Millet crop residue is the most preferred followed by *teff*, sosrghum, maize, barley and wheat is the least wanted by animals and given only when farmers run highly short of feeds because of different repercussions on the physiological performance and emaciation results to animals.

Dry matter of aftermath

Following the crop harvest in November aftermath grazing provides plenty of feeds for livestock in Alaba where it takes them up to the small rain through March, periods of three to four months. Farmers in the *Woreda* use aftermath grazing as one means to sustain their livestock for duration of about 4 - 5 months starting from November until almost the second short rains cultivation. Therefore, stubble grazing is one of the ways by which livestock keepers in the small holders greatly depend on and the majority of the maize Stover of greater than 50% is not collected to be stored for mitigation of dry period feed shortages. This was because farmers claimed that they had long years of experiences in that if all the Stover's are collected for storage in the cottage the time spent by their livestock to graze in the after math will be shorter hence cow dung drop on the aftermath will not be there resulting in infertility of the soil due to no manure and the subsequent yield of crops will lessen gradually. The following variables were found to have a significant linear effect over the dependent variable dry matter yield obtained from aftermath. The P-value (the minimum level of significance is presented in bracket with the corresponding variable. For this GLM model coefficient of variation (CV = 0.99) and the coefficient of determination ($R^2 = 0.999$) obtained indicates that the fitted model is very stable and has captured over 99% of the variation on the values of dependent variable this means only below 1 % is left for noise. Results of analysis of the model estimates for aftermath of the household showed household cropped land size (<0.0001), Area of land the household covered by maize (<0.0017), sorghum (<0.0001) and millet (<0.008). This clearly showed that majority of the crop stubbles used as feed for livestock for more than four months were obtained from the above major crops. The rest of the crops had insignificant effect

on the dry matter obtained from aftermath of the households. The main justification that could be given for these insignificant values are two the uneven distribution of these crop commodities and rare abundance among farm household. The fitted GLM model can be written as: Total dry matter yield obtained from aftermath of the household =0.0026 + 0.499 Household cropped land size total -0.012 Area of land of the household covered by maize + 0 .038 Area of land the of household covered by sorghum +0.026 Area of land of the household covered by millet used as covariates. The sign for the estimated coefficient of maize is negative and this is an indication that maize has an inverse relation on the dry mater yield obtained from aftermath but as the sign for the estimated coefficient of household cropped land size, area of land covered by sorghum and millet is positive it is an indication for this parameters to have a positive effect over the dependent variable dry mater yield obtained from aftermath.

Indigenous browse

The commonest woody genera include plants such as *Croton macrostachys*, different species of Acacia of which the predominant one's are *Acacia senegal*, *Acacia seyal, Acacia nilotica*, *Acacia tortilis, Cordia african, Olea europaea*, *Eucalyptus species*, *Erytriana brucei, Euphorbia trucalli, Justicia scimperiann, Ficus sur ,Moringa stenoptalla*, *Vernonia amygdalina ,Melia azandirachta, Catha edulis, Leucaena leucocephala, Sesbania sesban* as per the sample specimens of leaves, flower and seeds based identification made in the Alage ATVET natural resource department's herbarium and according to useful trees and shrubs for Ethiopia (Azene *et al.*,1993) in farming system I and additional tree species are *Ballanite aegyptica, Ziziphus mauritiana*, *Azandirachta indica, Euphorbia abyssinica ,Scinus molle ,Grewa villosa ,Oppuntia species* and various tree plants common to the midlands are abundantly available in farming system II part of Alaba. Five species of Acacia trees which are *Acacia seyal*, *Acacia senegal, Acacia tortilis, Acacia nilotica, Acacia abyssinica* and other browsable fodder trees like *Balanites aegyptica, Cordia africana, Ficus thonningii, Leucanea leucocephala, Moringa stenoptala, Olea europaea, Sesbania sesban, Vernonia amyigdalina* were taken in the measurement of their trunk diameter.

Non -conventional feed resources (NCFR)

These include feeds like residues of local drinks coffee, *areke*, *tela chat* left over called *geraba,* fruits and vegetables reject. Their share in the total dry matter of the *Woreda* is of due consideration but needs a clear system of the dry matter percentages of each residues. In our case, the degrees by which local residues are produced are quite rare except for chat where every household uses at least once in two days. It was not possible to get a clear data of household chat consumption in this case but one can assume this will increase the total yield.

Mineral or salt lick

A naturally obtained rift valley salt lick is abundantly available since the *Woreda* is found escarping with the rift and average annual use in tonne of household's salt lick was found to be 0.04± 0.02 with a local name of *bole.* Farmers in pepper / wheat /livestock have better access of this salt lick to get naturally from ground and this showed a significant difference in the use of this salt lick between the two study sites. Therefore, considering this availability of salt lick as an opportunity better strategy can be designed for ration formulation. The proportions of farmers using mineral or salt lick as animal feed resources in the *Woreda* is higher where 72.3% of the total respondents use as sources of feeds for their animals and only 25% of the total respondents did not use these as feeds for their animals and the remaining 2.7 % respondents do not have the access to it. Nutritionally, study in Sodo previously showed that two mineral-rich soils, locally known as *Bole* and *Megadua* are used as mineral supplement for ruminants and equines, respectively. These soils are rich in sodium but low in phosphorous and hence attempts should be made to correct phosphorus levels of these feeds when they are used as dry-season supplements to diets based on crop residues and dry pastures (Adugna, 1992).

Summary and conclusion

One of the greatest livestock development constraints in sub-Saharan Africa is not the creation of breeds that can give high yields of productivity; it is rather the optimum utilisations of the potentials of the existing genome which have high adaptive traits to the sub-Saharan agro-ecology by improving efficient utilizations of locally available resources as feeds. In this case, Ethiopia is not an exception and has to go through the same steps stated above. Feed shortage during dry period causes in Ethiopia tremendous losses to livestock productivity. These feeds are not only short in total production obtained and deficient in their nutrient content compared with the total tropical livestock unit of an existing area but are not also utilized to the optimum efficiency. Feed as an independent variable determining productivity contributes to nearly 65 % of the phenotypic expressions of the animals' performance and the same percent of running costs in pen feeding. Therefore, the productivity challenge in sub-Saharan Africa of livestock and in the smallholders has to be launched to resolve this area of the constraint where greatest feed resources are contributed by grazing lands, crop residues and stubbles.

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References

Abdinasir Ibrahim, 2000. Smallhholder dairy production and dairy technology adoption in the mixed farming system in Arsi Highland, Ethiopia. Ph.D Thesis, Humboldt University, Berlin, Germany.pp 146

Adugna Tolera; Said, A. N., 1992. Prospects for integrating food and feed production of Wolayita Sodo, Ethiopia. In: The complementarity of feed resources for animal production in Africa.Proceedings of the joint feed resources net-works workshop held in Gabrone,Botswana,4-8 March 1991.(eds Stares JES,Said AN and Kategile JA),309-318, African Feeds Research Network. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Alemayehu Mengistu and Sissay Amare, 2003. Integrated Livestock Development Project (ILDP). Livestock Feed Resources Survey. North Gondar, Ethiopia.pp. 75

Alemu Tadesse, 1998. The unexploited potential of improved forages in the mid altitude and low land areas of Ethiopia. pp.503-517. In: Dzwela B.H,Said A.N, Asrat Wendem Agengehu and Kategile J.A (eds.) PANES/ANRAB (Pasture Network for Eastern and Southern Africa/African Research Net work for Agricultural by-products) Utilization of Research Results on Forage and Agricultural by-products of the First Joint Workshop Held in LILONGWE, MALAWI,5-9 December 1988. PANESA/ANRAB, Addis Ababa, Ethiopia

Azene Bekele, Tessema, Anne Birnie and Bo Tengnäs, 1993. Useful Trees and Shrubs for Ethiopia. Propagation and management for Agricultural Community. Nirobi Regional Soil Conservation Unit (RSCU), Swedish International Development Authority (SIDA), Nirobi and Addis Ababa.

FAO (Food and Agricultural Organization of the United Nations), 1987. Master Land Use Plan,Ethiopian Range Livestock Consultancy Report Prepared for the Government of the Peoples Republic of Ethiopia. Technical Report. AG/ETH/82/020/FAO, Rome, 94pp

Gryseels, G. and Anderson, F.M., 1983. Research on farm and livestock productivity in the central Ethiopian highlands: Initial results, 1977-1978. ILCA Research Report No. 4, ILCA, Addis Ababa, Ethiopia pp 52

Petmak, M.V., 1983. *Primary productivity, Nutrient cycling and organic matter turn over of Tree plantation after Agricultural Intercropping practices in Northeast Thailand*. Ph D Thesis, University of the Philippines.228 pp.

SAS Institute Inc., 1987. SAS/STAT User's Guide, Release 8.2 Edition.Statstical Analysis systems Institue In C., Cary, NC, USA.

Solomon Bogale, 2004. Assesment of livestock production system and feed resource base in Sinana Dinsho Distirct of Bale highlands, South East Oromiya. M.Sc. Thesis presented to the school of graduate studies of Alemaya University of Agriculture.pp141

SSA (Sub Saharan African) feeds.http:// www.vslp.org/ssafeed/,accessed on August 20, 2007.

Zinash, S. and Seyoum, B., 1991. Utilization of feed resources and feeding systems in the central zone of Ethiopia.Proceedings of the Third National livestock improvement Conference, Addis Ababa,Ethiopia. pp.129-132.

Utilization of feeds, livestock unit versus dry matter requirement in Alaba, Sothern Ethiopia

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Abstract

This study was undertaken in Alaba, Southern Ethiopia with the objective of evaluating the efficiency of utilizations of livestock feed resources. General linear model was fitted for utilization efficiency of livestock feed resources and it was significant. This was achieved by using dummy variables of yes or no at each farm household for parameters of feed preservation technique, use of storage house, feed quality improvement systems of grazing and feeding calendar. Seasonal variation of feed is high and efficient utilizations of what is produced is still quite less than 65% because of non-storage of crop residues during crop harvest, wastage by trampling and lack of improvement of the quality of the feed. Plots of, private grazing lands in front of homestead are usually the main sources of feeds for livestock, during cultivation and hence is over grazed. High production of crop residues dry matter, locally available sodic soil of the area called bole in addition to better livestock market out let is an existing opportunity. Interventions to utilize locally available potential feeds, better access to forage and fodder development, water development and quality improvement of straws are optioned as a way out to profit from the livestock sector in the study areas. Nevertheless, these are not only enough unless backed up institutionally as a strategy for consistent and persistent monitoring.

Key words: *Farming systems, Livestock unit, Dry matter, Utilization Efficiency and Feed balance.*

Introduction

The basal feed resources for ruminants available in most developing countries in the tropics are crop residues, pasture from fertile land, for example communal land or agro-industrial by-products. These are low in protein and of low digestibility. Practical strategies for improving production of animals on these diets depend on supplementation to optimise both fermentive digestion in the rumen and the efficiency of metabolism of absorbed nutrients. Specific strategies employ molasses ureas multi-nutrient blocks to optimise digestion in the rumen. The smallholders of developing countries have limited available for feeding to their ruminant livestock. They often do not have the luxury of being able to select the basal diet, they use whatever is available and at no or low cost. The available resources are essentially low digestibility forages such as tropical pastures (both green and manure), straws and other crop residues and agricultural by-products which are generally low in protein. The major criteria for improvement in production are to optimise the efficiency of utilization of the available fodder resource and not to attempt to maximise animal production (Flavey L. and Chantalakhana C, 1999). Economic considerations of feed resources abundantly available in the tropics should therefore pay particular attentions to proper systems of grazing to the grazing land, use of feeding calendar to optimise efficient animal conversion, timely and proper storages of crop residues with good techniques quality improvement, minimise alternative uses of these feeds and their supplementation with appropriate fodder tree.

Material and methods

Description of Alaba Woreda, its farming systems, stratification and sampling methods

Please refer to the preceding paper because the procedures are same.

Study design and types of data collection

Questionnaire and time of data collection are same as the previous however; in this case qualitative data of dummy variables were collected for farm households that use the parameters of utilisation efficiency so that delineation was between users and non-user farm households.

Feed Utilization Efficiency, Estimation of Nutrient Supply and Requirement

Dry matter production from all feed resources was used to evaluate utilization efficiency of the feed resources at household level. Total production of each feed resource per annum was computed using the designed methodologies. Then after, values were set for increasing or decreasing utilization efficiency in each feed resource. These values had also literature supported and computed after consistent monitoring for a month at each household and season. Households were delineated as users and non-users to final multiply them with the percent upgrade or reduction of efficiency. Then the totals were summed for users and non-users to evaluate the utilization efficiency of feed resources. General Linear model was fitted based on parameters that affect utilization of livestock feed resources of grazing land and others. Grazing systems, feeding calendar and storage of crop residues, quality upgrading were the efficiency measuring parameters.

Statistical Models used for Data Analysis

$W_{ijlkm} = \mu + F_{i} + c_j + O_k + v_l + Z_m + e_{ijlkm,}$ This evaluates utilization efficiency, Where.
W_{ijlkm} is dry matter production of the households all
F_i is the effect of I th Preservation technique employed; hay making, i = 1 or 2
C_j is the effect of j th storage house constructed, j = 1 or 2
O_k is the k th quality improvement employed k = 1 or 2
V_l is the effect of l th Proper system of grazing employed l = 1 or 2
Z_m is the effect of proper feeding calendar employed on a grazing land z = 1 or 2
e_{ijlkm} is the random error

Data Analysis and Interpretation

Data of the survey results and relevant secondary data were organized, summarized and analyzed using SAS, 1987 (Version 8.2) statistical package. Descriptive and percentage values of various parameters were computed. The general linear model of univariate and multivariate was used to fit models, observe their significances and estimate the effect of covariates on a single dependent variable and the effect on many dependent variables, respectively. The model estimated the possible change values that might come because of one unit change of the covariates clearly.

Results and Discussion

Uses of grazing land

A total of 1.29 tones of dry matter were produced per household in Alaba which accounts for 11.9% of the total feed resources in the *Woreda* of which in the total surveyed households of 114 nearly 74.5% of the farm households graze the land continuously without control. Assuming 30% loss in efficiency due to not properly grazing this land the total utilization efficiency reduces to 9.21%.

Crop residues utilization

Crop residue is one of the abundantly produced feed resources in Alaba which is 63.8% of the total feed resources and its usage was highly hampered by alternative uses, failure to store properly to use during time of feed scarcity and not improving its quality by different techniques because it has low In Vitro and In Situ degradability values (Melaku *et al.*, 2003). Feeds with such nutritional characteristics, which are relatively abundant in tropical farming systems need to be

supplemented with better sources of crude protein (CP) in order to support reasonable animal production. The reduction contribution of all those mentioned above reduces the utilization efficiency to 40.6% for all the surveyed households.

Utilization of indigenous browses

Shrubs are receiving increasing attention as potential livestock forage and valuable re-vegetation species on disturbed lands, especially in arid regions. Management and integration of shrubs require considerably more information than is presently available. Fodder trees and herbaceous legumes offer an opportunity for use as potential feed supplements by smallholder farmers in the tropics due to their high CP content and degradability (Melaku *et al.*, 2003). These plant species are potentially available in Alaba and need to be incorporated in the total feed resources of animals after critical evaluation with appropriate use in the long run. In spite of all these incorporation of these feeds into livestock feed by human intervention is infrequent. This fact could reduce the utilization efficiency of these feeds to almost zero according the already set values. Nevertheless, indigenous browse are tremendously available in Alaba.

Utilization Efficiency of Feed Resources

It has been proved that livestock feed resources are obtained in the *Woreda* from grazing lands, after math, crop residues, indigenous browse, fallow land, forest and wood land and from naturally available salt lick called '*bole*' at the rate of 1.29, 1.35, 6.92, 1.14, 0.077, 0.0285 and 0.037 t DM per household, respectively. Therefore, of the total household production of 10.8 which can suffice 1/3 rd of the farmers TLU the percent utilization was 63.4%. What matters is not the production in this regard rather it is the proper utilization of these resources by small holders' livestock that is quite pressing and a point ponder able to the forage-Agronomist, natural resource conservationist (botanist), economist and the extension worker. There is, however, an abundant supply of crop residues; particularly cereal straw during this period because the dry season normally coincides with the harvesting time of cereal crops in addition to the 64% dry matter production being from crop residues at *Woreda* overall and 72% in the two farming systems. This is computed for about nine major commodities of crops where maize, *teff* and potato take the greatest proportion in *teff* / haricot bean /livestock producing system where as maize, wheat and pepper in pepper/wheat/ livestock production system. Efficient utilization of feed resources also has to take into account the combined knowledge packages of storages, preservation, processing and improvement in feed quality and the results of the survey in this regard showed that quite less than 20% of the farm households possess storage houses for storing the crop residues of their farm left over for use during dry period. In fact, these crop residues are not recommended as major feeds for livestock in animal nutrition because they are low in nutritive values; however, the effort of this research is to make use of them in the existing interaction between the crop and livestock. If livestock productivity is to keep pace with demand, the imperative is to enhance productivity per animal and reduce wastage.

Storage houses

The feed value of crop residues could be greatly improved if they were cut soon after harvest and stored. Cutting and storing will minimize wastage from grazing and if done soon after harvest, will retain relatively good quality feed for livestock. Cereal residues would provide mainly energy (TDN) and if mixed with available forage legumes and haulms (which supply protein), the nutritive value of the crop residues would greatly be improved. One of the utilization efficiency of feed resources is storage house. Not storing properly the feed during ample production for use during dry period, especially crop residues which are produced in great proportion was not found to be an adopted technology and based on theoretical survey and practical observation a conclusion was reached that this may reduce efficiency of utilization of dry matter yield of crop residues of a given household by 25% and to this is added alternative uses of crop residues which 20% according to

Zinash and Seyoum bringing down the total crop residues utilization of the *Woreda* to 40.56% of the total crop residues yield and 25.87% of the total feed resources produced.

Feed quality improvement

There are different techniques by which the quality of a feed could be improved to cite some of these physical treatment from a simple soaking with water, chopping, grinding and pelleting up to the high chemical treatment, especially the latter improves the nutritive value of crop residues by 30% there by removing the hard cover of plant cellulose. In this case, crop residues are not exposed to such treatments in the survey areas. Most of the time a feed coping mechanism of like this is the interventions recommended in cereal based high crop residue areas like that of Alaba. There is no doubt that the effect of sodium hydroxide on digestibility and intake of roughage. In general, digestibility increases between 10-20% can be expected with intake increases of 30-50% (Beckman, 1921). The results of analysis of efficiency utilization of feed resources model showed that there is entirely significant difference in efficiency between farmers using store and those not using, thus crop residues produced in higher proportion has to be stored and used properly to mitigate the feed shortage process. How ever, variation was not well observed amongst households in other efficiency parameters like uses of systems of grazing, feeding calendar. This is because the techniques by which the different households use in trying to efficiently utilize the feed resources for almost the available feed resources starting from collection, storage, preservation and improving the feed quality are similar. Therefore, this model is fitted to represent efficient utilization of feed resources in the smallholder systems where grazing lands and crop residues are the main feeds for livestock and has to be recommended for use by farmers.

Summary and conclusion

Improvement of the poor quality roughage feeds that do not meet the requirements of these livestock with available innovated technologies and use of alternative feeds available should be an area of intervention. It has been found by the survey that the *Woreda* is one of the highest livestock population areas where feed availability is less than one-third per se of tropical livestock unit and the efficiency of utilization is less than 65% of what is normally available.

Table 1.Theoretical efficiency of utilization of livestock feed resources

Feed resources	Amount and percent produced per household		Efficiency Problem	N (%)	Users n1 (%)	Non users n2 (%)	Percent feed utilization
	Amount t/hh	%		114 (100%)			
Grazing land	1.29	11.89	1	114 (100%)	29 (25.5)	85 (74.5)	1. 3.03x1+8.85x0.7 = 77.54%x11.89= 9.21%
Aftermath	1.35	12.45	1	114 (100%)	All		2.Perfect = 100%x12.45.0=12.45%
Crop residues Total	6.92	63.8		114 (100%)	21 (18.4)	93 (81.6)	1.27x1+5.64x0.75 = 100%x63.8=63.8
Crop residues minus 20% alternative use	6.92 -1.384= 5.536	63.8 51.05	6	114 (100%)	All		Uses almost 20%x63.8= =51.05
Crop residues	6.92	63.8	2	114 (100%)		All	Not improved and remains as it is
Crop residues utilized	6.92	63.8	3	114 (100%)	21 (18.4)	93 (81.6)	3.1.27x1+5.64x0.75 =79.47%x51.05=40.56%
Indi. browse	1.14	10.5	4	114 (100%)		All	All do not use = 0%x10.500 = 0.00%
Fallow land	0.077	0.71	1	114 (100%)	All		4. Perfect =100%x0.071 = 0.71%
Forest-Wood	0.0285	0.26	1 & 4	114 (100%)			5.Only 50% is used =0.5%x0.26 = 0.13%
Bole	0.037	0.34	5	114 (100%)	All		6. =100%x0.034 = 0.34%
Total	10.842	100					7. Percent total feed utilization =63.4%

Descriptions

1= grazing system and theoretical %ages of reduction that not using causes between any two time intervals is 30%

2= quality improvement: grinding, pelleting, treatment & etc improves utilization rate by 30%.

3= Storage houses: Not using causes 25% reduction

4= No usage at all has a value of 0%

5= No problem

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References

Beckmann E., 1921. Conversion of grain straw and lupines into feeds of high nutritive value.Festscher. Kasier Whilhelm Ges.Ford.Wiss.Zehnjaherigen Jubilaum, pp 18-26.

Flavey L. and Chantalakhana C. (eds), 1999. Smallholdr Dairying in the Tropics. ILRI (International Livestock Research Institute), Nairobi, Kenya.462 pp.

ILRI (International Livestock Research Institute). 2000. Livestock strategy to 2010: Making the Livestock Revolution Work for the Poor. ILRI, Nairobi, Kenya.

Improving Productivity and Market Success (IPMS) Ethiopia, 2005. Alaba Pilot Learning Site diagnosis and program design. IPMS, ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia. Unpublished Report.

Melaku S. Peters K. J., and Tegegne A., 2003. In Vitro and In situ eveluiation of selected multipurpose Trees, Wheat bran and lablab purpureus as potential feed supplements to teff (Eragrostis teff) straw. Animal Feed Sci.Technol.108,159-179.

SAS Institute Inc., 1987. SAS/STAT User's Guide, Release 8.2 Edition.Statstical Analysis systems Institutes In C., Cary, NC, USA.

Zinash S. and Seyoum B., 1991. Utilization of feed resources and feeding systems in the central zone of Ethiopia.Proceedings of the Third National livestock improvement Conference, Addis Ababa,Ethiopia. pp.129-132

Disparity of livestock feed requirement and supply in Adaa district of east show zone of Oromyia Regional State, Ethiopia

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Abstract

This study was carried out in Adaa Liben district of the east Showa administrative zone of Oromiya Regional State (ORS), located east-south-east direction of the capital Addis Ababa at 45km. The study was conducted to quantify the feed balance (requirement and supply) in livestock production activity of the district.

The district has a total livestock population of 255,368.8 TLU. By taking the average energy and protein requirement for maintenance, growth and production, with an average ME content of 7.9MJ and 4.9% of CP produced from different feed resources per kg of DM in the district, about 451.3 thousands tone of DM/year is required to meet the energy requirement of the total livestock for maintenance and production in the district. Moreover, to meet the protein requirement of the total animals in the district, about 19,627.6 t of DM per annum is required.

A total of 124,649.5 t DM and 5921.1 t of consumable crude protein is produced annually from the major feed resources (natural pasture, crop stubbles and residues) in the district. Of which, majority is originated from crop residue. As the total DM feed composition and production in the district indicates, the total DM feed production does not meet the yearly DM requirement of the animals. Hence, the total DM feed supply was only fulfill the maintenance and total DM demand by 34 and 27%, respectively. Moreover, the actual availability of digestible protein even not meets the maintenance needs of animals and it only meet about 36.7 and 28% of the maintenance and total requirements, respectively. Therefore, it can be argued that both energy and protein are the limiting factors to livestock production in Adaa Liben district.

Key words: Feed requirement, feed supply, Dry matter, maintenance requirement, Crude protein, metabolizable energy.

Introduction

Feed is the most important input in livestock production, and its adequate supply (quantity and quality) throughout the year is an essential prerequisite for any substantial and sustained expansion in livestock production.

The major livestock feed in the country are grazing and browsing natural pasture, crop residues and agro-industrial by-products, and cultivated pasture and forage crop species (Anteneh, 1984; Alemayehu, 1987).

Under nutrition and malnutrition are major factors constraining animal production in Ethiopia. Nutritional stress causes low growth rates, poor fertility and high mortality, which is compounded by diseases. About 76.6 percent of feed intake is used to meet the animals' maintenance requirements and only 20.4 percent is utilized for production (Bekele, 1991). Utilization of the feed resources is therefore highly inefficient. The area which is under improved pastures and fodder crops is insignificant and natural pastures are overgrazed causing invasion of inferior species like *Pennisetum schimperi* and others, which are able to survive under heavy grazing pressure (Sentayehu and Smith, 1989).

According to Daniel (1988), crop residues and post-harvest grazing contribute about 10–50 percent of the annual feed demand in the highlands. Moreover, Alemayehu (1985) reported that crop residue, aftermath grazing and pulse residues, respectively contribute 0.5, 1.84 and 0.404 million tonnes out of the total dry matter feed resources of 41.66 million tonnes available annually in the highlands of Ethiopia. However, these crop residues are characterized by low metabolizable energy and digestible protein contents, which sometimes barely cover animal maintenance requirements (Steinbach, 1997).

In the Ethiopian highlands, natural pasture can produce 6 tons DM/ha but when continuously grazed it yields only 2.5 tons DM/ha (Jutzi *et al*., 1987). As frequent grass out take leads to a reduction in DM yield up to 50 percent, yield from heavily grazed pasture may not exceed 1.5 tons DM/ha (Jutzi *et al*., 1987). According to Lulseged (1985), native pasture land in the Ethiopian highlands have been estimated to be 73 million hectares supporting about 24 million livestock units (LU) in the same area. These figures indicate that native pastures are an important feed source. However, even when a high average dry matter production of three tons per hectare per year is assumed for this grassland, these areas could only contribute a maximum of 50 percent of the total feed required. Thus, about half or more of all animal in the Ethiopian highlands obtain their feed in the form of crop residues (straws, stubble, chaff or weeds from crop plots). The dependence on this feed source is likely to continue along with increasing human population densities and corresponding extension of crop land into traditional grassland (Abate *et al*., 1993).

As the result of crop encroachment, currently crop residues represent the largest amount of feed and regularly conserved as a sole feed of dry season for animals in the highlands of Ethiopia (Alemu *et al*., 2000). Accordingly, crop residues provide 10 to 15 percent of the national intake of feed by livestock, and in some areas the estimate is up to 50 percent (Zinash *et al*., 2001; Alemayehu, 2003). In selected wheat based crop-livestock production systems of the Ethiopian highlands, the contribution of crop residues and aftermath grazing accounts for 70 percent of the total feed supply, while native pasture accounts for only 30 percent of the total feed supply (Seyoum *et al*., 2001). According to Bekele (1991), about 71 and 12 percent of the feed resources in Adaa Liben district originated from crop residues and natural pasture and fallow lands, respectively. Moreover, stubbles from crops account for about 15.6 percent of the feed resources in the district.

With this background, this study was carried out to quantify the feed requirement, supply and deficiency for the available total livestock population in the district.

Material and Methods

Description of the study area

This study was carried out in Adaa Liben district of the east Showa administrative zone of Oromiya Regional State (ORS), which is located at $8^{o}50$ to $8^{o}53$ latitude and $38^{o}55$ to $38^{o}59$ longitude.

The overall farming system in Adaa Liben district is characterized by mixed crop-livestock production system, and the system is well integrated. The crop production is a dominant system over the livestock system in the district. Livestock production is a second important system next to crop for the overall farming system in the study area. The major contribution of livestock production for the farming community is provision of draft power, transport and as a means of security. According to WOA (2003) report, the district has a total livestock population of 255,368.6 TLU. The livestock classes held by farmers in the study area include; cattle (oxen, cows, heifers, bulls and calves), equines (donkey, mule and horse), small ruminants (sheep and goat) and poultry (WOA, 2003).

Data collection and analysis

Feed sample for major feed resources (natural pasture, teff, wheat, cheack pea, and rough pea straw) were randomly collected with in the study area for chemical composition analysis (DM, DOM, CP, IVDMD and Metabolizable energy). Secondary data regarding land use pattern (Table 1), land coverage by crop type (Table 2), livestock population by species (Table 3) were collected from district office of agriculture.

Table 1. Land use (ha) pattern in Adaa district (2001/2002).

Land use type	Area (Ha.)	%
Arable	119181.4	74
Grazing/pasture	6442.24	4
Forest	3221.12	2
Bush & shrub	9663.36	6
Other	22547.84	14
Total	161056	100

SOURCE: WOA, 2003

Table 2. Area coverage (ha.) of different crop types in Adaa district (1997/98 -2003/04)

YEAR	TEFF	WHEAT	CHICKPEA	BARLEY	ROUPHPEA	Total
1997/98	44402	18620	2762	2300	508	68592
1998/99	45618	18631	2877	2421	556	70103
1999/2000	47900	19822.5	3010	2595	760	74087.5
2000/01	55032.5	27240	3176	2545	511	88504.5
2001/02	55878	30647	4375	2645	740	94285
2002/03	60876	33872	3100	2300	1450	101598
2003/04	63461	34034	4457	1560	341	103853
AVERAGE	53309.64	26123.79	3393.857143	2338	695.1429	85860.43

SOURCE: WOA, 2003

Table 3. Livestock population of Adaa district in year 2002/2003.

Livestock species	District	
	Number	TLU
Oxen	89057	97962.7
Cows	73145	73145
Heifers	40629	20314.5
Y-bulls	31781	19068.6
Calves	31074	6214.8
Sheep	49126	4912.6
Goats	64579	6457.9
Donkeys	48366	24183
Horses	2115	1692
Mules	2025	1417.5
TOTAL		255368.6

SOURCE: WOA, 2003
NA= Data not available

Moreover, multipliers developed by different authors were used to convert crop grain yield into crop residue equivalent and dry matter yield of crop residue (Table 4 and 5).

Table 4. Multipliers used in the study for converting grain yield to its crop residue equivalent.

Crop type	Average Grain : Straw ratio	Multipliers	Source
Teff	0.45	2.22	Bekele (1991)
Wheat	0.67	1.48	Bekele (1991)
Wheat	0.69	1.45	Gryseels (1988)
Barley	0.72	1.39	Gryseels (1988)
Chickpea	0.65	1.54	Bekele (1991)
Field peas	0.69	1.45	Gryseels (1988)
Horse beans	0.87	1.15	Gryseels (1988)
Lentil	0.64	1.56	Gryseels (1988)
Rough pea	0.65	1.54	Bekele (1991)

Table 5. Multipliers used in the study for estimation of yield of crop residue in dry matter bases.

Crop type	Region/Country	Grain : Straw Ratio	Multipliers	Source
Teff	Ethiopia	1.00	1.00	Mukasa-Mugerwa (1981)
Wheat	Ethiopia	0.69	1.45	Gryseels (1988)
Wheat	Africa	0.50	2.00	Kossila (1988)
Barley	Ethiopia	0.72	1.39	Gryseels (1988)
Barley	Africa	0.67	1.50	Kossila (1988)
Field pea	Ethiopia	0.69	1.45	Gryseels (1988)
Horse beans	Ethiopia	0.87	1.15	Gryseels (1988)

The energy (metabolizable energy) and protein (digestible crude protein) requirements of the animals for maintenance, growth and production were calculated using a methodology developed by Ministry of Agriculture Fisheries and Food (1975).

Finally the existing disparities between feed supply and requirements were assed by equating the estimated total produced dry matter (DM) and protein supply to the total availability of the same nutrients for the whole livestock population of the district converted into Tropical Livestock Units (TLU). The total livestock population, area of grazing lands and area under crops for year of 2002/2003 estimated figures given by Adaa Liben district Office of Agriculture, WOA (2003) were used in calculation of feed supply and requirements. Conversion of livestock into standard TLU was made according to Table 6.

Table 6. Tropical Livestock Unit (TLU) conversion factor used in the study.

Classes/Species	Average weight (kg)	TLU conversion factors
Oxen	275	1.1
Cows	250	1.0
Heifers	125	0.5
Young bulls	150	0.6
Calves	50	0.2
Sheep	25	0.1
Goats	25	0.1
Donkeys	125	0.5
Horses	200	0.8
Mules	175	0.7

Source: Bekele Shiferaw. 1991 based on average live weights of livestock in Adaa Liben by Mukasa-Mugerwa (1981)

Results and Discussion

Feed requirements

An animal's nutrient requirements are often partitioned into maintenance and production requirements. In this study, nutrient requirements per TLU were calculated for the two major nutrients, energy and protein. Dry matter requirement were calculated based on MJ of metabolizable energy (ME) per TLU per day. An average ME content of 7.9MJ/kg DM (determined by the nutrient composition of the major feed in the study) of feeds produced in Adaa Liben district (Table 7) were used all over for computations of daily dry matter requirements of animals.

Table 7. Average feed composition of partly air-dried feed stuffs at Adaa district.

Feed Stuffs	DM %	OM %	CP %	IVDMD %	DOM %	Met. Energy (MJ/Kg DM)	SOURCE
Natural Pasture (pooled)	92.40	-	7.45	-	53.6	7.3	Mukasa-Mugerwa, (1981)
Chick pea	94.12	76.26	5.16	62.72	57.58	8.63	Study data
Rough pea	94.83	75.35	5.50	51.70	47.12	7.06	Study data
Teff straw	95.05	78.37	3.94	62.20	57.09	8.55	Study data
Wheat straw	94.99	73.69	2.41	58.64	53.71	8.05	Study data

DM=Dry matter, OM= Organic matter, CP=Crude protein, IVDMD= Invitro dry matter digestibility, DOM= Digestible organic matter

Energy requirement

Maintenance requirement: Maintenance requirements of an animal is the ratio of the fasting metabolism (FM), representing the animal requirement for energy to maintain the animal, and the efficiency with which the ME is used for maintenance (Km) which is related to the energy concentration of the ration.

$$Fm\ (MJ\ days^{-1}) = 5.67 + 0.061W \quad (1)$$

Where: W=live weight in Kg

$$Km = 0.55 + 0.016M/D \quad (2)$$

Where M/D= MJ per kg DM

Maintenance requirement of a TLU is therefore Fm/Km and is estimated at 31.93 MJ pre day. In Adaa Liben district this energy maintenance requirement can be thus met if the animal consumes 3.9 kg DM per day. For the total livestock population in Adaa Liben district estimated at 255,368.6TLU, the total requirement will be 1021.5 t DM/day or 373.9 thousand t DM/year.

Growth (live weight gain) requirement: the net energy requirement for gain (Eg) is the energy content of the gain and is the product of the weight of the gain (LWG) and its energy value (EVg).

$$Eg\,(MJ) = \frac{LWG\,(6.28 + 0.0188W)}{(1 - 0.3LWG)} MJ \quad (3)$$

$$Kg = 0.0435\ M/D \quad (4)$$

Where, W= live weight of the animal
M/D= as defined above

Then the ME requirement (MJ) for growth = Eg/Kg (5)
Where, Eg= as defined above

Kg= Efficiency of utilization of ME for body gain

The growth requirement of a TLU gaining 250 g per day is thus calculated to be 8.6 MJ per day. With average ME content (7.9MJ/kg DM) of feed resources in the district, the DM of 1.09 kg/day/ TLU or 0.4 t DM/TLU/year is required to meet ME requirement for growth . Assuming that 50% of the livestock biomass is still growing, the total growth energy requirement will be estimated at 139.2 t DM/day or 50.9 thousands t DM per year.

Pregnancy requirement: metabolizable energy requirement of a pregnant cow (here considered as 1TLU) was computed as;

$$Ec = 0.03\, e^{0.017\, t}\ (MJ/day) \qquad (6)$$

$$HIG = 0.904 e^{0.01\, t}\ (MJ/day) \qquad (7)$$

Then the extra ME requirement for pregnancy will be;

$$ME\ (MJ/day) = Ec + 1.19\ HIG = 1.08\ e^{0.0106(t)}\ MJ/day. \qquad (8)$$

The total ME requirement of a pregnant cow will be;

$$Total\ ME\ (MJ/day) = Mm + 1.08\ e^{0.0106(t)}\ MJ/day \qquad (9)$$

Where, Ec = Uterine deposition of energy,
HIG= Heat increment of gestation,
t= number of days after conception,
e= 2.718, the base of the natural logarithm,
Mm= maintenance requirement.

Energy requirement of pregnancy for a 250kg (1TLU) of cow with gestation period of 270days is estimated at 18.9 MJ/day. Thus the ME for pregnant cow in Adaa Liben is equivalents to 2.39 kg DM/day. Adoption a calving rate of 50% per year for indigenous Zebu cows, the ME requirement of gestation for (36572.5 TLU) cows in the district will be 23.6 thousand tons DM per year (270day).

Milk production requirement: the minimum requirement of energy for milk production (El) is the product of the weight of milk (Y) in kg and its energy value (EVl). For cows milk energy value is given as:

$$EVl\ (MJ/kg) = 0.0386\ BF + 0.0205 SNF - 0.236 \qquad (10)$$

Where, BF= Butterfat content of the milk (g/kg)
SNF= Solids-not-fat content (g/kg)

The ME requirement for production of 1kg of milk is the ratio of EVI to the utilization efficiency of ME for milk production (given on average to be 0.62). Therefore, the total ME requirement for production of Y kg of milk is given by:

$$MI\,(MJ) = \frac{(EVI)Y}{0.62} = 1.61 EVI\,(Y) \qquad (11)$$

Although milk composition of different breeds of local cows is slightly variable, butterfat and SNF content of milk from indigenous Zebu cows at different stages of lactation in southern Ethiopia given by Fekadu and Abrahamson (1994) is used for computations in this study. The composition of milk of local cows of southern Ethiopia (average of 81 random samples of cows at different stages of lactation) was total solids (dry matter) 13.75%, crude protein 3.21%, butterfat 4.94%, lactose 4.92%, ash 0.68% and SNF 8.81%.

Therefore, the ME requirement of a local Zebu cow producing 2 litters of milk per day with a butterfat and solid-not-fat content of 49.4 and 88.1g/kg of milk respectively is estimated at 11.2 MJ/day which is equivalents to 1.4 kg DM/day in Adaa Liben. By taking a calving rate of 50% per year and lactation length 8 months in to assumption, the total requirement of cows for milk production in Adaa Liben is 51.2 t DM/day or 18.7 thousand t DM/year. The overall DM requirement as calculated from ME requirement of livestock in Adaa Liben district is summarized in Table 8.

Table 8. Estimated dry matter requirement of livestock in Adaa Liben district.

Functions	Effective TLU	kg DM/TLU/Day	t DM/day	Yearly requirement ('000 t DM)	% Total
Maintenance	255368.6	3.9	995.9	364.5	80.8
Growth	127684.3	1.09	139.2	50.9	11.3
Pregnancy	36572.5	2.39	87.4	23.6	5.2
Milk production	36572.5	1.4	51.2	12.3	2.7
Total			1273.7	451.3	100

TLU=Tropical Livestock Unit, DM= Dry matter,

Protein requirement

A digestible protein requirement of 160 g and 100g/TLU for maintenance and growth (for a TLU gaining 250g/day) respectively is used for estimating total requirement of livestock in the district. The total digestible protein requirement so estimated for maintenance and production (growth) for the total livestock population of the district is presented in Table 9.

Table 9. Estimated digestible protein requirement of livestock in Adaa Liben district.

Functions	Effective TLU	g/Day/TLU	t DM/year	Total t/year
Maintenance	255368.6	160	40.9	14954.4
Growth	127684.3	100	12.8	4673.2
Total		260	53.6	19627.6

TLU=Tropical Livestock Unit, DM= Dry matter,

Feed supply

In Ethiopian highlands, there is no systematic survey of herbage quality or productivity of natural pastures conducted at any significant scale, hence estimates of annual pasture yields vary between 1-2 t DM/ha of freely drained relatively infertile soils up to 4-6t DM/ha on seasonally waterlogged fertile areas (Bekele, 1991). Also Mukasa-Mugerwa (1981) reported that the natural pasture in Adaa Liben do not yield more than 2 t DM/ha under constant grazing. Hence, for the purpose of this study, it seems to be fairly reasonable to adopt an annual average primary production of 2 t DM/ha for the whole grazing areas of Adaa Liben district containing poorly managed and overgrazed unimproved pastures.

The actual proportion of the forage standing crop (total above ground biomass) utilized by the animals is also variable (Bekele, 1991). Available estimates are highly variable, but annual utilization rates for all estimates rarely exceed 50% of the total primary production (Bekele, 1991).

Utilization rate also depend on the season of the year which mainly relate with the amount of rainfall. In areas like Adaa Liben district where the rainy season is bimodal, the whole year may be roughly divided into two equal wet and dry seasons.

In this study, it is assumed that 70% and 30% of the total forage standing (ungrazed yield) will be consumed by the animal during wet and dry seasons (6 moths each) respectively. The annual utilization rate is thus 50% of the total standing crop. Adopting a total annual primary production of 2 t DM/ha and utilization rate of 50%, the actual consumable DM yield will be 1 t DM/ha. The

natural pasture provides consumable herbage to the animal throughout the year hence with the utilization rate of 50% the total consumable yield in the district is estimated at 6,442.24 t DM/ year.

Stubbles are also grazed during the dry season after all the crop are harvested and threshed. At this season animals are not restricted to crop land until the fields area cultivated gain, thus animals can move allover areas As aftermath grazing starts after the crops are cleared during the dry season, the utilization rate of 30% is used but it can declined to 15% of the total annual ungrazed yield as this continues only over half of the year. This estimate from stubbles may slightly inflate the actual proportion of consumable herbage since some of the fields are already devoid of any leftovers and other may be cultivated soon after the short rain. Therefore, with an assumption of average herbage yield 2 t DM/ha./year and utilization rate of 15% for half year, the total consumable DM produced in Adaa Liben district is estimated at 30,479 t DM during the dry season or half of the year.

Crop residue yields of different crops were estimated using multipliers developed based on grain to residue ratios (see Table 4). It is assumed that about 70% of all estimated non-edible portions of the total crop biomass can be utilized by the animal. The total amount of crop residue produced in the district is presented in Table 10. With the assumption of 70% utilization rate the total supplies of crop reside is estimated at about 87727.9 t DM/year. In this case all crop residue produce is assumed to be removed and is used by the animal.

Table 10. Estimated crop residue yield from different crops in Adaa Liben district.

Crop type	Grain yield* (t/ha)	Crop residue** yield (t/ha)	Area*** cultivated (ha)	Total residue t.
Teff	0.09	0.865	60876	52657.74
Wheat	0.13	1.841	33872	62358.35
Chickpea	0.1	1.582	3100	4904.2
Barley	0.11	1.557	2300	3581.1
Rough pea	0.08	1.258	1450	1824.1
Total			101598.0	125325.5

* Average grain yield in the district as estimated by the author in the study

** Crop residue dry matter as calculated using conversion factors given in Appendix 16

*** Total cultivated area for each crop from WOA for the year 2002/2003

The total amount of consumable feed supply in Adaa Liben is presented in Table 11. A total of 124.6 thousand tone of DM produced per year which is critically is short of the feed requirements estimated at 451.3 thousand t DM/year indicated in Table 8. The estimated DM feed supply even not satisfy to maintenance requirement estimated at 364.5 thousand t DM/year. This feed deficit is exacerbated by the fact that estimated yields include a very high percentage of poor quality feed in terms of digestible nutrients. Farmers also defer crop residue for use by draught oxen and lactating cows thus other classes of livestock are left to depend on low amount and quality pasture grasses from overgrazed pasture lands.

Table 11. Total consumable feed dry matter produced in Adaa Liben district.

Origin	Total area (ha)	Yield (t/ha)	Utilization rate (%)	Total yield (t DM)	% Total
Pasture land	6442.24	2.0	50	6,442.24	5.2
Stubbles	101598	2.0	15	30,479.4	24.5
Crop residue	101598	-	70	87,727.9	70.4
Total				124,649.5	100.0

As indicated in Table 11, the largest proportion (70.4%) of the feed supply originated from crop residues. This is mainly because grazing lands have been increasingly diminished by crop encroachment to the extent that it now supplies only about 5.2 % of the total feed produced in the area. The total DM feed production does not meet the yearly DM requirement of the animals. Hence, the total DM feed supply was only fulfill the maintenance and total DM demand by 34% and 27%, respectively.

As presented in Table 7, the crude protein content of crop residues is low (2-5%) and it is seldom meets livestock maintenance requirements. If an estimate of consumable crude protein is made based on nutrient composition of different types of feeds in the district (given in Table 7), natural pastures, stubbles and crop residues provide 479.9, 1712.9 and 3728.4 t /year respectively.

The total digestible protein supply (estimated by the formula given by FAO (1980) and Chandler (1984) as; ***Digestible protein= 0.929 Crude protein – 3.52***) is in the order of 5,490 t/year. Based on this, digestible protein supplies also leave much to be desired to meet animal requirements of 19,627.6 t per year (given in Table 9).

According to this estimate, the actual availability of digestible protein even not meets the maintenance needs of animals and it only fulfils about 36.7 and 28% of the maintenance and total requirements, respectively.

Therefore, it can be argued that both energy and protein are the limiting factors to livestock production in Adaa Liben district. With declining crude protein content of the feed, voluntary intake is depressed exacerbating the precarious balance between energy supply and demand.

The organic matter digestibility of feeds in Adaa district ranges between 47-57% (see Table 7). Intake of tropical grasses rapidly declines when crude protein content drops below 7% of the dietary dry matter. Cattle and sheep kept at diets of low organic matter digestibility (45-50%) and low protein content (below 7%) will invariable lose weight (Topps, 1969), hence productivity and off take is low and livestock populations will not grow. As the crude protein content further declines during the dry season, intake and digestibility are further depressed and animals will continue losing weight.

Crop residues in Adaa Liben district are high in lignin (see Table 7), which inhibits microbial digestion of cellulose and hemicelluloses, and low in nitrogen, which limits DM intake, and are deficient in readily available carbohydrate, which limits microbial activity in the rumen. Thus, voluntary intake and digestibility of crop residue-based ration will not meeting maintenance requirements (Mosi and Butterworth, 1985).

In general, continue expansion of cropping under increasing subsistence demand has substantially engulfed areas previously used for grazing now resulting in overstocking of the district to such as extent that animals are predominantly dependent on the supply of cheap quality crop residues. This has resulted to limit the productivity of animals in the district as well in the study area.

Conclusions

The available feed resources (natural pasture and crop residue) in the area are estimated to produce an average ME content of 7.9MJ and 4.9% of CP. With these nutrient value of the feed resources, about 451.3 thousands tone of DM is required to meet the energy requirement and about 19,627.6 t of DM required to meet the protein requirement of the total livestock annually in the district. However, a total of 124,649.5 t DM feed and 5921.1 t of consumable crude protein is produced annually from the major feed resources (natural pasture, crop stubbles and residues) in the district. However, these amount of DM feed and consumable crude protein only fulfill the total DM feed and crude protein requirement by 27 and 28 percent, and the maintenance requirement by

about 34 and 36.7 percent, respectively. Therefore, both energy and protein are in critical shortage of both for maintenance and total requirement of the animals every year.

As the result of this study indicates, there is critical loss of animal production loss in every year in the district. The feed production and management system of the farmers should be improved and need attention to solve this huge deficiency of feed which happen every year. The expansion of cropping area towards the limited grazing lands also one factor to contribute this disparity and it need government attention to limit the situation. However, this study may not give the exact feed requirement and supply situation in the area, therefore, further study is needed to identify the trend of feed supply and demand in the area and to develop both research and development strategies for the problem.

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References

Abate Tedla, M.A. Mohamed-Saleem, Tekalign Mamo, Alemu Tadesse and Miressa Duffera, 1993. Grain, fodder and residue management. pp. 103-137. In: Tekalign Mamo, Abiye Astatke, K. L. Srivastava and Asgelil Dibabe (eds.). Improved management of Vertisols for sustainable crop - livestock production in the Ethiopian highlands: Synthesis report 1986-92. Technical Committee of the Joint Vertisol Project, Addis Ababa, Ethiopia.

Alemayehu Mengistu, 1985. Feed resources in Ethiopia. In: Kategile J.A., Said A.N., and Dzowela B.H. (eds.). Animal feed resources for small-scale livestock producers- Proceedings of the second PANESA workshop, held in Nairobi, Kenya, 11-15 November 1985.

Alemayehu Mengistu, 2003. Country pasture/Forage resources profiles: Ethiopia. FAO web site: http://www.fao.org/ag/agp/agpc/doc/counprof/ethiopia/ ethiopia.htm

Alemu G/Wold, Alemu Tadesse and Asgelil Dibaba. 2000. Research and Development Experience of IAR in NRM and Crop Livestock Interaction in the Highlands of Ethiopia. In: Jabbar, M.A., Peden, D.G., Mohamed Saleem, M.A. and Li Pun, H. (eds.). Agro-ecosystems, natural resources management and human health related research in East Africa. Proceedings of an IDRC–ILRI international workshop held at ILRI, Addis Ababa, Ethiopia, 11–15 May 1998. ILRI (International Livestock Research Institute), Nairobi, Kenya. 254 pp.

Anteneh, A., 1984. Trends in Sub-Saharan Africa's livestock industries. ILCA Bulletin 18, Addis Ababa.

Anteneh, A., 1984. Trends in Sub-Saharan Africa's livestock industries. ILCA Bulletin 18, Addis Ababa.

AOAC, (Association of Analytical Chemists). 1990. Official method of analysis (15th ed.). AOAC Inc. Arlington, Virginia, USA.

Bekele Shiferaw. 1991. Crop-livestock interaction in the Ethiopian highlands and effect on sustainability of mixed farming: A case study from Adaa district. MSc. Thesis. Agricultural University of Norway. 163p.

Daniel Keftasa 1988. Role of crop residues as livestock feed in Ethiopian highlands. In: Dzowela B.H. (ed), African Forage Plant Genetic Resources, Evaluation of Forage Germplasm and Extensive Livestock

Production Systems. Proceedings of workshop held at Arusha, Tanzania, 27–30 April, 1987. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Fekadu, B. and Abrahamson, R.K. 1994. Present situation and future aspects of milk production, milk handling and processing of dairy products in southern Ethiopia. 1. Chemical and Microbial quality. PhD Thesis. Dept. of Food Science, Agri. Univ. of Norway. Norway. Pp1-16.

Gryseels, G., 1988b. Role of livestock on mixed smallholder farms in the Ethiopian highlands. A case study from the Baso and Worena woreda near Debre Berhan. A PhD. Dissertation presented to the Agricultural University of Wageningen, The Netherlands. 249p.

Jutzi, S., I. Haque and Abate Tedla, 1987. The production of animal feed in the Ethiopian highlands: Potential and limitations. pp. 141-142. In: Proceedings the first national livestock improvement conference. Addis Ababa Ethiopia, 11-13 Feb. 1987, Institute of Agricultural Research (IAR).

Kossila, V., 1988. The availability of crop residues in developing countries in relation to livestock populations. In: J.D. Reed, B.S. Capper and J.H. Neat (eds.). Plant breeding and nutritive value of crop residues. Proceeding of Workshop held at ILCA. Addis Ababa, Ethiopia, 7–10 Dec. 1987, International Livestock Centre for Africa (ILCA). 334p.

Lulseged Gebre-Hiwot, 1985. The status of pasture and forage research in Ethiopia. Paper presented at the National Workshop on Livestock, Pasture and Forage Research in Ethiopia. Ottawa Canada, .8-10 Jan. 1985, International Development Research Centre (IDRC).

MAFF, (Ministry of Agriculture, Fisheries and Food). 1975. Energy Allowance and Feeding System for Ruminants. Reference book 433. London her Majesty Stationary Office, UK.

Mosi, A. K., and Butterworth, M.H. 1985. The voluntary intake and digestibility of ceral crop residues and legume hay for sheep. Anim. Feed Sci. Technol. 12: 241-251.

Mukasa-Mugerwa, E. 1981. A study of traditional livestock production in Adaa district of Ethiopia. Mimeograph, ILCA. Ethiopia, Addis Ababa. 154p.

Sentayehu, G.M. and Smith, G. 1989. Productivity improvement in the Ethiopian Livestock Industry. Towards a food and nutrition strategy for Ethiopia. Peoples Democratic Republic Office of the National Committee for Central Planning. The proceeding of the national workshop on food strategies for Ethiopia held at Alemaya University of Agriculture. Addis Ababa, Ethiopia. Pp 297-320.

Seyoum Bediye, Getnet Assefa, Abate Tedla and Dereje Fekadu 2001. Present Status And Future Direction In Feed Resources and Nutrition Research Targeted For Wheat Based Crop-Livestock Production Systems In Ethiopia. In: Wall, P.C. (ed.). Wheat and Weeds: Food and Feed. Proceeding of two stockholder workshops. Mexico city. Mexico. pp 205-226.

Steinbach, J., 1997. Alternatives to Crop Residues as Feed Resources in Mixed Farming Systems. In: Renard, C. (ed.). Crop Residues in Sustainable Mixed Crop/Livestock Farming Systems. CAB INTERNATIONAL in association with the International Crops Research Institute for the Semi-Arid Tropics and the International Livestock Research Institute.

Topps, J. H. 1969. Nutritional problems of livestock production from semi-arid grasslands in the tropics. J. Br. Grassld. Soc. 24 (3): 250-257.

WOA, (Adaa Liben Woreda Office of Agriculture) 2003. General characters tics of Adaa Liben Woreda. Debre Zeit, Ethiopia. (unpublished data)

Zinash Sileshi, Aschalew Tsefahun, Alemu Yami and Azage Tegegne, 2001. Status of Livestock Research and Development in the Highlands of Ethiopia. In: Wall, P.C. (ed.). Wheat and Weeds: Food and Feed. Proceeding of two stockholder workshops. Mexico city. Mexico. pp 227-250.

Effect of nitrogen on morphological characters, yield, and quality of forage oat (*Avena sativa* L.)

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Abstracts

Experiment was conducted at the G. B. Pant University of Agriculture and Technology, India to study morphological characters, yield and quality of forage oat (A*vena sativa*) under different levels of nitrogen. The soil of the experimental site was Beni silty clay loam under the order mollisol, slightly alkaline in reaction (7.3), low in available nitrogen (238 kg ha^{-1}), medium in organic carbon (0.7%), P_2O_5 (47.3 kg ha^{-1}) and K_2O (284.37 kg ha^{-1}). The experiment was conducted in a Randomized Complete Block Design with four replications consisting of five levels of nitrogen (0, 40, 80, 120 and 160 kg ha^{-1}) and two forage oat varieties namely Kent and UPO-212. The result revealed that increased application of nitrogen significantly ($P< 0.05$) affected morphological characters of the crop. Higher number of shoot, leaves and dry matter accumulation were recorded at 120 kg N ha^{-1} with maximum plant height, leaf area index, emergence count and lodging percentage being at 160 kg N ha^{-1}. Green forage, dry matter, crude protein and digestible dry matter yields were significantly ($P < 0.05$) higher upto 120 kg N ha^{-1} with better quality forage in terms of digestibility and crude fibre content. Between the two varieties, UPO-212 revealed significantly ($P < 0.05$) higher performance in terms of most morphological characters with significantly ($P < 0.05$) higher green forage, dry matter, digestible dry matter and crude protein yields than Kent. Whereas, crude protein and digestible dry matter contents were better in Kent than in UPO-212.

Key words: Forage oat; morphological characters; nitrogen levels; quality; yield

Introduction

The mismatch between general paucity in area devotion to forage cultivation at 6.9 million hectares for the last four decades and the livestock population growing at 1.4 per cent per annum is the challenge to the Indian feed production. The available feed resource in the country is merely meager. Only 550 million tons dry fodder from crop residues, pasture and grazing resources; 370 million tons green fodder from cultivated forages, tree fodders, weeds and sugar cane tops is available against the 949 million tons dry fodder, 1136 million tons green forages and 6.0 million tons concentrates (Hazra and Singh, 1996; ICAR, 1997) required to feed the livestock population of the country.

In efforts to bridge the gap, oat has gained great attention particularly in the northern and western parts of the country where the climate is very conducive for production. To date, several varieties have been released (Mishra and Verma, 1992; Bhagmal, 1998) which are grown on over 100 thousand hectares of land (Hazra and Singh, 1996) with 35 to 50 tons ha^{-1} green forage productivity (Hazra and Singh, 1996). On the other hand, there is a long established universal fact that apart from genetics, the external factors viz, climate, nutrient and humans managerial interventions, collectively called environment, contributes upto 79.96% to the full production potential of a crop (Gezahegn *et al.*, 2008). Climate mainly through temperature and moisture, determines the spatial and seasonal distribution of crops, while nutrients play decisive role on growth and productivity of the crop in its area of adaptation.

Among the essential nutrients to plant, nitrogen is the most important element takenup by plants (Miles and Manson, 2000). Both the deficiency and excess supply of this nutrient has adverse effect on growth and yield of crops, animal health and on socio economic and environmental welfare. As one way to get out of it, interests of identifying genetic differences in responsiveness to nitrogen fertilizer are intensifying. Producers, agricultural consultants and researchers often see genotypic variation as one way to fine-tune fertilizer management (Below, 1995). There is a desire to develop

or identify genotypes that perform well under low nitrogen supply or conversely to find genotypes that will respond to high fertility conditions (Below, 1995). Therefore, it was with this in mined that study was conducted using two commercial varieties of oat to see the response to different levels of nitrogen in terms of morphological characters, yield and quality.

Materials and Methods

The study was conducted at G. B. Pant University of Agriculture and Technology, India, situated at an altitude of 243.8 meters above mean sea level between 29.5° N latitude and 79.3°E longitude. The region is characterized by subhumid tropical and subtropical climate having shallow water table and gentle slop with mean annual rainfall of 1385mm.The air temperature ranges from below 10°C in winter to over 40°C in summer. The soil was slightly alkaline in reaction (7.3), low in available nitrogen (230 kg ha^{-1}), medium in organic carbon (0.7%), P_2O_5 (47.3 kg ha^{-1}) and K_2O (284.37 kg ha^{-1}).

Experimental design, treatments and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. The treatments consist of five nitrogen levels (0, 40, 80, 120, and 160 $kgha^{-1}$) and two forage oat varieties namely Kent and UPO-212. Kent was introduced from USA in 1960's and adapted well to the Indian condition. It is a medium to late maturing variety with long, narrow and droopy light green leaves; resistant to rust, blight and lodging (Singh, 1998). Whereas, UPO-212 is a medium late variety released from Pantnagar in 1990. It is resistant to crown rest, blight, lodging and shattering (Mishra and Verma, 1992). The two varieties and the five levels of nitrogen were combined factorally making a total of ten treatments each with gross and net plot size of 4 m x 3 m = 12 m^2 and 2 m X 2 m = 4 m^2, respectively. Each of these ten treatments was replicated four times giving a total of 40 plots.

Experimental plots management

The field was disc-ploughed once followed by two cross harrowing and planking. Seeds were sown at 100kg ha^{-1} seed rates by drilling in rows with 25 cm spacing in between. Each plot was supplied at planting with a uniform two-third quantity of the total dose of nitrogen through urea as per treatment, 40 kg ha^{-1} K_2O as murate of Potash and 60 kg ha^{-1} P_2O_5 as single supper phosphate as basal dressing. The remaining one-third of the total dose of nitrogen left after basal application was top-dressed 30 days after sowing. Irrigation was given to all plots a week after planting and subsequently at 20-25 days interval depending on moisture /precipitation/ condition and the need of the crop. A total of 4 irrigations were given to meet water requirement of the crop. Herbicide 2-4, D was also applied 25 days after sowing at 1.0 kg ha^{-1} a. i. and supplemented with one hand-weeding 50 days after sowing.

Data collection and Analysis

Morphological characters

The crop was harvested at 50% heading stag (D50) after taking measurement on plant height (PLH) and counting number of shoot (NSH) from a half meter row length. The entire herbage from the half meter row length was cut close to the ground and separated into leaves and stem; count was taken on number of green leaves (NGL), number of dry leaves (NDL), and total number of leaves (TNL). Leaf area, leaf area index (LAI), dry matter accumulations through leaves (DMAL), stem, (DMAS), and whole aerial plant part (TDMA), and the leaf to stem ratio (L/S) were all determined. Detail of the procedures are published elsewhere (Aklilu and Alemayehu (2007). Lodging percentage (LGP) was determined as percentage of the ratio of lodged area to the

total area of the plot as given by Bhat *et al*. (2000). Emergence count (EGC) was taken at 15 days after planting by counting all plants from 0.5 meter row length.

Yield and quality

For the purpose of yield determination, the entire herbage from the net plot area (2m x 2m) was cut close to the ground. The harvested green forage was weighed plot wise using hanging scale of 25 kg capacity and the green forage yield (GFY) in q ha^{-1} was estimated by extrapolation. Sub samples of about 250 gm was taken from each plot and dried in oven at $70^{0}C$ to constant weight from which dry matter content (DM) was determined by dividing the oven-dried weight to its fresh weight expressed as percentage. The dry matter yield (DMY) in qha^{-1} was estimated by multiplying the green forage yield (qha^{-1}) with that of the dry matter content divided by 100. For crude protein, crude fibre and digestibility determination, the oven-dried samples were ground by laboratory Willley mill to pass 1 mm sieve size; two gm samples were analyzed for total nitrogen content by Micro-kjeldhal method (Jackson, 1973) and the nitrogen content was multiplied by 6.25 to determine the per cent crude protein content (CP). The crude protein yield (CPY) in qha^{-1} was determined by multiplying the DMY with the CP and dividing by 100. The crude fibre content (CF) was also determined by digesting the samples with 16% boiling Na OH and H_2SO4 each for 30 minutes followed by washing and drying in oven to constant weight. At the same time, five gram of the ground sample was incubated in rumen of three rumen fistulated animals for 72 hours. The fistulated bullocks were maintained for one week on basal diet of forage sorghum supplemented with 2 kg concentrate per day. After incubation period of 72 hours, the bags were removed from rumen and washed with clean running tap water and dried in oven at $70^{0}C$ to constant weights. Digestibility of the samples (DDM) were calculated by dividing the difference in dry weight between the before and the after incubation with that of the weight before incubation multiplied by 100. Digestible dry matter yield (DDMY) in qha^{-1} was then determined by multiplying DMY with that of the DDM divided by 100.

Finally the data on all parameters were subjected to analyses of variance for RCBD as described by Cocharan and Cox (1957) at probability level of 5 per cent.

Results and discussions

Morphological characters

Analyses of variance showed significant ($P<0.05$) difference in all morphological characters due to nitrogen levels (Table 1). PLH, NSH, NGL, NDL, TNL, LAI, DMAL, DMAS, TDMA, and EGC all increased with levels of nitrogen. Maximum NSH (51.9), NGL (158), NDL (83.4), TNL (241.4), DMAL (33.25), DMAS (86.13) and TDMA (119.38) were recorded at 120 kg N ha^{-1}, while the PLH, LAI, EGC and LGP continued to increase upto the maximum dose of nitrogen, indicating the need for higher amount of nitrogen to establish apparatuses involved in photosynthesis (Below, 1995).

Application of nitrogen at beyond 120 kg N ha^{-1}, however, resulted in slight decrease in NSH, NGL, NDL and TNL. The observed decrease might be doing to increased EGC, because of nitrogen effect, might have caused death of weaker and less competitive tillers (Joshi, 1996) and decomposition of leaves. Sexton (1995) also observed leaf losses associated with low light intensity in crop canopy. The observed increase in LAI (Table 1) with nitrogen could also be due to enhanced synthesis of enzymes, co-enzymes, chlorophyll and other nitrogen containing compounds (Rusel, 1973) which are essential for full expansion of individual leaf. Higher leaf area enables the crop to intercept more solar energy and synthesis more sugars for higher dry matter accumulation as reported by Saxena *et al.,* (1971), Tiwari *et al.* (19 71), Verma (1984) and Chakraborty *et al.* (1999). A positive correlation of dry matter accumulation with LAI has also been documented by Rao *et al.* (1978) and Joshi (1980). The observed increase in total dry matter accumulation with the increasing levels of nitrogen could thus be due to higher LAI, increased light interception (Dhaliwal

et al., 1984), root growth and uptake of other essential elements (Hopkins *et al.*, 1994; Brady and Weil, 2002).

Though not significant (P>0.05) the D50 of present study decreased progressively with levels of nitrogen from 111.6 days to 105.1 days. The implication is that application of nitrogen hastens plant growth and development to early maturity. Likewise the L/S of present study declined significantly (P<0.05) with successive level of nitrogen from 0.54 at 0 kg N ha^{-1} to 0.37 at 160 kg N ha^{-1}. The reason could be due to more accumulation of dry matter in stem than in leaves (Table 1) and leaf senescence as reported by Sexton (1995).

Between the two varieties UPO-212 showed significantly (P<0.05) superior performance with respect to most morphological characters vis PLH, NSH, NDL, TNL, LAI, DMAS, TDMA, D50 and LGP. It was also responsive to higher doses of nitrogen in terms of TNL, DMAS, TDMA and PLH (Table 3). The higher dry matter accumulation of UPO-212 could be due to more assimilatory surface areas reflected by more number of shoots with higher LAI (Table 1). The dry matter accumulation through leaves however, was significantly (P<0.05) higher in kent than in UPO-212. The possible reason might be better leaf thickness and specific leaf weight which were not considered in the present study. But Rao *et al.* (1978) reported negatively correlated leaf area index with specific leaf weight in some genotypes.

The higher total dry matter accumulation in UPO-212 might be doing to the observed L/S and late heading (Table 1). Collin *et al.* (1990) also reported more dry matter accumulation in late heading genotypes than in early heading genotypes. Higher percentage of lodging was also observed in UPO-212 which might be due to nitrogen-induced excessive vegetative growth (Das,1996) and more number of shoots with greater crop canopy development (Pinthus, 1973).

Yield and quality

Application of nitrogen significantly (P<0.05) affected all yield and quality parameters (Table 2). The GFY increased upto the maximum dose of nitrogen, while the increase in DMY, CPY, and DDMY was only upto 120 kg N ha^{-1} with a short fall thereafter, indicating that application of nitrogen above this dose level is not beneficial. Similar trends of increase in yield were reported by several authors, among which Thakuria and Gogoi (2001) in experiment with three levels of nitrogen (0, 40, and 80 Kg N ha^{-1}) noticed significant improvement in GFY with 80 kg N ha^{-1} and DMY with 40 kg N ha^{-1}. Hasen *et al.* (2000) also investigated increased GFY and DMY both upto 160 kg N ha^{-1}. Singh *et al.* (2000) in turn reported 55.5, 85.5 and 106.5 percent increment in green forage yields each with application of 30, 60 and 90 kg N ha^{-1}, respectively. The increase in green forage yield with nitrogen at above the optimum dose level could be attributed to lush growth of the crop with formation of more protoplasm and increase in its volume. Since protoplasm is highly hydrated, there would be more succulent plant growth with excessive moisture in tissues as the level of nitrogen increased (Das, 1996). The DM content of present study thus decreased with successive levels of applied nitrogen (Table 2) and the observation corroborates reports of Kumar *et al.* (2001), Thakuria and Gogoi (2001) and Singh *et al.* (2000). The decrease in DM content with increased level of nitrogen might be due to loss of significant portion of the weight of plant tissue upon dehydration.

Contrary to the DM and DDM, the CP and CF of present study showed increasing trend which is in agreement with Ayub, *et al* (2001) in Maize and Ammaji and Suryanaraana (2003) in sorghum. The implication is that application of nitrogen made more nitrogen to be available in soil for increased uptake and contents in plant tissue. The increase in CF with nitrogen level could also be related to the observed decrease in L/S (Table 1). Kilcher and Troelsen (1973) found much higher structural cell wall constituents in stems than in leaves of oat. Since the structural carbohydrates (lignin, cellulose and hemicelluloses) are less digestible, the observed increase in CF with nitrogen levels might have reduced the DDM in plant tissue (Table 2). The observation is in agreement

with Collin *et al.* (1990) and Kumar *et al.* (2001) who found more indigestible components of fibre with increased levels of nitrogen. Kilcher and Troelsen (1973) also reported negative correlation of digestibility with lignin in oat.

Between the two varieties UPO-212 reveald significantly ($P < 0.05$) higher GFY, DMY, CPY, and DDMY (Table 2) with significantly ($P< 0.05$) more response to the higher doses of nitrogen at 120 and 160 kg N ha^{-1} (Table 4) which is in conformity with earlier reports of Kumar *et al.* (2001). The higher yield of UPO-212 over Kent could be due to better genetic makeup of the variety with inherently higher potential for taller growth , more number of shoots, and leaves, better LAI, and more dry matter accumulation (Table1 and 3).

In the present study UPO-212 also showed non significantly ($P>0.05$) more DM than Kent (Table 2 and 4) which is in conformity with reports of Kumar (2001). The higher dry matter content of UPO-212 might be doing to the observed more number of days taken to attain 50% heading, more dry matter accumulations in stem and lower L/S. This is in agreement with findings of Collin *et al.* (1990) who reported more dry matter content in late heading cultivars than in early heading cultivars. The higher crude fibre content observed in UPO-212 than in Kent (Table 2 and 4) could also be due to more structural carbohydrates deposit such as, lignin, cellulose, and hemicelluloses.

In the present work Kent showed higher digestible dry matter content than UPO-212, is in agreement with findings of Raghubanshi *et al.* (2002) and Kumar *et al.* (2001). The higher digestible dry matter content in Kent could be due to more L/S in Kent than in UPO-212, is in agreement with the higher digestibility of leaves than stem reported by Kilcher and Troelson (1973). The non significantly ($P> 0.05$) higher CP observed in Kent (Table 2 and 4) contradicts Raghubanshi *et al.* (2002) and Kumar *et al.* (2001). The deviation of the present finding might be due to combined effects of high nitrogen induced lodging and late heading in UPO-212 (Table 1). Lodged plants are often subjected to nutrient loss due to leaf shattering and decomposition. Similarly late heading cultivars have less crude protein with more fibre contents than early heading ones (Collin *et al.,* 1990*)* 1990. In the present work UPO-212 recorded significantly ($P<0.05$) higher crude fibre content than Kent is in agreement with Raghubanshi *et al.* (2002).

Conclusions

Apart from genetics, the level of management also influences the yield and quality of forage crops. In the present study application of nitrogen significantly affected the morphological characters, yield and quality of the crop. The observation revealed that, increased application of nitrogen fertilizer increased plant height, number of shoot, number of leaves, leaf area index, and dry matter accumulations. The increase in these yield contributing traits has been reflected in yield and quality of the crop. The green forage yield increased upto the maximum dose, while the increase in dry matter yield, crude protein yield and digestible dry mater yields was only upto 120 Kg N ha^{-1}. The dry matter and the digestible dry matter contents of the crop however decreased with increased levels of nitrogen while there was consistent increase in crude protein and crude fibre contents. The present study also revealed varietal difference in response to levels of nitrogen. UPO-212 showed superior performance with respect to most morphological characters and thus gave more green forage yield, dry matter yield, crude protein yield and digestible dry matter yields with more dry matter and crude fibre contents than Kent. Kent however, revealed more crude protein and digestible dry matter contents than UPO-212. In a nutshell, it can be concluded that application of nitrogen upto 120 Kg ha^{-1} might be recommendable for higher biological yield and further work need to be done to exploit more varietal differences in improving fertilizer use-efficiency.

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Table 1: Effect of nitrogen on morphological characteristics of forage oat

Morphological characters	PLH	NSH	NGL	NDL	TNL	LAI	DMAL	DMAS	TDMA	L/S	EGC	D50	LGP
Nitrogen level (kg ha-1)													
0	113.9d	33.6d	101.1d	54.6b	155.6d	4.11d	22.38c	41.80d	64.18e	0.54a	26.4c	111.6a	0
40	134.6c	41.8c	113.3c	76.6a	189.9c	6.65c	28.38b	65.50c	93.88d	0.43b	27.8bc	106.0b	0
80	145.4b	48.3b	129.4b	79.4a	208.8bc	7.78b	31.38a	77.00b	108.38c	0.41bc	28.9abc	104.5b	0
120	149.1a	51.9a	158.0a	83.4a	241.4a	8.33a	33.25a	86.13a	119.38a	0.39bc	29.6ab	104.1b	16.3b
160	151.2a	49.5ab	136.0b	79.5a	215.5b	8.40a	31.75a	85.13a	116.88b	0.37c	31.0a	105.1b	28.1a
SEm+	0.8	1.1	3.6	5.8	7.6	0.14	0.73	1.55	0.50	0.02	0.8	1.1	2.7
LSD (p < 0.05)	2.8	3.3	10.5	16.9	21.9	0.42	2.14	2.94	1.43	0.04	2.5	3.3	7.8
Variety													
Kent	130.4b	43.3b	130.4	68.3b	193.0b	6.99b	30.95a	68.38b	99.33b	0.45	31.2a	104.9b	2.3b
UPO-212	147.3a	46.9a	127.6	81.1a	211.5a	7.05a	27.90b	73.84a	101.74a	0.38	26.3b	107.7a	15.5a
SEm+	1.0	0.7	2.3	3.8	5.9	0.90	0.47	0.98	0.31	0.01	1.3	0.6	1.7
LSD (p < 0.05)	1.8	2.1	NS	10.7	13.9	0.26	1.35	1.86	0.90	NS	3.9	1.72	4.9

NS= non significant
Figures with the same alphabetical letters in a column are not significantly different at P> 0.05

Table 2: Effect of nitrogen on yield and quality of forage oat

Yield and quality	GFY	DMY	CPY	DDMY	DM	CP	DDM	CF
Nitrogen level (kg ha-1)								
0	239.2d	51.3e	3.8d	40.1e	21.4ab	7.3d	78.0a	27.7e
40	345.5c	75.1d	6.1c	58.0d	21.8a	8.1c	77.2ab	29.3d
80	418.8b	86.7c	8.3b	65.7c	20.7ab	9.5b	75.6abc	30.4c
120	491.2a	95.6a	10.4a	71.4a	19.5bc	10.7a	74.7bc	31.2b
160	495.2a	93.6b	10.1a	69.4b	18.9c	10.7a	74.2c	31.9a
SEm+	4.9	0.4	0.1	0.6	0.5	0.3	1.0	0.1
LSD (p < 0.05)	14.3	1.2	0.3	1.7	1.49	0.8	2.9	0.3
Variety								
Kent	379.1b	77.1b	7.5b	59.1b	20.3	9.7	76.7	29.8b
UPO-212	407.5a	83.9a	8.0a	63.1a	20.6	9.5	75.3	30.5b
SEm+	3.1	0.3	0.1	0.4	0.3	0.5	0.7	0.06
LSD (p < 0.05)	9.1	0.7	0.2	1.1	NS	NS	NS	0.2

NS= non significant
Figures with the same alphabetical letters in a column are not significantly different at P> 0.05

Table 3: Interaction effect of nitrogen and variety on morphological characteristics of forage oat

Morphological characteristics	PLH		NSH		NGL		TNL		DMAS		TDMA	
Nitrogen level (kg ha-1)	Kent	UPO-212	Kent	UPO-212	Kent	UPO-12	Kent	UPO-212	Kent	UPO-212	Kent	UPO-212
0	89.5g	38.4h	30.8de	36.5d	95.8f	106.5ef	174.5d	137.0e	40.62g	42.97g	62.38h	65.97g
40	126.8f	142.5d	35.3de	48.3b	108.3ef	118.3de	181.0cd	198.8bcd	62.75f	68.25ef	89.25f	98.50e
80	148.6bc	142.2d	46.5bc	50.0b	133.5bc	125.3cd	187.8cd	229.8b	74.00de	80.00cd	103.25d	113.50c
120	151.4b	146.8c	48.0b	55.8a	174.8a	141.3b	210.5bc	272.3a	81.50bc	90.75a	112.75c	126.25a
160	134.9e	166.6a	56.8a	42.3c	139.8bc	132.3bc	211.3bc	219.8	83.00bc	87.25ab	114.00c	120.00b
SEm+	1.4		1.6		5.12		10.7		2.20		0.70	
LSD (p < 0.05)	4.0		4.7		14.86		31.1		6.38		2.02	

Figures with the same alphabetical letters in a column are not significantly different at P> 0.05

Table 4: Interaction effect of nitrogen and variety on yield and quality of forage oat

	Yield and quality									
	GFY		DMY		CPY		DDMY		CF	
Nitrogen level (kg ha-1)	Kent	UPO-212	Kent	UPO-212	Kent	UPO-212	Kent	UPO-212	Kent	UPO-212
0	235.4f	243.3f	49.9h	52.8g	3.6g	4.0f	39.8g	40.3g	27.4i	28.0h
40	313.2e	378.9d	71.4f	78.8e	5.7e	6.5d	56.2f	59.7e	29.0g	29.5f
80	418.2c	419.4c	82.6d	90.8c	7.3c	9.3b	62.8d	68.6c	30.1e	30.7d
120	471.2b	508.3a	90.1c	100.9a	9.5b	11.2a	67.0c	75.9a	30.9c	31.5b
160	483.8b	506.3a	91.2c	96.0b	9.3b	10.8a	68.2c	70.7b	31.1c	32.7a
SEm+	6.9		0.7		0.2		0.8		0.14	
LSD ($p < 0.05$)	20.2		1.6		0.5		2.4		0.14	

Figures with the same alphabetical letters in a column are not significantly different at $P > 0.05$

References

Aklilu Mekasha and Alemayehu Mengistu .2007. Measurements in pasture and forage cropping systems. Technical manual 18. Ethiopian Agricultural Research Institute.

Ammaji, P. and Suryanaraana, K. 2003.Yield and nutritive value of fodder sorghum varieties as influenced by different levels of nitrogen. *The Andhra Agric. J.*48 (3&4): 1999-2002.

Ayub, M.; Choudhry, M. A.; Tanveer, A. and Ahmad, B. 2001. Effect of different levels of nitrogen and seeding density on growth , yield and quality of maize fodder. The *Andhra Agric. J.*48 (3&4): 205-210.

Below, S. 1995. *Nitrogen metabolism*. *In*: Handbook of plant and crop Physiology. Marcel Dekker, New York.

Bhagmal 1998. Forage research in India-the post independence scenario. *Indian J. agric. Sci.* 68 (8): 439-447.

Bhat, M. D.; Singh, K. N.; Bali., A. and Shah, M. H. 2000. Grain yield of oat (*Avena sativa)* as influenced by sowing time and nitrogen levels under temperate conditions of Kashmir. *Indian J. Agron.* 45 (1): 199-204

Brady, N. C and Weil, R. R. 2002. Nature and properties of soils. 13th edition, Pearson education Inc., India.P 544.

Chakraborty, T.; Subrata, M.; Saswat, H.; Mandal, S. and Haldar, S. 1999. Effect of different levels of nitrogen and cutting on growth , forage and grain yield of oat (*Avena sativa*). *Crop Res. Hisar* 18(1): 39-45.

Cochran, W. G. and Cox, G. M. 1957. *Experimental Design*,2nd edition. John Willey and Sons, INC, New York.

Collin, M.; Brinkman, M. A. and Salman, A. A. 1990. Forage yield and quality of oat cultivars with increasing rate of nitrogen fertilizers. *Agron. J.* 82(4): 724-728.

Dalwadi, M. R.; Patel, K. A. and Patel, G. R. 1987. Effect of different rates, methods and time of nitrogen application on dry matter and NPK accumulation in oat forage. *Intern.J. tropical Agric.* 5(1):49-55.

Das, D.K 1996. Introductory soil sciences. Kaliani Publishers, New Delhi

Gezahegne Bogale, Van Rensburg, J.B.J. and Van Deventer, C.S. 2008.AMMI Analysis of Genotype x Environment Interaction for grain Yield in Drought-Tolerant Maize (*Zea mays* L.) *East African J. Science* 2(1): 1-6.

Hasan, B.; Shah, W. A. and Hasan, B. 2000. Biomass, grain production and quality of oats (*Avena sativa*) under different cutting regimes and nitrogen levels. *Creal Res. Commun.* 28(1-2): 203-210.

Hazar, C. R. and Singh, N. C. 1996. *Forage seed production*: Technical development, South Asian publishers, Daryaganji, New Delhi

Hopkins, A.; Adamson, A. H. and Bowling, P. J. 1994. Response of permanent and reseeded grassland to fertilizer nitrogen. II Effect on concentrations of Ca, Mg, K, Na, S, P, Mn, Zn, Cu, Co, and Mo in herbage at a range of sites. *Grass and forage Sci.* 49:9-20.

Joshi, Y. P.; Singh, V. and Verma, S. S. 1996. Effect of Nitrogen levels on the growth and yield of forage oat varieties. *Forage Res.* 22(1): 67-70

Kilcher, M. R. and Troelsen, J. E. 1973. Contribution and nutritive value of the major plant components of oats through progressive stages of development. *Canadian. J. plant sci.* 53: 251-256.

Kumar, A. 1998. Effect of nitrogen levels and cutting management in three varieties of oats on nutrient composition and nylon bag dry matter digestibility. Thesis, M.Sc., Govind Ballabh Pant University of Agriculture and Technology, Pantnagar.

Kumar, A.; Jaiswal, R. S.; Verma, M. and Joshi, Y. P. 2001. Effect of nitrogen level and cutting management on yield and quality of different varieties of oat fodder.*Indian J. Anim. Nutr.*18 (3):262-266.

Miles, N. ad Manson, A.D. 2000. *Nutrition of plant pasture. In*: Taintain, N. (ed.) Pasture management in South Africa. University of Natal Press, Pietermaritzburg

Mishra, S. N. and Verma, J. S. 1992. *Forage legumes and oat breeding .In*: 25 years of plant breeding research at Pantnagar (1967-1992), Silver jubilee publication, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar.

Pinthus, M. J. 1973. Lodging in wheat, and oat: The phenomenon, its causes and preventive measures. *Adv. Agron.* 25:163-202.

Rao, C. N.; Patil, B. D. and Krishna, P. R. 1978. Analysis of growth attributes in relation to fodder yield in oat (*Avena sativa* L.) Plant types. *Forage Res.* 4: 143-148.

Russell, E. W. 1973. *Soil conditions and plant growth* . The English language book Society and Longman, London, Tenth ed.: 31-36

Saxena, M. C.; Joshi, L. and Rai, S. D. 1971. Studies on the performance of two varieties of oat as affected by dates of planting and levels of nitrogen fertilization. *Indian J. Agron.* 16: 288-292

Sexton, R. 1995. Abscission. *In:* Handbook of plant and crop Physiology. New York, Marcel Dekker.

Sheoran, R. S.; Rana, D. S. and Sharma, H. R.1998. Biofertilizers for sustainable fodder yield and quality of oat (*Avena sativa* L.). *Forage Res.* 24 (2): 93-95.

Singh, J.; Yadav, J. S.; Kumar, V. and Yadav, B. D. 2000. Response of oat to Azotobactor at different nitrogen levels. *Indian J. Agron.* 45(2): 433-436.

Singh, S. S. 1998. *Crop management*, 3rd edition. Kalyani Publishers, New Delhi.

Thakuria, K. 1992. Effect of nitrogen and Azotobacter on fodder yield and quality of oat. *Indian J. Agron.* 37 (3): 571-572.

Thakuria, K. and Gogoi, P. K. 2001. Performance of oat (*Avena sativa*) in rice (*Orayza sativa*) under different levels of nitrogen and sowing method. *Indian J. Agron.* 46(2): 361-363

Tiwari, K. P.; chandrawanshi, J. D. and Sirivastava, J. P. 1971. Note on studies on forage oats. *Indian J. Agron.* 16: 522-523.

Verma, S. S. 1984. Studies on growth , yield and quality of forage oats (*Avena sativa*) under different levels of nitrogen and cutting managements. Ph.D. Thesis, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar.

Feed resource availability, utilization and management in smallholder livestock production system in Yerer watershed of Adaa Liben district.

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Abstract

The study was carried out in 'Yerer watershed' of Adaa Liben district which comprises two peasant associations namely Yerer Silassie and Gende Gorba, with an objective of identifying the major feed resource, availability, utilization pattern, feed management and feeding systems, and feeding calendar of different feed resources. A total of 150 sample farmers or 10 percent of household heads in the watershed were included in the study.

Crop residues (teff and wheat straws), natural pastures (comprising Gecha 'Pennisetum schimperi' and Serdo 'Cynodon dactylon') and commercially available feeds (Noug cake 'Guizotia abyssinica' and wheat bran) were major feed resources in decreasing order of importance. Except improved forage growing, provision of supplemental feeds, feed conservation and crop residues treatments were common practices in the feed management system.

About 89.6 percent (n=121) of the farmers have feed shortage problem that extends from the month of June up to December. Purchase of additional feed and reduced feeding were major measures taken to overcome this problem. About 98.5 percent (n=133) of the farmers give priority for oxen, cows and calves in decreasing order to provide available quality and quantity of feed mainly crop residues and commercially available feeds. Crop residues were utilized throughout the year as a major feed. Natural pasture was utilized from the month of June up to December. Commercially available feeds were utilized from the month of April up to September. Only about 42.2 percent (n=57) of the farmers posses private grazing land with an average holding of 0.22 ± 0.02 ha.

Key words: feed availability, feed resource, feed utilization, crop residue, natural pasture.

Introduction

Feed is the most important input in livestock production, and its adequate supply (quantity and quality) throughout the year is an essential prerequisite for any substantial and sustained expansion in livestock production.

The major livestock feed in the country are grazing and browsing natural pasture, crop residues and agro-industrial by-products, and cultivated pasture and forage crop species (Anteneh, 1984; Alemayehu, 1987).

Subsistence-oriented smallholder is the main mode of agricultural production in the highlands and, therefore, no special effort is made to grow feed for farm animals. All ruminants as well as the equines depend on two major feed resources, namely natural pasture and crop residues. Concentrates are well known but are seldom fed to livestock on a regular basis although there is severe feed shortage during every year (Abate *et al.*, 1993).

Under nutrition and malnutrition are major factors constraining animal production in Ethiopia. Nutritional stress causes low growth rates, poor fertility and high mortality, which is compounded by diseases. About 76.6 percent of feed intake is used to meet the animals' maintenance requirements and only 20.4 percent is utilized for production (Bekele, 1991). Utilization of the feed

resources is therefore highly inefficient. The area which is under improved pastures and fodder crops is insignificant and natural pastures are overgrazed causing invasion of inferior species like *Pennisetum schimperi* and others, which are able to survive under heavy grazing pressure (Sentayehu and Smith, 1989).

According to Daniel (1988), crop residues and post-harvest grazing contribute about 10–50 percent of the annual feed demand in the highlands. Moreover, Alemayehu (1987) reported that crop residue, aftermath grazing and pulse residues contribute 0.5, 1.84 and 0.404 million tones out of the total dry matter feed resources of 41.66 million tonnes available annually in the highlands of Ethiopia. However, these crop residues are characterized by low metabolizable energy and digestible protein contents, which sometimes barely cover animal maintenance requirements (Steinbach, 1997).

In the Ethiopian highlands, natural pasture can produce 6 tons DM/ha but when continuously grazed it yields only 2.5 tons DM/ha (Jutzi *et al*., 1987). As frequent grass out take leads to a reduction in DM yield up to 50 percent, yield from heavily grazed pasture may not exceed 1.5 tons DM/ha (Jutzi *et al*., 1987). According to Lulseged (1985), native pasture land in the Ethiopian highlands have been estimated to be 73 million hectares supporting about 24 million livestock units (LU) in the same area. These figures indicate that native pastures are an important feed source. However, even when a high average dry matter production of three tons per hectare per year is assumed for this grassland, these areas could only contribute a maximum of 50 percent of the total feed required. Thus, about half or more of all animal in the Ethiopian highlands obtain their feed in the form of crop residues (straws, stubble, chaff or weeds from crop plots). The dependence on this feed source is likely to continue along with increasing human population densities and corresponding extension of crop land into traditional grassland (Abate *et al*., 1993).

As the result of crop encroachment, currently crop residues represent the largest amount of feed and regularly conserved as a sole feed of dry season for animals in the highlands of Ethiopia (Alemu *et al*., 2000). Accordingly, crop residues provide 10 to 15 percent of the national intake of feed by livestock, and in some areas the estimate is up to 50 percent (Zinash *et al*., 2001; Alemayehu, 2003). In selected wheat based crop-livestock production systems of the Ethiopian highlands, the contribution of crop residues and aftermath grazing accounts for 70 percent of the total feed supply, while native pasture accounts for only 30 percent of the total feed supply (Seyoum *et al*., 2001). According to Bekele (1991), about 71 and 12 percent of the feed resources in Adaa Liben district originated from crop residues and natural pasture and fallow lands, respectively. Moreover, stubbles from crops account for about 15.6 percent of the feed resources in the district.

With the poor quality of livestock feed in the country, the feed shortage is also exaggerated by its erratic and seasonal supply. Hence, there is sever feed shortage during the dry season and at the beginning of the main rains. The most critical period is between April and the beginning of July, when all feed resources is virtually depleted (Getachew *et al*., 1993). In spite of this fact, seasonal feed deficiencies cause loss of weight that was gained during more favorable periods. Fodder conservation to help eliminate seasonal feed-supply fluctuations is rarely practiced.

With these backgrounds, the study was carried out to identify the major feed resource, feed availability, utilization pattern, feed management and feeding systems, and feeding calendar of different feed resources in the area.

Material and Methods

Description of the study area

This study was carried out in Adaa Liben district of the east Showa administrative zone of Oromiya Regional State (ORS). The specific study area “Yerer watershed” comprises two peasant asso-

ciations (PAs) namely Yerer Silassie and Gende Gorba. These two PAs are part of the 45 PAs in the district. Yerer Silassie and Gende Gorba PAs share common boundaries and are totally part of the watershed, and cover a land mass of about 3372 and 3820 ha., respectively (WOA, 2003) and are located at $8^{o}50$ to $8^{o}53$ latitude and $38^{o}55$ to $38^{o}59$ longitude.

The overall farming system in Adaa Liben district in general and in the study area in particular is characterized by mixed crop-livestock production system, and the system is well integrated. The crop production is a dominant system over the livestock system in the district in general and in the watershed in particular. Livestock production is a second important system next to crop for the overall farming system in the study area. The major contribution of livestock production for the farming community is provision of draft power, transport and as a means of security. According to WOA (2003) report, the specific study PAs (Yerer Silassie and Gende Gorba) has a total livestock population of 5,269.4 and 6,777.2 TLU, respectively. The livestock classes held by farmers in the study area include; cattle (oxen, cows, heifers, bulls and calves), equines (donkey, mule and horse), small ruminants (sheep and goat) and poultry (WOA, 2003).

Sampling methods

The two peasant associations in the study watershed namely Yerer Silassie and Gende Gorba were used for the study. All the three villages from each PA: Buti, Korke and Makana for Yerer Silassie, and Goditi, Dedema and Worko for Genda Gorba were included in this study. Due to shortage of time and resource, about 10 percent of the household or total of 150 sample household farmers were randomly selected based on the proportion of total households in the two PAs using Probability Proportional to Size (PPS) approach. Therefore, out of the total households (525) in Yerer Silassie and (950) in Gende Gorba, proportion of 54 and 96 household were included in the study, respectively. At village level, in Yerer Silassie 12, 15, and 27 households were selected randomly for Buti, Korke and Makana, and at Gende Gorba 28, 39, and 29 households were selected randomly for Goditi, Dedema and Worko, respectively. Moreover, in order to capture household head gender effect in using different feed resource, utilization pattern, feed management and feeding systems, the sample households on each village were stratified to female and male headed households. At this level the numbers of female (22) and male (128) headed households were determined using Proportional Probability to Size (PPS) approach.

Data collection and analysis

In order to address the objectives of the study, two methods/approaches namely discussion with key informants for baseline information and formal (diagnostic) survey using well structured questionnaire were used.

In the primary phase of the study, group discussion was held with key informants to investigate and have an overview about the major feed resource, availability, utilization pattern, feed management and feeding systems, and feeding calendar of different feed resources in livestock production sub-system. The information generated in the group discussion phase was used for the preparation and development of the questionnaire for the formal survey. The questionnaire was pre-tested on sample households out of the study area. Single visit multiple subject survey method was employed in diagnostic survey.

The raw data collected from the formal survey were entered in Excel for data arrangement and cleaning. Finally, cleaned data were analyzed by a computer using person chi-square test and logistic regression of SPSS release version 12.0.1 (SPSS, 2003).

Results and Discussions

Feed source and type

The major livestock feed sources identified in the area were crop residues, natural pasture and commercially available feeds. However, the use of these sources depends on factors like availability, income status, etc. Therefore, differences in feed resource utilization between the two PAs and gender of household heads were identified.

The differences between the two PAs and gender of household heads for crop residues utilization as major livestock feed were not significant. Hence, crop residues are equally important feed sources and about 99.2 percent of the farmers use this feed at first priority in the area (Table 1). This is in agreement with the report of Abate *et al*. (1993) who found that about half or more of all animals feed in the Ethiopian highlands is in the form of crop residues (straws, stubble, chaff or weeds from crop plots). Moreover, Daniel (1988) has stressed the importance of crop residues and post-harvest grazing in contributing about 10–50 percent of the annual feed demand in the highlands.

Table 1. Variation of farmers response in utilization priority of livestock feed resources between PAs and gender of household heads in Yerer watershed.

FEED RESOURCE	GROUPS	TOTAL HH (N)	UTILIZATION PRIORITY						
			1st		2nd		3rd		X2 P-VALUE
			N	%	N	%	N	%	
Crop residue	PA								
	YS	51	51	100.0	0	0.0	-	-	0.617
	GG	82	81	98.8	1	1.2	-	-	
	HHSEX								
	MALE	116	115	99.1	1	0.9	-	-	0.872
	FEMALE	17	17	100.0	0	0.0	-	-	
	TOTAL	133	132	99.2	1	0.8	-	-	
Natural pasture	PA								
	YS	50	1	2.0	49	98.0	-	-	0.575
	GG	61	2	3.3	59	96.7	-	-	
	HHSEX								
	MALE	96	3	3.1	93	96.9	-	-	0.644
	FEMALE	15	0	.0	15	100.0	-	-	
	TOTAL	111	3	2.7	108	97.3	-	-	
Commercial feed	PA								
	YS	40	-	-	2	5.0	38	95.0	0.001
	GG	51	-	-	16	31.4	35	68.6	
	HHSEX								
	MALE	82	-	-	17	20.7	65	79.3	0.433
	FEMALE	9	-	-	1	11.1	8	88.9	
	TOTAL	91	-	-	18	19.8	73	80.2	

YS= Yerer Silassie, GG=Gende Gorba, PA.= Peasant associations, HHSEX=Household Head Sex, HH= Household head

Also the difference was not significant between the two PAs and gender of household heads in utilization priority of natural pasture, and this feed source was considered as the second important feed source by about 97.3 percent farmers in the area (Table 1).

However, there was significant (P<0.001) difference between the two PAs in the priority of using commercial feed as their livestock feed. Hence, more farmers (31.4%) at Gende Gorba used commercial feed as their second important feed resource than (5.0%) of the farmers at Yerer Silassie. This may be due to the closeness of the PA to Debre Zeit town where these feed resource are available at market and the poor access to pasture land in the area. In general, about 80.2 percent of

the farmers in the study area use commercial feed as third priority feed source for livestock (Table 1).

A very few farmers use chickpea and rough pea straw to small extent. Among different grasses on natural pasture, 'Gecha' *Pennisetum schimperi* and 'Serdo' *Cynodon dactylon* are relatively more abundant in Yerer Silassie and Gende Gorba, respectively (Table 2). As indicated by Sentayehu and Smith (1989) these grass species are low in feed value and mainly resulted due to overgrazing because they are able to survive under heavy grazing pressure. The principal commercially available feed types were Noug cake, (*Guizotia abyssinica*) and wheat bran. Therefore, based on farmers response, sole Noug cake, (*Guizotia abyssinica*) and in combination with others are the major commercial feeds being used in the area (Table 3).

Table 2. Farmers response for available grasses species on natural pasture between the two PAs in Yerer watershed.

Grass's Local name*	TOTAL HH (N)	YERER SILASSIE		GENDE GORBA	
		N	%	N	%
Balemi & Yebeglat	1	0	0	1	1.6
Chekorsa	1	0	0	1	1.6
Chekorsa & Balema	1	0	0	1	1.6
Gecha	13	11	22	2	3.3
Gecha & Serdo	32	19	38	13	21.3
Muachera, Gecha & Serdo	4	4	8	0	0
Muja, Gecha & Serdo	1	1	2	0	0
Serdo	52	13	26	39	63.9
Serdo & Chara	2	2	4	0	0
Serdo & Muachera	1	0	0	1	1.6
Yebeglat & Serdo	3	0	0	3	4.9
X2 P-VALUE			0.000		
TOTAL	111	50	100	61	100

HH= Household heads

* Balemi= Andropagon spp., Yebeglat= Capsella rubella, Chekorsa= Eleusine floccifoliu, Gecha=Pennisetum schimperi, Serdo= Cynodon dactylon, Muachera= Brachiaria spp., Muja= Snowdenia polystachya

Table 3. Farmers response difference in using major commercial available feed types between the two PAs in Yerer watershed.

FEED TYPES	TOTAL HH (N)	YERER SILASSIE		GENDE GORBA	
		N	%	N	%
Noug cake	57	23	57.5	34	66.7
Noug cake and Wheat bran	25	12	30.0	13	25.5
Noug cake, Wheat bran and Linseed cake	2	2	5.0	0	0.0
Noug cake and Molasses	1	1	2.5	0	0.0
Noug cake and Linseed cake	3	0	0.0	3	5.9
Wheat bran	1	0	0.0	1	2.0
Noug cake, wheat bran and chicken let	1	1	2.5	0	0.0
Young maize stalk	1	1	2.5	0	0.0
X2 P-VALUE		0.225			
TOTAL	91	40	100.0	51	100.0

HH= Household heads

Feed production, management and conservation

Improved forage production

As reported by farmers and indicated in Table 4, growing of improved forage was not a common practice in the area. However, relatively more (P<0.05) farmers at Yerer Silassie cultivate improved forage compared to farmers at Gende Gorba. Similarly Abate *et al.* (1993) indicated the fact that no special effort is made to grow feed for farm animals in subsistence-oriented smallholder production system in the Ethiopian highlands. Thus, all ruminants as well as the equines depend on two major feed resources, namely natural pasture and crop residues.

Table 4. Difference of farmers response between PAs and gender of household heads in Yerer watershed on cultivation of improved fodders.

VARIABLES	GROUPS	TOTAL HH (N)	NO OF FARMERS GROWING IMPROVED FORAGE				X2 P-VALUE
			GROW		NOT GROW		
			N	%	N	%	
PA	YS	52	5	9.6	47	90.4	0.031
	GG	83	1	1.2	82	98.8	
HHSEX	MALE	118	5	4.2	113	95.8	0.561
	FEMALE	17	1	5.9	16	94.1	
TOATAL		135	6	4.4	129	95.6	

YS= Yerer Silassie, GG=Gende Gorba, HHSEX=Household Head Sex, PA= Peasant association, HH= Household head

The major reasons for not growing improved forages were assessed through farmers comment. As per farmers response indicated in Table 5, lack of planting material and poor experience by Yerer Silassie farmers and land shortage for Gende Gorba farmers were identified as the major reasons for not growing improved forages. Thus, the reasons were significantly (P<0.05) different between the two PAs.

This result indicates that the involvement of governmental and non-governmental organizations in providing training and planting material of improved forage are not sufficient.

Table 5. Variation of farmers reasons for not cultivating improved forages between PAs and gender of household heads in Yerer watershed.

REASONS	TOTAL HH (N)	PA		HHSEX	
		YS %	GG %	MALE %	FEMALE %
Labour shortage	1	0.0	1.2	0.9	0.0
Poor knowledge	21	27.7	9.8	15.0	25.0
Land shortage	42	17.0	41.5	33.6	25.0
Lack material	41	40.4	26.8	31.0	37.5
Land shortage & lack material	6	6.4	3.7	4.4	6.3
Poor knowledge & lack material	9	6.4	7.3	8.0	0.0
Poor knowledge & lack income	1	0.0	1.2	0.9	0.0
Land shortage & lack income	1	0.0	1.2	0.9	0.0
Poor knowledge & land shortage	3	0.0	3.7	2.7	0.0
Area not suitable	4	2.1	3.7	2.7	6.3
X2 P-VALUE		0.044		0.900	
TOTAL	129	47	82	113	16

YS= Yerer Silassie, GG=Gende Gorba, PA.= Peasant associations, HHSEX=household head sex, HH= Household head

Use of supplementary feeds

Provision of supplemental feed for animals particularly for oxen and cows was found to be a common practice in the study area. About 72.6 percent (n=98) of the farmers in the area used additional feed for their animals as supplementary feed. Providing supplementary feed for animals was important practice for both PAs and gender of household heads.

The types of supplementary feed used were identified and are presented in Table 6. Among the different supplementary feeds used, Noug cake (*Guizotia abyssinica*) as a sole and in combination with others was the main supplementary feed being used by farmers in the area. Wheat bran is also frequently used in combination with others. However, the type of supplementary feeds used were different (P<0.05) between the gender of household heads.

Table 6. Household proportion difference in additional feed type given to livestock between PAs and gender of household heads in Yerer watershed.

FEED TYPE	TOTAL HH (N)	PA				HH SEX			
		YS		GG		MALE		FEMALE	
		N	%	N	%	N	%	N	%
NC	36	13	31.7	23	40.4	33	37.1	3	33.3
LBBP	7	1	2.4	6	10.5	7	7.9	0	0.0
MS	1	1	2.4	0	0.0	1	1.1	0	0.0
NC,SL & LBBP	6	3	7.3	3	5.3	6	6.7	0	0.0
WB & LBBP	1	0	0.0	1	1.8	0	0.0	1	11.1
NC & LBBP	12	5	12.2	7	12.3	12	13.5	0	0.0
NC & WB	23	12	29.3	11	19.3	20	22.5	3	33.3
NC, WB & LBBP	4	2	4.9	2	3.5	4	4.5	0	0.0
NC & MLS	1	0	0.0	1	1.8	1	1.1	0	0.0
NC, WB & MLS	2	2	4.9	0	0.0	1	1.1	1	11.1
NC & MO	1	1	2.4	0	0.0	1	1.1	0	0.0
NC, WB, SL & MLS	1	1	2.4	0	0.0	0	0.0	1	11.1
NC & SL	1	0	0.0	1	1.8	1	1.1	0	0.0
NC, SL & MLS	2	0	0.0	2	3.5	2	2.2	0	0.0
X2 P-VALUE		0.340				0.010			
TOTAL	98	41	100.0	57	100.0	89	100.0	9	100.0

NC=Noug cake, WB=wheat bran, SL=Salt, LBBP=Local beverage by-product, MLS=Linseed mile MO=Molasses MS=Maize stalk, YS= Yerer Silassie, GG=Gende Gorba, PA.= Peasant associations, HHSEX=Household Head Sex, HH= Household head

Strategies to overcome feed shortage

Different strategies followed by farmers to provide available feed throughout the year were identified. About 94.8 percent of farmers practiced feed conservation as major strategy to overcome feed shortage. Table 7 indicates that strategies used to overcome feed shortage between two PAs were different (P<0.01). It is worth noting that 21.8 percent of the farmers at Gende Gorba reduced the amount of feed offered to the livestock to insure feed availability throughout the year. Thus, for them survival of the livestock is more important than the production and reproduction.

Table 7. Farmers response difference in strategies to overcome feed shortage between PAs and gender of household heads in Yerer watershed.

VARIABLES	GROUPS	TOTAL HH (N)	METHOD OF FEED CONSERVATION					X2 P-VALUE
			CONS. AVA. GRAS	CRS	CRS & LSF	LSF.	LSF & REP. CR.	
			%	%	%	%	%	
PA	YS	50	2.0	68.0	22.0	6.0	2.0	0.003
	GG	78	0.0	38.5	39.7	21.8	0.0	
HHSEX	MALE	112	0.9	49.1	31.3	17.9	0.9	0.412
	FEMALE	16	0.0	56.3	43.8	0.0	0.0	
TOTAL (N)		128	0.8	50.0	32.8	15.6	0.8	

CRS= Crop residue stacking, LSF= Less feeding, CONS. AVA. GRAS. = Conserve available grass, REP.CR.=Replacing crop residue with other feed, YS= Yerer Silassie, GG=Gende Gorba, PA.=Peasant associations, HHSEX=Household Head Sex, HH= Household head

Crop residue treatment

In order to increase the palatability and nutritive value of the crop residues most farmers (83.0%, n=112) in the area (Table 8) were found to add and mix local beverage by-product, salt and Noug cake (*Guizotia abyssinica*) with crop residues. The Yerer Silassie farmers were more progressive (P<0.01) in this regard than Gende Gorba farmers (Table 8).

Table 8. Farmers response difference in having crop residue treatment experience between PAs and gender of household heads in Yerer watershed.

VARIABLES	GROUPS	TOTAL HH (N)	NO OF FARMERS PRACTICING CROP RESIDUE TREATMENT				X2 P-VALUE
			PRACTICE		NOT PRACTICE		
			N	%	N	%	
PA	YS	52	49	94.2	3	5.8	0.004
	GG	83	63	75.9	20	24.1	
HHSEX	MALE	118	99	83.9	19	16.1	0.322
	FEMALE	17	13	76.5	4	23.5	
TOTAL		135	112	83.0	23	17.0	

YS= Yerer Silassie, GG=Gende Gorba, PA.= Peasant associations, HHSEX=Household Head Sex, HH= Household head

Feed availability and feeding calendar

In the mixed farming of the Ethiopian highlands, the function of livestock encourages expansion of herd/flock sizes, the available grazing areas are disappearing because of crop encroachment (Bekele, 1991). The major sources of feed available in the highlands are crop residue, stubble and roadside grazing. The remaining grazing resources are highly overgrazed and can barely meet the maintenance requirements of the huge livestock population (Bekele, 1991). Thus, feed shortage becomes a critical problem in the Ethiopian highlands.

Feed availability and shortage

In the study area, about 89.6 percent (n=121) of the farmers in the study area reported feed shortage as a problem for their animals (Table 9). The result in Table 9 indicates that the problem seems more important (P<0.05) for farmers at Gende Gorba than Yerer Silassie. However, as the total proportion indicates the problem is also important for Yerer Silassie farmers too.

Table 9. Farmers response difference in having feed shortage problem between the two PAs and gender of household heads in Yerer watershed.

VARIABLES	GROUPS	TOTAL HH (N)	NO OF FARMERS HAVING FEED SHORTAGE PROBLEM				X2 P-VALUE
			HAVE		NOT HAVE		
			N	%	N	%	
PA	YS	52	42	31.1	10	19.2	0.017
	GG	83	79	58.5	4	4.8	
HHSEX	MALE	118	108	80.0	10	8.5	0.078
	FEMALE	17	13	9.6	4	23.5	
TOTAL		135	121	89.6	14	10.4	

YS= Yerer Silassie, GG=Gende Gorba, PA.= Peasant associations, HHSEX=Household Head Sex, HH= Household head

The season of feed shortage was not different between the two PAs and gender of household heads. In general, for about 48.8 percent (n=59) of the farmers of the area feed shortage would start in June and ends up in December. This is the period from which the available crop residues of the previous harvest were fully utilized to the period when the next crop residue would be available. However, Zelalem and Lendin, (2000) reported that the feed shortage condition around Debre Zeit occurs almost year round except for the short time after the crop harvest.

Feeding calendar for different feed resources

The feeding calendars for major feed resources namely crop residue, natural pasture and commercially available feeds were identified using farmers comment for the starting and ending period of feeding.

As reported by farmers, about 62.7 percent (n=81) of the farmers in the watershed use crop residues from the month of December of the pervious year to November of the next year. This result indicates that crop residues being utilized throughout the year as major livestock feed resource in the area. Thus, there was no difference between the two PAs in feeding calendar of crop residues (Table 10).

The second important livestock feed resource (natural pasture) is utilized staring from June when the main rain starts to the month of December when all available grasses on the ground are completely dried up and crop residues would be available from the coming harvest. The difference in feeding calendar for natural pasture was not significant between the two PAs (Table 11).

Table 10. Variation of farmers response for crop residue feeding calendar between the two PAs in Yerer watershed.

FEEDING CALENDER	TOTAL HH (N)	YERER SILASSIE		GENDE GORBA	
		N	%	N	%
All year	15	9	18.0	6	7.6
May-November	1	1	2.0	0	0.0
July – January	1	0	0.0	1	1.3
November - October	18	4	8.0	14	17.7
April – September	1	0	0.0	1	1.3
June – December	9	2	4.0	7	8.9
December – November	66	24	48.0	42	53.2
January – September	18	10	20.0	8	10.1
X2 P-VALUE			0.134		
TOTAL	129	50	100.0	79	100.0

HH= Household heads

Table 11. Variation of farmers response for natural pasture feeding calendar between the two PAs in Yerer watershed.

FEEDING CALENDER	TOTAL HH (N)	YERER SILASSIE		GENDE GORBA	
		N	%	N	%
All year	2	2	4.5	0	.0
September –December	43	21	47.7	22	43.1
August – December	1	0	0.0	1	2.0
June – November	33	12	27.3	21	41.2
June – January	5	2	4.5	3	5.9
December – January	2	2	4.5	0	0.0
October – December	9	5	11.4	4	7.8
X2 P-VALUE			0.293		
TOTAL	95	44	100.0	51	100.0

HH= Household heads

Similarly, the feeding calendar of commercially available feed resources was also not different between the two PAs. According to farmers response, about 63.8 percent (n=30) of the farmers in the watershed indicated that they use this feed resources from April to September (Table 12). This feeding period may relate with supplementation of draft animal for the upcoming crop land preparation and fattening of their livestock for sale during the New Year holiday (*Enkutatash*).

Table 12. Variation of farmers response for commercial feeds feeding calendar between the two PAs in Yerer watershed.

FEEDING CALENDER	TOTAL HH (N)	YERER SILASSIE		GENDE GORBA	
		N	%	N	%
All year	4	2	8.7	2	8.3
April – September	30	14	60.9	16	66.7
December – June	2	1	4.3	1	4.2
January – August	11	6	26.1	5	20.8
X2 P-VALUE			0.977		
TOTAL	47	23	100.0	24	100.0

HH= Household heads

Feeding system and feeding priority

As reported by farmers, giving priority for different livestock species and classes to provide the available quality and quantity of feed resources is a common practice. About 98.5 percent (n=133) of the farmers in the area use feeding priority for their livestock species and classes in their herd/ flock.

As reported by farmers and indicated in Table 13, more farmers gave priority for oxen, cows and calves in decreasing order of priority. This is in agreement with the report of Brännäng and Persson (1994) who indicated that available limited amounts of crop residues are given to draught animals at first priority because they are the sole draught source for intensive crop cultivation in the area. No difference was observed between the two PAs and gender of household heads in the feeding priority of these animals. Crop residues (teff and wheat straw) and commercial feeds (Noug cake and wheat bran) are the major feed types being given for these animals.

Table 13. Farmers response difference for feeding priority among livestock classes in Yerer watershed.

LIVESTOCK CLASSES	TOTAL HH		FEEDING PRIORITY					
			1st		2nd		3rd	
	N	%	N	%	N	%	N	%
CALF	42	15.6	2	1.5	5	5.4	35	81.4
CHICKEN	7	2.6	2	1.5	2	2.2	3	7.0
COW	85	31.6	3	2.3	80	86.0	2	4.7
DONKEY	5	1.9	0	0.0	4	4.3	1	2.3
OX	126	46.8	126	94.7	0	0.0	0	0.0
SHEEP	4	1.5	0	0.0	2	2.2	2	4.7
TOTAL	269	100.0	133	100	93	100.0	43	100.0

HH= Household head

Grazing land ownership

Grazing land was found to be a scarce resource in the study area because of high demand of crop land due to increase in human population. It has also been decreasing from time to time due to crop land encroachment. However, about 42.2 percent (n=57) of the farmers in the study area posses private grazing land (Table 14).

As reported by farmers, more (57.7%) farmers at Yerer Silassie hold private grazing land compared to farmers at Gende Gorba. Thus, the private grazing land ownership status was different (P<0.01) between the two PAs.

Table 14. Differences in ownership of private grazing land between the two PAs and gender of household heads in Yerer watershed, according to farmers response.

VARIABLES	GROUPS	TOTAL HH (N)	OWNERSHIP OF GRAZING LAND				X2 P-VALUE
			OWNERS		NOT OWNERS		
			N	%	N	%	
PA	YS	52	30	57.7	22	42.3	0.005
	GG	83	27	32.5	56	67.5	
HHSEX	MALE	118	50	42.4	68	57.6	0.147
	FEMALE	17	7	42.2	10	58.8	
TOTAL		135	57	42.2	78	57.8	

YS= Yerer Silassie, GG=Gende Gorba, PA.= Peasant associations, HHSEX=Household Head Sex, HH= Household head.

The locations of grazing lands were identified and its association with the two PAs was tested. The difference in locations of grazing lands between the two PAs was significant (P<0.001). Farmers of Yerer Silassie (56.7%) had their grazing land located at hillsides, while about 46.4 percent of the farmers at Gende Gorba have their grazing land located around the farm boundaries (Table 15).

Table 15. Farmers response differences for private grazing land locations between the two PAs in Yerer watershed.

GRAZING LAND LOCATION	TOTAL HH (N)	YERER SILASSIE		GENDE GORBA	
		N	%	N	%
Hill side	18	17	56.7	1	3.6
Road side	10	8	26.7	2	7.1
Farm boundaries	15	2	6.7	13	46.4
Homestead/backyard	12	3	10.0	9	32.1
Farm bound. & homestead	2	0	0.0	2	7.1
River side	1	0	0.0	1	3.6
X2 P-VALUE			0.000		
TOTAL	58	30	100.0	28	100.0

HH= Household head

The more of grazing land location at hillsides in Yerer Silassie may be related to the close proximity of Mount Yerer for most villages of the PA. Whereas much of the land mass at Gende Gorba consist of flat land and is used for crop cultivation; hence this would be the reason for the grazing land location nearer to farm boundaries and the homestead. Similarly, Getachew *et al.* (1993) have reported that natural grasslands in the Ethiopian highlands are generally confined to degraded, shallow upland soils, fallowed crop land and to soils which cannot be successfully cropped because of physical constraints such as flooding and water logging.

The average grazing land holding for the study area was 0.22 ± 0.14 ha. Which is similar with individually owned pasture lands of 0.2, 0.5 and 0.1 ha at Dogollo, Ginchi and Inewari, respectively (Getachew *et al.*, 1993), The average grazing land holding of 0.27 ± 0.17 ha by Yerer Silassie farmers was higher (P<0.05) compared to farmers of Gende Gorba (Table 16). The highest average grazing land holding at Yerer Silassie may be related to better access of uncultivated land on Yerer Mountain.

Table 16. Mean difference in grazing land (ha.) holding between the two PAs and gender of household heads in Yerer watershed.

VARIABLES	GROUPS	N	$\overline{X}$	SE	P-VALUE
OVERALL		58	0.22	0.02	
PA	YERER SILASSIE	30	0.27b	0.03	0.019
	GENDE GORBA	28	0.18a	0.02	
HH SEX	MALE	51	0.22	0.02	0.850
	FEMALE	7	0.23	0.02	

Mean in the column within variable followed by different superscript letters were significantly (P<0.05, T-test) different.
PA.= Peasant associations, HHSEX=Household Head Sex

Results of multiple correlations indicated that grazing land size was not associated with number of livestock and crop land holdings.

Conclusion

Growing improved forages is not common in the area. Shortages of land, planting materials and poor knowledge were the major reasons for not having improved forages in the area. Provision of additional feeds, feed conservation and crop residue treatments were identified as a common livestock feed management systems in the area. Feed in the area was not sufficient for the existing livestock population and the feed shortage was the major problem for livestock production especially from the beginning of June up to the end of December. Purchasing of additional feeds was identified as the major means for solving feed shortage problem in the area. Grazing land is a scares resource in the livestock production sub-system of the area.

Similar to other Ethiopian highlands, crop residue (teff and wheat straw), natural pasture ('Gecha' *Pennisetum schimperi* and 'Serdo' *Cynodon dactylon*) and commercially available feeds (Noug cake and wheat bran) are major feed sources in the study area in decreasing order of importance. Most of the farmers (95.6%, n=129) in the area have no experience of growing improved forages mostly due to lack of planting material and experience (at Yerer Silassie) and land shortage (at Gende Gorba). Farmers in the area have good experience in providing supplementary feed to their animals mostly Noug cake *'Guizotia abyssinica'* and wheat bran in sole and/or in mixture with others. As reported by farmers, about 89.6%, n=121 of the farmers have feed shortage. About 48.8%, n=59 of the farmers reported that this problem would start in June and ends up in December. Regarding strategy used to overcome feed shortage problem, most of the farmers (94.8%) used feed conservation as a major means. Most of the farmers (98.5%, n=135) in the area practiced feeding priority to offer the available feed to their different species and classes of livestock. Hence, oxen, cows and calves get priority to get feed in decreasing order. Grazing land is found to be a scarce resource in the area, as a result only about 42.2% (n=57) of the farmers owned private grazing land with average size of 0.22 ha.

Reference

Abate Tedla, M.A. Mohamed-Saleem, Tekalign Mamo, Alemu Tadesse and Miressa Duffera, 1993. Grain, fodder and residue management. pp. 103-137. In: Tekalign Mamo, Abiye Astatke, K. L. Srivastava and Asgelil Dibabe (eds.). Improved management of Vertisols for sustainable crop - livestock production in the Ethiopian highlands: Synthesis report 1986-92. Technical Committee of the Joint Vertisol Project, Addis Ababa, Ethiopia.

Alemayehu Mengistu, 1987. Feed resources in Ethiopia. In: J.A. Kategile, A.N. Said and B.H. Dzowela (eds.). Animal feed resources for small-scale livestock producers. Proceedings of the second Pastures Network for Eastern and Southern Africa (PANESA) workshop, held at the International Laboratory for Research on Animal Diseases (ILRAD), Nairobi, Kenya, 11-15 Nov. 1985, International Development Research Centre (IDRC). 271p.

Alemayehu Mengistu, 2003. Country pasture/Forage resources profiles: Ethiopia. Food and Agriculture Organization of the United Nations (FAO), http://www.fao.org/ag/agp/agpc/doc/counprof/ ethiopia/ethiopia.htm

Alemu Gebre-Wold, Alemu Tadesse and Asgelil Dibaba, 2000. Research and Development Experience of IAR in NRM and crop-livestock interaction in the highlands of Ethiopia. In: M.A. Jabbar, D.G. Peden, M.A. Mohamed Saleem and H. Li Pun (eds.). Agro-ecosystems, natural resources management and human health related research in East Africa. Proceedings of an IDRC–ILRI international workshop held at ILRI Addis Ababa, Ethiopia. Nairobi, Kenya, 11–15 May 1998, International Livestock Research Institute (ILRI). 242p. Anteneh, A., 1984. Trends in Sub-Saharan Africa's livestock industries. pp. 7-15 In: ILCA Bulletin No. 18. Addis Ababa, Ethiopia, April 1984, International Livestock Centre for Africa (ILCA).

Bekele Shiferaw, 1991. Crop-livestock interaction in the Ethiopian highlands and effect on sustainability of mixed farming: A case study from Ada district. An MSc. Thesis presented to the Agricultural University of Norway. 163p.

Brännäng, E. and S. Persson, 1990. Ethiopian animal husbandry a Handbook. South eastern agricultural development zone. Uppsala. Sweden. 127p.

Daniel Keftasa, 1988. Role of crop residues as livestock feed in Ethiopian highlands. In: B.H. Dzowela (ed.), African forage plant genetic resources, Evaluation of forage germplasm and extensive livestock production systems. Proceedings of the third Pastures Network for Eastern and Southern Africa (PANESA) workshop held at Arusha, Tanzania. Addis Ababa, Ethiopia, 27–30 Apr. 1987, International Livestock Centre for Africa (ILCA). 488p.

Getachew Asamenew, Haily Beyene, Workineh Negatu and Gezahegn Ayale, 1993. A survey of the farming system of vertisol areas of the Ethiopian highlands. pp. 29-49. In: M. Tekaligne, A. Abiye, K.L. Srivastava and D. Asegelil (eds.). Improved management of vertisols for sustainable crop-livestock production in the Ethiopian highlands: Synthesis report 1986-92. Technical Committee of the joint vartisol project. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia.

Jutzi, S., I. Haque and Abate Tedla, 1987. The production of animal feed in the Ethiopian highlands: Potential and limitations. pp. 141-142. In: Proceedings the first national livestock improvement conference. Addis Ababa Ethiopia, 11-13 Feb. 1987, Institute of Agricultural Research (IAR).

Lulseged Gebre-Hiwot, 1985. The status of pasture and forage research in Ethiopia. Paper presented at the National Workshop on Livestock, Pasture and Forage Research in Ethiopia. Ottawa Canada, .8-10 Jan. 1985, International Development Research Centre (IDRC).

Sentayehu, G.M. and G. Smith, 1989. Productivity improvement in the Ethiopian livestock industry. Towards a food and nutrition strategy for Ethiopia. Peoples Democratic Republic Office of the National Committee for Central Planning. pp. 297-320. In: The proceeding of the national workshop on food strategies for Ethiopia held at Alemaya University of Agriculture, Dire Dawa, Ethiopia.

Seyoum Bediye, Getnet Assefa, Abate Tedla and Dereje Fekadu, 2001. Present status and future direction in feed resources and nutrition research targeted for wheat based crop-livestock production systems in Ethiopia. pp. 205-226. In: P.C. Wall (ed.). Wheat and Weeds: Food and Feed. Proceeding of two stockholder workshops. Mexico city, Mexico. 10-11 Oct. 2000. CIMMYT.

SPSS., 2003. Statistical Program for Social Study. Version 12.0.1, release of 2003 Chicago, Illinois, USA.

Steinbach, J., 1997. Alternatives to crop residues as feed resources in mixed farming systems. In: C. Renard (ed.). Crop residues in sustainable mixed crop/livestock farming systems. CAB International in association with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the International Livestock Research Institute (ILRI). Wallingford, United Kingdom. 322p.

WOA, 2003. (Woreda Office of Agriculture Adaa Liben). General characteristics of Adaa Liben Woreda. Debre Zeit, Ethiopia. (Unpublished data)

Zelalem Yilma and I. Ledin, 2000. Milk production, processing, marketing and the role of milk and milk products on smallholder farms' income in the central highlands of Ethiopia. pp. 139-154. In: Proceeding of the eighth annual conference of Ethiopian Society of Animal Production (ESAP). Addis Ababa, Ethiopia, 24-26 Aug. 2000.

Zinash Sileshi, Aschalew Tsefahun, Alemu Yami and Azage Tegegne, 2001. Status of livestock research and development in the highlands of Ethiopia. pp. 227-250. In: P.C. Wall (ed.). Wheat and Weeds: Food and Feed. Proceeding of two stockholder workshops. Mexico City, Mexico, 10-11 Oct. 2000, CIMMYT.

Marketing and socio economics Implicit Prices of Indigenous Cattle Attributes in Central Ethiopia: Application of Revealed and Stated Preference Approaches

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Abstract

The diversity of animal genetic resources has a quasi-public good nature that makes market prices less relevant as indicator of its economic worth of the diversity. Applying the characteristic theory of value, this research estimated the implicit prices and relative economic worth of the attributes of cattle genetic resources in Central Ethiopia. Transaction level data were collected over four seasons in a year and choice experiment survey was done in five markets to generate data on both revealed and stated preferences of cattle buyers. Heteroscedasticity efficient estimation and random parameters logit were employed to analyze the data. The results essentially show that attributes related to the functions of cattle important to subsistence are more valued than attributes that directly influence marketable products of the animals. The findings imply the strong need to invest on attributes of cattle that enhance the functions with high priority for the (semi) subsistence livelihoods of people in the study area.

Introduction

Livestock in general and cattle in particular are indispensable components of rural livelihoods in Ethiopia. In arid and semi-arid parts of the country, the pastoral communities depend entirely on their livestock for their livelihoods (Little et al., 2001; Barrett et al., 2003; Ouma et al., 2007). In the more dominant crop-livestock mixed livelihood system, cattle serve in providing traction power, in generating cash, in buffering shocks, as sources of consumables and as sources of prestige, being the main indicator of wealth. The importance of cattle in the rural livelihoods and the global threat of the erosion of animal genetic resources justify a thorough analysis of the preferred characteristics of the animals to guide conservation and improvement programs.

Accordingly, proper identification, valuation, and maintenance of the different traits of the genetic resources are necessary to make it available for future use without compromising current consumption. The main challenge in this regard is that the economic implications of the erosion of the genetic diversity and consequently that of its conservation are not well understood. This is so essentially because the diversity of AnGR has a quasi-public[3] nature (Scarpa *et al.*, 2003a) and this makes the revealed preferences for genetic resources in ordinary markets incomplete to value the diversity.

Both revealed and stated preference techniques have been employed to analyze the marketing or pricing of livestock in Africa. The revealed preference analyses virtually employed the hedonic pricing model approach. The studies which used this method are Andargachew and Brokken (1993), Fafchamps and Gavian (1997), Jabbar (1998), Barrett et al. (2003) and Jabbar and Diedhiou (2003). The studies in general showed that weight, age, sex, body condition, body size, coat colour, reason of purchase, season, rainfall pattern, holidays, district location, breed type, market locations, and restrictions such as quarantines determine livestock prices observed in the market.

3 The quasi-publicness emanates from the fact that although cattle are privately owned, the genetic diversity embedded in them can be accessed with no or low cost by others, especially in a system where mating of cattle is uncontrolled. Similarly, the payment made while buying an animal is not for the invaluable genetic diversity due to the animal and yet the buyer can benefit from this diversity.

The stated preference method has become more common currently in analyzing the preferences and valuation of livestock attributes. The significance of stated choice based valuation of attributes has generated a considerable amount of interest and research in the area of AnGR in recent times. After the pioneering work by Sy *et al.* (1997) in Canada, many authors have analysed economic values of cattle traits for some African countries. Tano *et al.* (2003) analysed the economic values of traits of indigenous breeds of cattle in West Africa focusing on trypanotolerance by employing conjoint ranking and ordered probit model. Using choice experiments (CE) and mixed logit model, Scarpa *et al.* (2003a) quantified the economic values of the traits of a creole – local – pig in Yacutan Mexico. Scarpa *et al.* (2003b), employing the same approach, estimated the values for the traits of indigenous cattle in Northern Kenya. Ouma *et al.* (2007) employed choice experiments and mixed logit and latent class models to analyze the relative values of traits and heterogeneities in trait preferences in the pastoral areas of Northern Kenya and Southern Ethiopia. Zander (2006) employed conjoint ranking and mixed and multinomial logit models to study the relative values of traits and preference heterogeneities of Borana cattle keeping pastoralists in Northern Kenya and Southern Ethiopia. Roessler *et al.* (2007) employed choice experiments and multinomial logit model to investigate the relative economic weights of pig traits in Vietnam, while, Ruto *et al.* (2008) examined the relative values cattle traits and preference heterogeneities in Northern Kenya using choice experiments and latent class modelling.

The present study contributes to the literature by employing revealed and stated preference approaches for identifying the factors that influence the actual prices in the markets and for valuation of the preferred attributes of indigenous cattle, respectively, in Central Ethiopia. The remaining part of the paper is organized as follows; next, a description of the study area, and the data generation and management procedures are described. These are followed by results and discussion. The final section contains conclusions and implications of the results.

The Approach

The study area

The study was conducted in the Dano district, which is located 250 km west of the Ethiopian capital Addis Ababa. The district is about 66,000 hectares wide, with a human population of 83,000. Livestock, particularly cattle, are important assets of the community. Semi-subsistence crop-livestock mixed farming system is the mainstay of livelihoods for the district's human population. The most important annual objective of the average household is producing sufficient food for the family.

The study covered five markets. Four of the markets, namely, Sayo, Menz, Dano-Roge and Awadi-Gulfa, are situated within Dano district. Sayo, the administrative and economic capital of the district, has two different cattle markets that set on Wednesdays and Saturdays. Menz is a small market located at about 12 km north of Sayo and sets on Tuesdays. Dano-roge is located at the northern tip of the district some 28 km far from Sayo. Roge sets on Thursdays and, unlike in other markets, cows and calves are the cattle frequently exchanged. Awadi-Gulfa market is located 24 km northeast of Sayo and sets on Wednesdays. Awadi is mainly a market for male cattle brought from both within and outside the district. The fifth market is Ijaji that is located in neighboring Cheliya district and it sets on Saturdays. All types of cattle are brought to Ijaji market and it is the only fenced market of about 30m by 80m area. Comparatively, traders are more frequent in this market than in others. Animals are trekked to and from the markets throughout the year. All cattle markets are dominated with male buyers and sellers with virtually no women around. All the markets set for half a day mostly in the afternoons.

Sampling and Data Generation

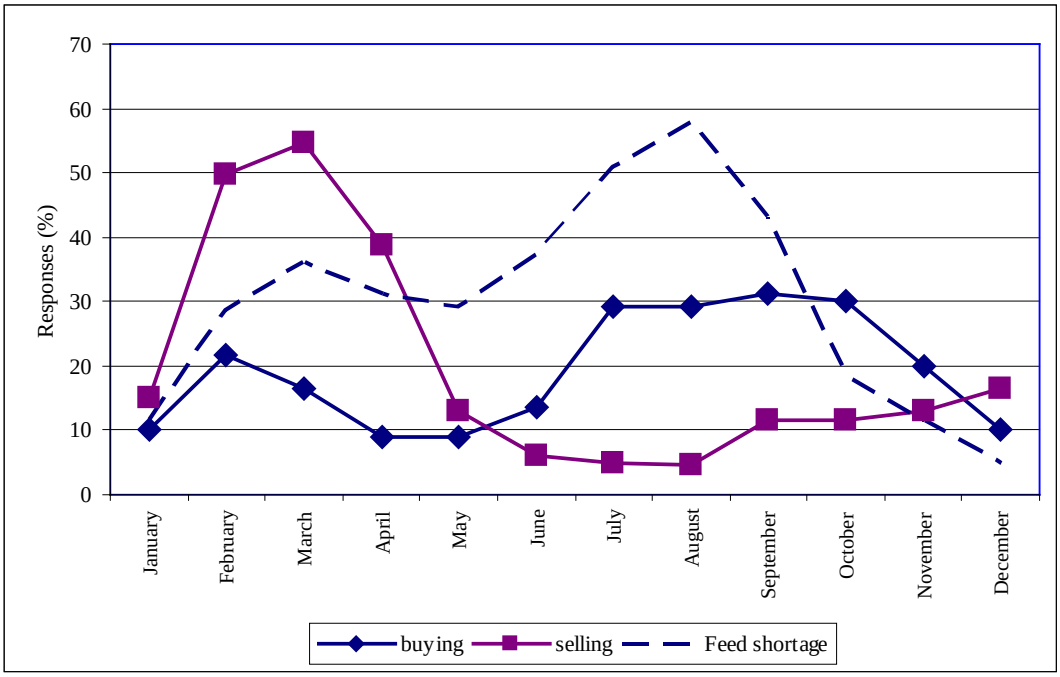
Revealed Preference Analysis

Data were generated through a survey in the five rural markets described above. The survey was a quarterly cattle transaction survey in the five rural markets with a sample of 20 cattle buyers in each season from each market. Given that some of the buyers purchased two animals at a time, the final sample size was 411. The survey focused on the phenotypic traits of the animals traded, places where the animals were brought from, price, and the characteristics of the buyers. The phenotypic characteristics were identified in the initial survey and included colour, class, age and body size of the animal bought.

Data collection for each season was carried out over two weeks (two market days) simultaneously in all of the markets. The first season was end of February to beginning of March. This is immediately after the crop harvesting period where crop prices are normally low and livestock prices are high. Most of the cattle keepers want to sell their animals during this period against the challenge of the imminent feed scarcity. This is evident from Figure 1. Data collection for the second season was carried out after three months in late May to early June. This is a period when prices of cattle decline, as buyers, predominantly farmers, usually lack funds to purchase cattle. Moreover, since it is the beginning of the rainy season, farmers tend to focus on their cropping activities.

The third round of data collection was conducted in late August to early September, a period of serious feed shortage. Prices are normally expected to be low for the animals that are yet to regain weight they lost in the dry season and for those that are subjected to restricted free grazing in the rainy season. As expected, this is the most favoured period by buyers and the least preferred by sellers (see Figure 1). The last round of data was collected in late November. This is the beginning of the harvesting period for early maturing crop varieties and the declining prices for crops. The animals normally recover from the weight losses of the past seasons and farmers can then postpone their selling decisions, if the prices offered are not attractive enough.

Figure 1: Feed availability calendar and cattle selling and buying season preferences of Dano farmers.



An important observation in this study is the kind of classification farmers have for cattle and the influence of this classification on cattle prices. Male cattle which have ploughed for more than 2 seasons and sometimes castrated are called '*sangota*'. Younger male cattle with ploughing experience of less than 2 seasons and uncastrated are called '*jibbota'*. A Female cattle which has delivered more than once is called '*sa'a'*. Young female cattle that have delivered only a calf or none are called '*gorba'*. Very young female and male cattle with no parturition or ploughing experience are called '*jabbota'*. In this paper we use ox, bull, cow, heifer, and calf to mean '*sangota'*, '*jibbota'*, '*sa'a'*, '*gorba'*, and '*jabbota',* respectively. It is worth noting that these classifications somehow overlap and might differ for the buyers and sellers. For instance, a younger cow for a seller might be a heifer for the buyer. The present study employs the buyers' classification.

Stated Preference Analysis - Choice Experiment

Choice experiment (CE) is a popular stated preference method which is used to elicit preferences for attributes of differentiated goods based on statistically efficient designs of attributes and attribute levels. CE surveys have already become routine in the fields of, *inter alia*, environmental (e.g., Rolfe *et al.*, 2000; Campbell, 2007), food and beverage (e.g., Rigby and Burton, 2005; Mtimut and Albisu, 2006), and plant genetic resource (e.g., Windle and Rolfe, 2005; Birol *et al.*, 2006) economics. Application of CE for the valuation of attributes of livestock is very recent and only a few studies (Scarpa *et al.,* 2003a,b; Ouma *et al.,* 2007; Roessler *et al.*, 2007; and Ruto *et al.*, 2008) employed it to elicit preferences.

The most important issues in designing a CE survey are attribute and attribute level determination, generation of statistically efficient and practically manageable experiment design, and management of the field interview. In this study, trait identification and trait level determination were done after a series of informal and focus group discussions both in the villages and in the markets where people of Dano district make a living and undertake cattle transactions. Respondents were asked to mention the attributes they consider to value the animals they keep or buy.

After further discussions with farmers, and based on additional information generated by pair wise ranking during subsequent surveys, seven traits were identified for cow traits CE and six traits for bull traits CE. Age was fixed to be 3 years for cows based on the average of the figures indicated by farmers that is in line with fact that the average age of a cow at its first parturition is about 3.2 years in this part of the country (Workneh and Rowlands**,** 2004). For bulls, age was fixed at 4 years, as this is the age at which a bull would have ploughed for a year. The price levels used in the CE are averages of the minimum, average and maximums of the price distributions generated from respondents in the villages and markets for an 'average' cow and 'average' bull – average as perceived by respondents. Table 1 presents the traits and trait levels used in the choice experiments.

The traits and trait levels were statistically combined in an efficient way to generate profiles based on the attributes and attribute levels. The more comprehensive approach suggested by Kuhfeld (1997, 2005) to generate statistically efficient design with SAS algorithm was employed in this study. In addition to orthogonality, statistically efficient designs are characterized with balanced distribution of attribute levels, balanced utility across alternatives, and minimum overlap of levels in a choice set (Huber and Zwerina, 1996).

Table 1: Traits and levels included in the choice experiments

Variable	Levels	Reference level
Origin	Dano Nearby districts Wellega Keffa	Dano
Body size	Small Medium Big	Small
Fertility (Cows only)	A calf/ 2 years A calf/ year	A calf/2 years
Milk yield (Cows only)	1 litre/day 2 litre/day 3 litre/day	1 litre/day
Ploughing potential (Bulls only)	Poor Good	Poor
Calf vigour	Poor Good	Poor
Disease resistance	>2 times per year <2 times per year	>2 times per year
Price – Cows	Small price = 500.00 Birr* Medium price = 700.00 Birr High Price= 900.00 Birr	500.00 Birr
Price - bulls	Small price = 800.00 Birr Medium price = 1000.00 Birr High Price= 1200.00 Birr	800.00 Birr

* Birr is the local currency in Ethiopia. One USD ≈ 8.8 Ethiopian Birr in 2007.

The design generated 36 profiles classified into 18 choice sets (two profiles in each set) blocked into three so that each respondent could be presented with six choice sets. Similarly, the design for the bull traits CE generated 24 profiles categorized into 12 choice sets blocked into two so that each respondent receives six choice sets. In total, each respondent received 12 choice sets. Attributes and attribute levels were described with pictures and sketches which were carefully selected to clearly show the attributes and the differences in the levels of the attributes (Annex 1). The survey was enumerated by three experienced researchers from the department of livestock improvement at Bako Agricultural research Centre (BARC) and an agricultural economist for a consistent and clear explanation of all the attributes and attribute levels considered.

Valid numbers for experiments were 195 for cows and 198 for bulls. Accordingly, the total number of cow choice sets responded to were 1170 and that of bulls were 1188 with three alternatives in each set. The third alternative was an opt-out option included for the purposes of avoiding forced choice and of generating theoretically sound taste parameter estimates. In each market, one or two well-known brokers were identified and briefed about the objectives of the study and the equal opportunity sampling procedure to be employed. Then broker(s) identified respondents from the different spots in the markets. This is a relatively isolated community and the five markets are virtually the only markets where cattle in the district are traded. The sample is therefore believed to be representative of the cattle buyers in Dano district.

Analytical Framework

Revealed Preference Analysis

Theoretically, the prices cattle sellers receive are reflections of the utility anticipated by the buyers and this utility is derived from the attributes of the product as cattle can be considered as quality (attribute) differentiated goods (Lancaster, 1966; Rosen, 1974). This research focuses on the main phenotypic attributes that buyers inspect when buying an animal. The external features

farmers look at and attach value to are age, colour, body size, sex, and the place where the animals were brought from.

The different levels of the homogenous attributes that differentiate cattle are known to both buyers and sellers. The levels considered in this analysis are those perceived by the buyers, despite the possibility of imperfect knowledge and differences in measurement. The buyers and sellers in the markets considered are mainly farmers who raise the cattle. In line with the household modelling literature, where goods are produced, consumed and sold by households, a hedonic model can be employed to value the attributes of the quality differentiated indivisible goods. Therefore, estimation of the relationship between the characteristics of the cattle and their prices can be made through hedonic price analysis.

Under competitive market conditions, implicit prices will normally be related to product attributes alone, without accounting for producer or supplier attributes. However, as widely documented in the literature, rural markets in developing countries, particularly in Sub-Saharan Africa, are rarely competitive (Barrett and Mutabatsere, 2007).This is essentially due to poor communications and transport infrastructure, limited rule of law, and restricted access to commercial finance, all of which make markets function much less effectively. Several empirical studies have shown that prices are also related to the attributes of buyers, season and market location (e.g., Oczkowski, 1994; Jabbar and Diedhiou, 2003). Hence, season, market location and education level of the buyer were included in the models estimated in this research. As mentioned above, cattle price discovery in the rural markets surveyed is done through a one-to-one bargaining with the help of brokers. Brokers are usually invited by buyers, in this case farmers, as they have much less market information about prices and tend to be price takers. Therefore, the bargaining power of the buyer is very important in influencing the price paid. No direct information was gathered on bargaining power, but education level was taken as a proxy to indicate strength in bargaining, under the assumption that higher education increases the bargaining skills of buyers.

Another important issue in estimating hedonic functions is the identification of the appropriate functional form and estimation procedure. In general, the functional form of the hedonic price equation is unknown (Haab and McConnel, 2002). Parametric, semi-parametric and non-parametric estimation procedures have all been suggested and used in different applications (e.g., Anglin and Gencay, 1996; Parmeter et al., 2007). As this research focuses on the estimation of the relative weights of cattle attributes (first step hedonic analysis), the technical details of these alternative approaches are not of interest.

The estimation strategy adopted in this study is a simple linear model based on the suggestion by Cropper et al. (1988) as well as Haab and McConnel (2002). Cropper et al. (1988) employed Monte-Carlo simulation analysis to show that the linear and linear-quadratic functions give the smallest mean square error of the true marginal value of attributes. However, when some of the regressors are measured with error or if a proxy variable is used, then the linear function gives the most accurate estimate of the marginal attribute prices. Haab and McConnel (2002) also argue that when choosing a functional form and the set of explanatory variables, the researcher must bear in mind the almost inevitable conflict with collinearity. High collinearity makes the choice of a flexible functional form less attractive, since the interactive terms of a flexible functional form result in greater collinearity. Given these considerations, we begin with a restrictive basic linear model[4] given by

$$h\left(\boldsymbol{price}\right) = \boldsymbol{X}b + e \qquad (1)$$

4 Taking the natural log of price as dependent variable makes the estimated coefficients approximations of the percentage price change associated with a unit change in the independent variable.

where $\boldsymbol{X}$ is the vector of independent variables including the constant term, characteristics of cattle and the socioeconomic variables considered, $\boldsymbol{\beta}$ is a vector of parameters to be estimated and $\boldsymbol{\varepsilon}$ is an independent and identically distributed (iid) error term.

The iid assumption for the error term implies that the conditional distribution of the errors given the matrix of explanatory variables has zero mean [$E\{\varepsilon\} = 0$], constant variance [$V\{\varepsilon\} = \sigma^2$], and zero covariance [$V\{\varepsilon\} = \sigma^2 I$], where I is the identity matrix. These assumptions and hence the reliability of the estimates based on such assumptions hardly hold in analyzing survey data. We tested the basic model for specification error and heteroscedasticity. Ramsey's RESET test of the hypothesis of no omitted variables generated F (3, 381) value of 1.54 which is much below the critical value of 2.60 at $\alpha = .05$ implying non-rejection of the null hypothesis. Both White and Breusch-Pagan tests rejected the hypothesis of homoskedasticity at the one percent level of significance, suggesting the presence of heteroscedastic error terms[5].

The data analysis employed in this study follows the approach used by Barrett et al. (2003) in their study of the determinants of price and price variability in Northern Kenya. They applied the well established concepts of structural heteroscedasticity and GARCH-M models to iteratively estimate price of cattle simultaneously accounting for price variability in the estimation.

Two equations are estimated simultaneously. The first equation regresses the conditional mean of the ln(price) on the independent variables discussed above and the standard deviation of the residual for each observation from the original OLS regression given by

$$\ln(price) = X\beta + \gamma\sigma + \varepsilon \qquad (2)$$

where $\boldsymbol{\sigma}$ is the conditional standard deviation of the natural log of price and $\boldsymbol{\gamma}$ is its coefficient.

The second model is the regression of $\boldsymbol{\sigma}$ on selected exogenous variables (Z) in X.

$$\sigma = Z\lambda + \upsilon \qquad (3)$$

where $\boldsymbol{\lambda}$ is the vector of parameter estimates and $\boldsymbol{\upsilon}$ is an iid error term.

The estimation is conducted such that the predicted values of equation (3) will be substituted into equation (2) in each step until the parameters converge[6]. This simultaneous estimation strategy is suitable for an analysis of price risk and the risk premiums relevant to cattle marketing (Barrett et al., 2003).

Stated Choice Analysis

Values of (quasi-) public goods are not exclusively derived from private use of resources and, therefore, the revealed preferences in the markets can not be used to generate the marginal effects of attributes of an animal (Drucker *et al.*, 2001; Anderson, 2003; Roosen *et al.*, 2005). Random utility theory (McFadden, 1974) formulates utility (U) as an additive function of deterministic and random components:

$$U_{njt} = X'_{njt}\beta_n + \varepsilon_{njt} \qquad (4)$$

where, X_{njt} is a vector of explanatory variables including attributes of alternatives and interactions of attributes and socioeconomic characteristics, and ε_{njt} is unexplained utility assumed to be independently and identically distributed (iid) across individuals, alternatives and choice sets with extreme value type I distribution. β_n is a conformable vector of the unknown weights the respondent assigns to the explanatory variables. Interaction variables of attributes and socioeco-

5 According to Long and Ervin (2000) and Verbeek (2004), the immediate procedure in this case is to assume the heteroscedasticity to be of an unknown form and to modify the error terms accordingly. The regression analyses employed here therefore aim at addressing this heteroscedasticity.

6 We used STATA 9.2 SE's default convergence level of three stages iterative least square estimation.

nomic characteristics are introduced to account for sources of preference heterogeneity among the respondents. Significance of the coefficient of an interaction term indicates that there is heterogeneity of preferences around the mean of the attribute because of the respective socioeconomic variable (Hensher *et al.*, 2005).

Given the stochastic component of utility is distributed iid extreme value type I, the probability conditional on β_n (CP_{njt}) that the cattle buyer chooses alternative '*j*' out of '*m*' alternatives in a choice set '*t*' is a conditional logit (McFadden 1974):

$$CP_{njt}(\beta_n) = \frac{\exp X'_{njt}\beta_n}{\sum_{l=1}^{m} \exp X'_{nlt}\beta_n} \tag{5}$$

However, this assumes homogeneous preference for traits across all respondents and the taste parameters of each individual (β_n) are known and completely explained by their means only.

Preference heterogeneity is, however, known to be common among cattle producers and consumers (e.g., Sy *et al.*, 1997; Scarpa *et al.,* 2003a; Ouma *et al.,* 2007). A random parameters logit model which accounts for heterogeneity is therefore used here. In random parameters logit (RPL), the β_n's are specified to be random and normally distributed[7]:

$$b_n \sim N[b, \Sigma_b] \tag{6}$$

where β is the mean and Σ_β is the covariance of the distribution of β_n.

The random taste parameters (β_n) are unobserved and so the unconditional probability that a cattle buyer will choose alternative '*j*' is estimated by integrating the conditional probabilities over all values of each of the random taste coefficients weighted by its density function. That is

$$P_{njt} = \Pr[y_{nt} = j] = \int \frac{\exp(x'_{njt}\beta_n)}{\sum_{l=1}^{m} \exp(x'_{nlt}\beta_n)} \phi(\beta_n \mid \beta, \Sigma_\beta) d\beta_n \tag{7}$$

where the integral is multidimensional and $f(b_n \mid b, \Sigma_b)$ is the multivariate normal density for β_n with mean β and variance Σ_β.

The maximum likelihood estimation then maximizes

$$\ln L_N = \sum_{n=1}^{N} \sum_{j=1}^{m} y_{njt} \ln P_{njt} \tag{8}$$

with respect to β and variance Σ_β. This maximization can not be solved; because, the integral (equation 7) has no closed form solution as its dimension is given by the number of components of β_n that are random, with non-zero variance. Simulated maximum likelihood estimation is, therefore, employed to estimate the unconditional choice probabilities (Train, 2003; Cameron and Trivedi, 2005). Following Cameron and Trivedi (2005), the integral (equation 7) is replaced by the average of R evaluations of the integrand at random draws of β_n from the N[$\boldsymbol{\beta}$, Σ_β] distribution. The maximum simulated likelihood estimator then maximizes

7 Other possible distributions the random taste parameter can take include lognormal, uniform and triangular (Train, 2003; Hensher et al., 2005). We have tried different distributional assumptions for the random parameters before deciding to use the multivariate normal distribution.

$$\ln \hat{L}_N(\beta, \Sigma_\beta) = \sum_{n=1}^{N} \sum_{j=1}^{m} y_{njt} \ln \left[\frac{1}{R} \sum_{r=1}^{R} \frac{e^{x'_{njt} \beta_n^{(r)}}}{\sum_{l=1}^{m} e^{x'_{njt} \beta_n^{(r)}}} \right] \tag{9}$$

where y_{njt} is 1 if alternative j is chosen and 0 otherwise, and $b_n^{(r)}$, r = 1,2,…, R, are random draws from the density $f(b_n \mid b, \Sigma_b)$.[8].

Results and Discussion

Revealed Preference Analysis

The econometric estimation shows that season, market location, class of cattle, body size and age are very important determinants of cattle prices in the rural markets of central Ethiopia (Table 2). Cattle prices from seasons one and two were found to be similar. However, the prices in season three were significantly lower than those in season one. This is the period when farmers have not harvested their crops and their liquid assets are also quite low. This implied that they could be forced to sell their cattle to generate cash with the market reacting with lower price due to excess supply. Season three is, therefore, the least preferred period to sell cattle by farmers (see **Figure** 1). Price in season four was found to be significantly higher than that of season 1. This is expected because it is the period when farmers can postpone their cattle selling decisions if the prices are not acceptable, since they can easily rely on the recently harvested crop yield.

Most of the coefficients of the market dummies were also found to be significantly different from zero, implying price differentials for cattle relative to Dano, the base market. The frequency of each class of animal is also decisive in this particular estimation. It is only at Roge market that the frequency of the bigger animals – oxen and cows – is less than that of Sayo. This clearly undermines the prices in Roge as compared to other markets and hence the negative coefficients. Cattle prices in Menz and Awadi markets are significantly higher than in Sayo. These markets have higher frequency of oxen and cow transactions as compared to others. In addition, Awadi is one of the routes out of the district to trek to secondary markets such as Guder and Ambo. Traders in Menz also trek their cattle to these secondary markets via Awadi.

Table 2: Modified SHM model parameter estimates

	Modified SHM [ln(price)]		Modified SHM [St.dev. ln(price)]	
ln(price)	Coef.	St. Err.	Coef.	St. Err.
Constant	6.265*	0.079	0.540*	0.038
Season 2	0.017	0.016	0.004	0.018
Season 3	-0.032‡	0.019	0.018	0.019
Season 4	0.101*	0.017	0.033‡	0.018
Menz	0.118*	0.024	0.017	0.023
Awadi	0.088*	0.020	-0.025	0.021
Ijaji	0.008	0.025	-0.015	0.027
Roge	-0.063	0.040	0.095*	0.023
Ox	0.252*	0.053	-0.110*	0.018
Cow	-0.077	0.093	-0.255*	0.023
Heifer	-0.098*	0.037	0.061*	0.026

8 This study employed a range of numbers of draws (100 – 1000) and the results were found to be consistent. 1000 Shuffled Halton draws were used to avoid undesirable correlation patterns that arise in standard Halton sequences (Hensher *et al.*, 2005).

	Modified SHM [ln(price)]		Modified SHM [St.dev. ln(price)]	
Bull	0.059†	0.027	-0.103*	0.025
Medium Body	0.028	0.020		
Big body	0.174*	0.019		
Color-red	0.036	0.026		
Color-black	-0.091*	0.029		
Color-white	0.021	0.053		
Age	0.181*	0.029		
Age square	-0.011*	0.002		
Neighbor distr	-0.036	0.031	-0.075*	0.034
Wellega	0.113‡	0.066	0.110	0.073
Keffa	-0.067	0.056	0.080	0.064
Read and write	-0.037	0.032	0.025	0.035
Elementary	-0.020	0.024	0.002	0.023
Secondary	0.067†	0.028	-0.009	0.031
Above second.	0.074	0.066	-0.054	0.058
Religious study	-0.078	0.050	0.028	0.055
St.dev. ln(price)	-0.155	0.267		

*, †, and ‡ significant at α = 0.01, α = 0.05, and α = 0.05, respectively

Farmers' classification of cattle into sex and functional categories was found to be important determinant of prices. For example, oxen have a price premium of about 25% over calves. This is the highest premium followed by that of bull. The heifers were found to have lower prices than the calves. Given the frequency of heifer and calf transactions, the fact that the calves include mainly male young cattle might have inflated the prices for calves over heifers. Coefficient for the cow dummy has the unexpected negative sign. Though the cow dummy coefficient is not statistically significant, the result generally shows that the relative value attached to female cattle is lower, since milk is not tradable in the district.

Body size was found to be very important determinant of cattle prices, with big size having a price premium of about 18% over small ones. This is a clear indication of the interests of cattle keepers/buyers of the area and conforms to previous studies on the topic (Jabbar and Diedhiou, 2003; Barrett et al., 2003; Scarpa et al., 2003a). The most consistent variable in determining the price of cattle in these rural markets was age of the animal. The results show a strong quadratic relationship between age and price of cattle that at younger ages an increase in age increases the price of the animal.

The coat colour of cattle is also an attribute buyers normally consider when purchasing an animal. The results reveal that red and white colours have no significantly different influences on prices, as compared to mixed colour, which is the base level. However, black coat colour, relative to mixed colour, has a significant price lowering effect on cattle. The coefficient for black coat colour dummy is not only statistically significant but also exhibits the highest value among the colours included in the model. Specifically, black coated cattle will attract a downward premium of about 9% as compared to mixed colour coated cattle. The survey results showed that this is essentially due to the fact that black coated animals are considered very susceptible to trypanosomosis that is prevalent in the area.

Among the origin of cattle dummies included, only Wellega appears to be marginally significant. These results show that cattle from Wellega have a price premium of up to 11% over those within Dano district. This is expected as the field surveys revealed that cattle from Wellega are considered to be big in size, disease free and highly marketable. Although statistically insignificant, the Keffa dummy has the expected negative sign as cattle from this zone are considered to be suscep-

tible to diseases. Literacy variables included as proxies for bargaining power did not reveal any statistically significant influence on cattle price.

The coefficient of the conditional standard deviation of the natural log of price in the natural log price equation is negative as expected but statistically insignificant. The negative sign implies the commonly observed phenomenon that as market prices grows more volatile, those who, nonetheless, opt to sell their animals in the markets are somewhat more desperate for cash and so are less able to hold out for a good price from traders (Barrett et al., 2003). The variability of the natural log of price is indicated to be influenced mainly by the age and functional classes of cattle defined by marketers as well as season, market, and origin of the cattle.

Stated Preference Analysis

Cow Trait Preferences

Choosing a profile in the choice sets, as opposed to opting out, was found to be highly preferred as indicated by the significant constant term (Table 3). Fertility, disease resistance, calf vigor and milk yield were found to be highly significant ($P << 0.001$) in influencing the choice of a cow. Body size, price and some locations were found to be statistically insignificant. The signs of all the taste parameters are as expected, except that of medium body size. The model in general is highly statistically significant ($P << 0.001$) at 29 degrees of freedom (Table 3).

The magnitude of the parameter estimates show that fertility – or short calving interval – is much more important than all other attributes considered by cattle buyers. Disease resistance was also found to be more important than calf vigor, milk yield and the origin of the cow. Vigor of the calf was also identified to be very important in influencing cow choice. These findings conform to the basic objectives of rural life in this part of Ethiopia in general and with the specific purposes for which animals are kept.

The primary goal of majority of the households in this part of rural Ethiopia is producing sufficient food for the annual demand of the family. Secondly, households aim at supplying part of their produces to generate cash to pay for other costs of life including food, as food shortage is not uncommon. The main contribution of livestock in achieving these objectives is through traction power generated from bulls and through selling of live animals. Shorter calving interval implies more animals to sell and higher possibility of getting male calves to replace the aging bulls. Disease resistance is so important not only because it assures the herd stays productive but also saves the scarce cash resources of the rural people. A vigorous calf is described in the area as one that is fast growing, healthy and strong. The high value assigned to larger herd and the medication cost implications show the importance of calf vigour. The importance of these traits is comparable to the corresponding findings of the studies which analyzed preferences for cow traits (Tano *et al.*, 2003; Ouma *et al.,* 2007; Zander, 2006) with apparent differences in the relative weights of the attributes.

Table 3: Random Parameters logit model parameter estimates for cows

Variable	Structural Parameters		SD of the parameter distributions	
	Coefficient	St. Error	Coefficient	St. Error
Random parameters				
Medium body size	-0.42	0.30	0.21	1.62
Big body size	0.28	0.47	0.07	3.34
Fertility	1.80*	0.61	1.06‡	0.60
Milk yield	1.00*	0.33	0.60	0.37
Calf vigour	1.05*	0.29	0.11	1.88
Disease resistance	1.59*	0.51	1.45*	0.54
Medium price	-0.20	0.29	0.98	0.99
High price	-0.13	0.32	0.79	0.77
Non-random parameters				
Nearby districts	0.55‡	0.30		
Wellega zone	-0.47	0.32		
Keffa Zone	-0.27	0.29		
Constant	-2.98*	0.65		
Heterogeneity in mean parameters				
Big body*education	0.17‡	0.1		
Fertility* farmer trader	-0.29‡	0.16		
Fertility*family size	-0.09†	0.04		
Milk*trader	-0.51†	0.24		
Disease res.*farmer trader	-0.81†	0.35		
Disease res.*other occupant.	1.00‡	0.58		
High price*trader	-1.00‡	0.56		
High pr.*farmer trader	-0.31	0.30		
High Pr.*other occupant.	1.25‡	0.66		
N = 1170	LL = - 630.47		Pseudo R2 = 0.51	
$\chi 2$ (df=29)= 1309.80	LL* = -1285.4		Adj. R2 = 0.50	

, †, and ‡ significant at alpha is equal to 0.01, 0.05, and 0.1. N is number of observations, LL is value of log-likelihood function, LL is value of the restricted (no coefficient) log likelihood function and χ^2 is chi-squared.

Milk yield is also a highly significant attribute of cows. However, the relative weight assigned to milk potential of cows is lower than those for other traits. In Dano and the neighbouring districts, milk is only produced for household consumption and selling milk is a social taboo that people would rather give it free. Some households milk their cows every other day as they do not have the storing facilities, or can not sell it. This result differs from the high importance attached to milk yield by the latent class of crop-livestock farmers in Kenya (Ouma *et al.*, 2007). Given the fact that all the livestock development efforts have focused on dairy cows, the relative weight of milk trait shows the considerable disparity between the government's livestock development agenda and rural livelihood objectives.

The area the cows are brought from is another important attribute cattle buyers consider. The concept of breed does not have any recognition within the cattle keeping population in the area or among cattle buyers in the markets. People ask for the origin of the cow to judge its adaptability, in addition to examining some phenotypic characteristics which show considerable difference across locations. The regression results show that cows from the closely neighbouring districts are preferred to that of the district. Although it does not seem that there is so much difference among the cattle populations within and around the district, farmers must have some reasons in the details of the characteristics of the cows. Taste coefficients of Wellega and Keffa zones were found to be negative and statistically insignificant. The negative sign implies that cows from these areas, which are very far, are less preferred.

Identification of traits (including price) and trait levels was completed four months before the CE survey. In the following four months, the inflation that has been rampant in Ethiopia since May 2005 made the prices of the CE quite low. The respondents apparently considered the price levels small for most of the profiles presented. The three price levels were entered as categorical variables like all other traits with low price (500.00 Birr) fixed as reference level. The coefficients of the two price levels are statistically insignificant showing that the price levels used in the CE did not significantly influence the choices of alternatives.

Bull trait preferences

Body size was found to be a not so important trait in influencing bull type choices in these rural markets (Table 4). Negative sign of the medium body size level was, however, unexpected and this might potentially be due to the lack of distinct level description in the survey or the levels were too close to differentiate from respondents' perspective. The mixed crop-livestock production system depends very much on the traction power of bulls for all the activities from first ploughing to threshing. Only bulls are used for ploughing in this area, making traction power a crucial characteristic of a bull. That is essentially what the model results reflect (Table 4). Ploughing suitability has the largest taste coefficient with the expected positive sign and high statistical significance, indicating that good ploughing potential is a trait that respondents consider when purchasing bulls.

The rural community has multiple objectives in buying and keeping cattle in such a production system. The bulls are bought and kept at least for two purposes - traction and reproduction. The reproductive contribution of bulls is very important as there are no communal or village owned bulls selected for this purpose. In particular, farmers normally do not take within-the-herd mating for granted and focus on traction suitability only. They usually inquire about the reproductive characteristics of the bull, which is proxied here with the calf strength. The attribute's coefficient is highly significant. The more vigorous the offspring of a bull is, the higher the probability that it will be chosen and the higher the utility derived. Disease resistance was also found to be positive and statistically significant, indicating preferences for healthy or disease tolerant animals. With limited resources to employ on medication and hygienic costs for their animals, rural livestock keepers are expected to be very interested in healthy animals.

Table 4. Random Parameters logit model parameter estimates for bulls

	Structural Parameters		SD of the parameter distributions	
Variables	Coefficient	St. Error	Coefficient	St. Error
Random parameters				
Medium Size	-0.254†	0.108	0.005	0.300
Big Size	0.836*	0.192	0.655	0.480
Plowing	1.994*	0.218	1.357*	0.255
Calf strength	0.752*	0.084	0.006	0.300
Illness freq.	0.821*	0.124	0.003	0.307
Price 1 (1000.00 birr)	0.237	0.183	0.003	0.245
Price 2 (1200.00 birr)	-0.267‡	0.170	0.014	0.444
Non-random parameters				
Constant	-2.476*	0.226		
Nearby districts	-0.417‡	0.240		
Wellega zone	0.223	0.130		
Keffa zone	-0.634*	0.193		
N= 1188 LL = -792.9	LL base = -1305.15 Ps. R2 = 0.392		χ2= 1024.4, df=18	

*, †, and ‡ significant at alpha is equal to 0.01, 0.05, and 0.1. N is number of observations, LL is value of log-likelihood function, and χ^2 is chi-squared.

The RPL estimation resulted in negative and statistically significant coefficients for nearby districts and Keffa zone. The negative signs of the coefficients indicate that bulls from both origins are less preferred to those from Dano and will result in less probability of choice for a bull. The differences in absolute magnitudes of the structural parameters of the location variables show that the probability of not selecting an animal will be higher if the origin is Keffa than neighbouring districts. This is an exact reflection of the preferences of farmers in Dano, as cattle from Keffa region are considered trypanosomosis infected and less adaptable within the Dano district. This again implies that most of the buyers give high value to the fact that they know the pedigree of the cattle they buy which could only be possible if the animals were raised in their proximity. Given the lack of information and the uncertainties under which farmers make decisions, it is obvious that cattle buyers in this semi-subsistent farming system would prefer cattle from their districts.

The results also show that both medium (birr 1000.00) and high (birr 1200.00) levels of price have no significantly different influence on choice as compared to small price. These results appear realistic, given that the price levels used during the choice experiment were already low (in four months time - due to the lingering inflation) and the low and medium levels of prices were nearly indifferent for the respondents. Even the high level of price was considered quite acceptable for almost all the hypothetical profiles presented in the choice sets.

Willingness to Pay (WEIGHTP) Values for Bull Attributes

The marginal rate of substitution between the traits and the monetary coefficient provides estimates of the implicit prices for the traits. These implicit prices are also referred to as willingness to pay (WEIGHTP) or willingness to accept. The price volatility prevalent in the study area makes the absolute magnitude of the willingness to pay (WEIGHTP) values less important. In order to assess prioritization of traits by the buyers, only the relative magnitudes of the WEIGHTP weights should be used. The willingness to pay values computed for each attribute (**γ**) at the highest price (**p**) level show that changing the traction potential level from poor to good is valued 2.65, 2.42, and 2.39 times more than a comparable change in offspring vigour, disease resistance and big body size, respectively (Table 5).

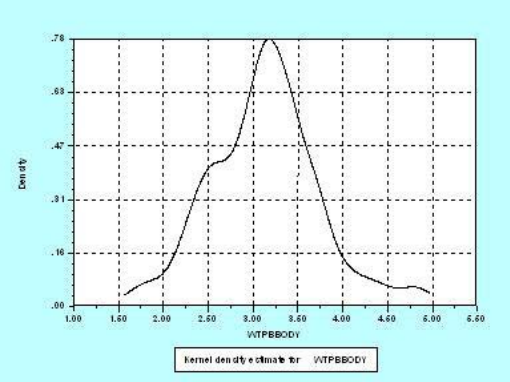
Table 5: Willingness to pay for bull traits computed at the highest price level

Trait	WEIGHTPγ =E(-ß γ/ßp)	SD = E(-δγ/ßp)	Min.	Max.
Medium Body	-0.954	0.018	-0.956	-0.951
Big body	3.134	2.382	1.698	4.842
Plowing potential	7.476	4.550	-1.624	11.286
Calf strength	2.819	0.021	2.811	2.824
Illness freq.	3.078	0.013	3.070	3.084

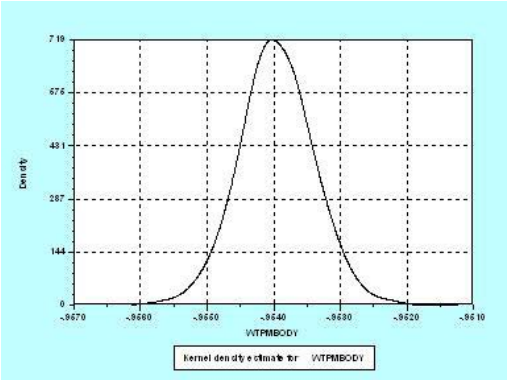
Kernel density estimators were plotted to examine the distribution of the WEIGHTP for the individual traits. These distributions are presented in figure 2 a-e. The distributions of WEIGHTP values for traits of bulls show that, with the notable exception of the change from small to medium body size, cattle buyers generally have positive willingness to pay for improvement in each of the traits. The distributions are generally normally distributed with slightly negative skewness (-0.808) for the WEIGHTP values distribution for traction suitability and slightly positive skewness (0.342) for big body size.

The WEIGHTP distributions for big body size and traction potential indicate heterogeneity in preferences of the taste parameters for these traits. The differences in taste for the change from small to big body size are essentially due to the fact that meat is not the primary objective of the majority of the buyers, although there are some who buy bulls for immediate consumption. The preferences for the traction potential attribute are also heterogeneous as there are still some marketers who are not so much interested in the traction potential, although most of the respondents

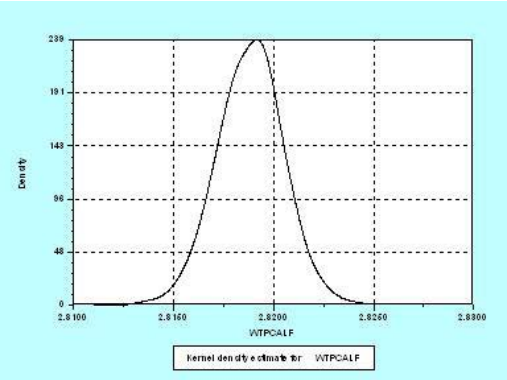
are expected to be otherwise. Notably, the WEIGHTP distributions of all, but medium body size level, traits and trait levels lie in the positive quadrant as expected.



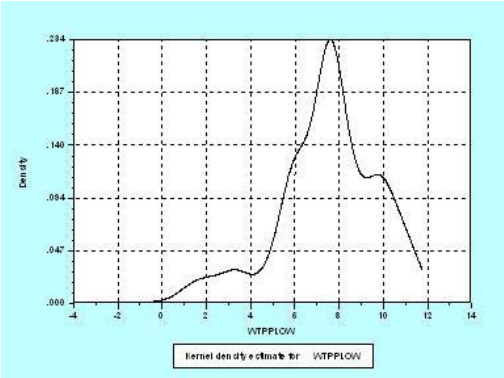
a. Big body size



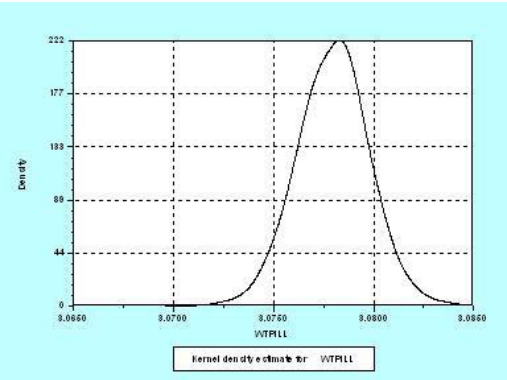
d. Medium body size



b. Calf vigour



e. Ploughing strength



c. Illness frequency

Figure 2 a-e: Kernel distribution of the willingness to pay for important bull traits.

Conclusion and Recommendation

This study used both revealed and stated preference approaches to determine the values attached to the different features of indigenous cattle in central Ethiopia. For the revealed preference analysis a hedonic model was employed to examine the determinants of cattle prices in the primary rural markets of central Ethiopia. Transaction level data of cattle farmers and farmer-traders were used in the analyses. Data collected in rural markets to identify cattle price determinants result in estimates with standard errors that are mostly heteroscedastic. We employ SHM estimations to account for heteroscedastic errors. Based on Akaike, Bayesian and log-likelihood criteria of model selection, we found that the modified SHM formulation is very appropriate for examining price functions in such rural markets.

The empirical estimation showed that market place, seasonal differences, sex and function based classification of cattle, body size, and age were very important factors influencing the market prices cattle sellers receive. The significance of the characteristics of animals in influencing prices paid for the animals reveals the importance of the preferences for traits in the decision-making process related to buying and selling of cattle. These preferences at the farmers and farmer-traders levels are the ones that matter most in shaping up the diversity of animals kept at farm level. This diversity of the cattle genetic resources is essential for generating or identifying best suited breeds of cattle in the context of the livelihood objectives of the target community. Thus, the cattle breeding strategies and activities should duly consider the preferences expressed through the prices paid for animals in such markets, where the cattle keepers are the main sellers and buyers.

For the stated preference analysis the study employed choice experiments and random parameters logit to elicit and analyze cattle trait preferences of buyers in the semi-subsistence livelihood systems of rural central Ethiopia. The results of the cows CE revealed that in areas where livestock serve multitude of purposes and where the production and marketing system is semi-subsistence, cows have other functions more important than milk production. Fertility, disease resistance and strength of the calves they bear are as much or more important than milk. The breed concept which is very much associated in Ethiopia with the area where the animal is brought from (Workneh and Rowlands 2004), was found to be less important as such and it appears that farmers are interested in obtaining animals from the district or locations in which they live in. This is essentially because cattle buyers, who are mostly farmers, are more concerned about adaptability and therefore give high value to the fact that they know the pedigree of the cattle they buy.

The results of the CE for bulls indicate that cattle buyers assign high values for good traction potential, disease resistance, calf vigour, and for places of origin when choosing bulls in the market. The preferences cattle buyers have for these attributes do vary essentially due to differences in occupation, education and age. The primary objective of the rural community to produce sufficient food for the family for each year was manifested through the value assigned to traction potential which is more than twice that of disease resistance. These results are consistent with the basic reasons why animals are kept in the area, but appear to be incoherent with the government funded interventions of livestock development. An observation which needs to be emphasized is the consistency of the preferences of the cattle buyers in such a system characterized by lack of information in every aspect. Given the importance of livestock, bulls in particular, for the livelihoods of the communities in rural Ethiopia, such consistent valuation of the traits show that the objectives of the agrarian life are quite clear among the community – farmers, farmer traders, traders, and others – that production and marketing decisions are made on broader considerations than just milk and meat production.

The government of Ethiopia needs to revise the structure of the livestock improvement programs still running and needs to make note of the important details that influence the production, marketing and utilization of livestock products. The smallholder community in this part of Ethiopia

depends on semi subsistence agriculture and so livestock development interventions should focus on reproductive and adaptive traits that stabilize the herd structure, rather than focusing on traits that are only important for commercial purposes. It can also be observed that improving these traits of cows owned by small holder farmers in the area will facilitate adoption of the new innovations or improvements instead of bringing over cattle from unknown sources and obviously with low adaptability.

References

Andargachew, K., Brokken, R.F., 1993. Intra-Annual Sheep Price Patterns and Factors Underlying Price Variations in the Central Highlands of Ethiopia. Agricultural Economics 8, 125 – 138.

Anderson, S. 'Animal genetic resources and sustainable development', *Ecological Economics*, Vol. 45 (2003) pp. 331 – 339.

Anglin, P. M., Gencay, R., 1996. Semi-parametric Estimation of a Hedonic Price Function. Journal of Applied Econometrics 11, 633-648.

Barret, C., Mutambatsere, E., 2007. Agricultural Markets in Developing Countries. Entry in S. N. Durlauf and L. E. Blume, (Editors), The New Palgrave Dictionary of Economics, 2nd Edition, Palgrave McMillan , London.

Barret, C. B., Chabari, F., Bailey, D., Little, P., Coppock, D., 2003. Livestock Pricing in the Northern Kenyan Rangelands. Journal of African Economies 12 (2), 127 – 155.

Birol, E., Smale, M., and Gyovai, A. 'Using Choice Experiment to estimate farmers' valuation of agrobiodiversity on Hungarian small farms', *Environmental and Resource Economics*, Vol. 34 (2006) pp. 439-469.

Cameron, A. C. and Trivedi, P. K. *Microeconometrics: Methods and Applications* (Cambridge University Press, 2005).

Campbell, D. 'Willingness to pay for Rural Landscape Improvements: Combining Mixed Logit and random Effects Model', *Journal of Agricultural Economics*, Vol. 58, (2007) pp. 467-483.

Cropper, M. L., Deck, L. B., McConnel, K. E., 1988. On the Choice of Functional Form for Hedonic Price Functions. The Review of Economics and Statistics 70 (4), 668 – 675.

Drucker, A. G., Gomez, V. and Anderson, S. 'The Economic Valuation of Farm Animal Genetic Resources: A Survey of Available Methods', *Ecological Economics*, Vol. 36 (2001) pp. 1-18.

Fafchamps , M., Gavian, S., 1997. The Determinants of Livestock Prices in Niger. Journal of African Economies 6 (2), 255-295.

Haab, T.C., McConnel, K. E., 2002. Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation. Edward Elgar, Cheltenham, UK, Northampton, MA, USA.

Hensher, D., J. Rose, and W.A. Greene. *Applied Choice Analysis: A Primer*. (Cambridge University Press, 2005)

Huber, J. and Zwerina, K. 'The Importance of utility Balance and Efficient Choice Designs', *Journal of Marketing Research*, 33 (August), (1996) pp. 307-317.

Jabbar, M. A., 1998. Buyer Preferences for Sheep and Goats in Southern Nigeria: A Hedonic Price Analysis. Agricultural Economics 18 (1), 21 -30.

Jabbar, M. A., Diedhiou, M. L., 2003. Does Breed Matter to Cattle Farmers and Buyers? Evidence from West Africa? Ecological Economics 45, 461 – 472.

Kuhfeld W.F. *Efficient Experimental Designs using Computerized Searches* (Saweightooth Software Research Paper Series. SAS Institute, Inc., 1997).

Kuhfeld, F. Warren. *Marketing Research Methods in SAS: Experimental Design, Choice, Conjoint, and Graphical Techniques* (SAS Institute Inc., Cary, NC, USA, 2005 http://support.sas.com/techsup/technote/ts722.pdf)

Lancaster, K., 1966. A New Approach to Consumer Theory. Journal of Political Economy 74, 132-57.

Little, P., Smith, K., Cellarius, B., Coppock, D., Barrett, C., 2001. Avoiding Disaster: Diversification and Risk Management among East African Herders. Development and Change 32 (3), 401 – 433.

Long, J. S., Ervin, L. H., 2000. Using Heteroscedasticity Consistent Standard Errors in the Linear Regression Model. The American Statistician 54, 217 – 224.

McFadden, D. 'Conditional Logit Analysis of Qualitative Choice Behavior', in Zarembka, P. (ed.) *Frontiers in Econometrics* (Academic Press, New York, 1974).

Mtimet, N. and Albisu, L. M. 'Spanish Wine Consumer Behavior: A Choice Experiment Approach', *Agribusiness*, Vol. 22 (3), (2006) pp. 343–362.

Oczkowski, E., 1994. A Hedonic Price Function for Australian Premium Table Wine. Australian Journal of Agricultural Economics 38, 93 – 110.

Ouma, E., Abdulai, A., Drucker, A., 2007. Measuring Heterogeneous Preferences for Cattle Traits amongst Cattle Keeping Households in East Africa. *American Journal of Agricultural Economics* 89(4), 1005-1019.

Parmeter, C.F., Henderson, D.J., Kumbhakar, S. C., 2007. Nonparametric Estimation of a Hedonic Price Function. Journal of Applied Econometrics 22, 695 – 699.

Rigby, D. and Burton, M. 'Preference heterogeneity and GM food in the UK', *European Review of Agricultural Economics*, Vol. 32 (2005) pp. 269-288.

Roessler, R., Drucker, A. G., Scarpa, R., Markemann, A., *et al.* , 'Using choice experiments to assess smallholder farmers' preferences for pig breeding traits in different production systems in North-West Vietnam', *Ecological Economics* (2007), doi:10.1016/j.ecolecon.2007.08.023

Rolfe, J., Bennet, J., and Louviere, J. 'Choice modelling and its potential application to tropical rainforest preservation', *Ecological Economics*, Vol. 35 (2), (2000) pp. 289-302.

Roosen, J., Fadlaoui, A. and Bertaglia, M. 'Economic Evaluation for Conservation of farm animal genetic resources', *Journal of Animal Breeding and Genetics*, Vol. 122 (2005) pp. 217-228.

Rosen, S., 1974. Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. Journal of Political Economy 82 (1), 34 -35.

Ruto, E., Garrod, G. and Scarpa, R. 'Valuing animal genetic resources: a choice modeling application to indigenous cattle in Kenya' *Agricultural Economics* 38(1), (2008) pp. 89-98.

Scarpa, R., A. Drucker, S. Anderson, N. Ferraes-Ehuan, V. Gomez, C. Risoparion, and O. Rubio-Leonel. 'Valuing Animal Genetic Resources in Peasant Economies: The Case of the Box Keken Creole Pig in Yacutan', *Ecological Economics*, Vol. 45 (2003a) pp. 427-443.

Scarpa, R., P. Kristjanson, E. Ruto, M. Radeny, A. Drucker, and J.E.O. Rege. 'Valuing Indigenous Farm Animal Genetic Resources in Kenya: A Comparison of Stated and Revealed Preference Estimates', *Ecological Economics*, Vol. 45 (2003b) pp. 409-426.

Sy, H. A., Farminow, M.D., Johnson, G.V. and Crow, G. 'Estimating the Values of Cattle Characteristics Using an Ordered *Probit* Model', *American Journal of Agricultural Economics*, Vol. 79 (1997) pp. 463-476.

Tano K., M.D. Faminow, M. Kamuanga, and B. Swallow. 'Using Conjoint Analysis to Estimate Farmers' Preferences for Cattle Traits in West Africa' *Ecological Economics,* Vol. 45, (2003) pp. 393 –408.

Train, K. *Discrete Choice Methods with Simulation* (Cambridge University Press. Cambridge, 2003).

Verbeek, M., 2004. A Guide to Modern Econometrics. Second Edition. John Wiley and Sons Ltd, The Atrium, Southern Gate, Chichester, England.

Windle, J. and Rolfe, J. 'Diversification choices in agriculture: a Choice Modeling case study of sugarcane growers', *The Australian Journal of Agricultural and Resource Economics* 49(1), (2005) pp. 63-74.

Workneh Ayalew and Rowlands J. (eds). *Design, Execution and Analysis of the Livestock Breed Survey in Oromiya Regional State, Ethiopia* (Oromia Agricultural Development Bureau, Addis Ababa Ethiopia and ILRI, Nairobi, Kenya, 2004).

Zander, K.K. *Modelling the Value of Farm Animal Genetic Resources – Facilitating Priority Setting for the Conservation of Cattle in East Africa* (PhD Dissertation; University of Bonn, 2006).

Observations on the Limnology and fishery of G/gibe reservoir

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Abstract

Basic features of the physical and biological limnology of Gilgel Gibe reservoir (altitude about 1640 m a.s.l) with the abundance of the fishery were studied from December 2004 - March2006 The main objective was to generate baseline limnological and fishery information important for future research and development activities. It appears to be similar to natural lakes in the region. Water quality was generally good and water clarity during the study was low (mean SD 7.89cm). The water turbidity is due to suspended sediment inputs associated with river inflows. Surface chlorophyll is low about 70µgl^{-1}. The water is neutral (pH 7.65) and is apparently calcium-dominated. In terms of biological limnology phytoplankton was dominated by 'competitive' green algae and'Stress-tolerant' cynophytes were also the second abundant. Diatoms and other disturbance-tolerant algae were present. Zooplankton was dominated by copepod, Cladoceran Daphnia barbata and D. longispina and Rotifer such as Brachionus quaridentatus. The fish community was dominated by Tilapia (Oreochromis niloticus L.) and Labeo barbus. Recommended optimum mesh size for Gilgel Gibe fishery is 10cm gillnet and calls for careful monitoring and management of the system.

Key words: physical limnology, biological limnology, fish, Gilgel Gibe, gillnet

Introduction

Considerable information exists on the limnology of the natural lakes of Ethiopia but little is known about the country's reservoirs. Since hydroelectric power plays an increasingly important part in the economy of Ethiopia, this lack of information could pose problem for water and fishery management because reservoirs differ from natural lakes in a number of ways (Baxter, 1985).

The art of controlling water by the construction of dams is one of the oldest branches of civil engineering, dating back to the third or even the fourth millenium B.C. (Biswas, 1975; Henderson-Sellers, 1979). It probably originated independently in several regions such as China, India, Mesopotamia and Egypt, and attained a level of development under the Roman Empire that was not reached again for several centuries.

An important purpose of the reservoirs in Ethiopia is for generation of energy (hydroelectric power) besides which it does well for fishery activities. Present trends in the use of natural lake waters for fisheries indicate that the production to be anticipated from such systems is limited for two reasons. Firstly, declining quality of the aquatic environment resulting from eutrophication, pollution and habitat modification which have led to increasing incapability on the part of native fish assemblages to adapt and maintain their form, diversity and biomass. Secondly, poor fisheries management has resulted in inability on the part of many fish species to compensate through natural reproduction for excessive or inappropriate fishing pressure. As a result of these two stresses catch from inland water fisheries based on naturally reproducing fish populations is declining world wide. Although many developing countries need to increase fish production from inland water bodies in order to alleviate the problems of malnutrition and poverty.

A variety of natural and man-made water bodies are often described as small water bodies, although a precise and universally acceptable definition is yet to be made. Anderson (1987) included the following water bodies under small water bodies: small reservoirs and lakes less than 10 km^2

in area; small ponds, canals including irrigation canals; seasonal inland floodplains and swamps; and, small rivers and streams less than 100 km in length. At the present time, there is a growing realization that the enhancement of fisheries in small inland water bodies can emerge as a possible solution to resolve the conflicts by combining environmental concerns with the growing aquaculture ventures. In the context of relatively environment-friendly fisheries development of traditional and enhanced fisheries, the small water bodies assume some significance.

Small water bodies should attract the attention of both researchers and developmental agencies as these water bodies can play a vital role in nutrition and food. Despite the overwhelming importance of the small water bodies in the fisheries development, exploitation of this resource should remain essentially organized resulting in adequate documentation of the fish yield, catch composition and fishing effort security (FAO, 1997).

The main purposes of this survey were

- To analyze the water quality of the reservoir
- To asses the fishery of reservoir
- To generate baseline information for further research and development works

Gilgel Gibe (little Gibe) river

The river Gilgel Gibe flows through Jimma Zone Administration, from south-west to north-East direction. It is a major tributary of the Great Gibe River also known as the Omo River further downstream and is extremely variable in course and gradient. A previous study made on (Gilgel Gibe Hydroelectric project, Environmental Impact Assessment, November 1997) the stretch of the Gilgel Gibe River in the project area indicated that the river is shallow, slow moving and for the most part fairly turbid and with poorly oxygenated waters. Its banks are occupied with hydrophilic and aquatic vegetation. The river bottom is generally muddy with the occasional rock wing above the surface. The macro-benthic population consists mainly of oligochates, but the abundance of Ephemeroptera and Trichoptera (caddis flies) indicates high water quality from a biological point of view.

The reservoir

The dam is built on by damming the Gilgel Gibe river in 19 . The reservoir is located in Jimma Zone of oromia regional state, about 260 km South-West of Addis Ababa and about 70km North-East of Jimma (7°50'N, 37° 20'E) at an altitude of 1640 m a.s.l. (Gilgel Gibe Hydroelectric project, Environmental Impact Assessment, November 1997). The reservoir area at the maximum normal level is about 51km^2. Maximum normal water level (FSL) is 1671 m.a.s.l. whereas minimum normal water level (DSL) is 1653 m.a.s.l. The catchment area is 4,225km^2; annual average flow is 50.4m^3/sec. the maximum depth is 35m, min depth of 2m and average depth 20m (Ethiopian Electric Power Corporation, February 2004).

The area is a fairly flat plateau, about 1,650 m.a.s.l., and consists of a series of gentle sloping low hills and broad plains surrounded by hills or mountains. In the project area, the average annual air temperature is 19.2°C. The annual rainfall of the Gilgel Gibe catchments varies from the minimum of 1300mm near the confluence with the Great Gibe River to a maximum of about 1800mm in the Utubo and Fego mountains. Rain fall decreases throughout the catchments with a decrease in elevation (Gilgel Gibe Hydroelectric project, Environmental Impact Assessment, November 1997).

The change from a river environment to a lake environment affects fish population, its composition and dynamics. The reservoir is providing an enriched food supply in the form of submerged

plant life which will nourish the invertebrate food chain for several years. This will likely increase biological productivity and overall fish yield.

Materials and Methods

Limnology

The study was undertaken from December 2004 – March 2006 where sampling was done regularly from three stations at three months interval. The limnology of the water was assessed by using different techniques. The transparency was estimated by using a Secci disc. The Secci depth (**Z_{SD}**) values were also used to approximate euphotic depth (**Zeu**) using the relationship, (i.e. **Zeu = 3 x Z_{SD}).**The chemical nature of the reservoir water was also determined by National Soil Research Center laboratory.

Phytoplankton samples were obtained at each station from a depth 0.5 meters by using a Van Dorn water sampler, (Approximately 20 micrometers) and preserved with Lugol's and formaldehyde solution (1.5%). The preserved samples were used for taxonomic analysis of phytoplankton. Zooplankton samples were taken with vertical net hauls at each station from near the bottom to the surface. Enough samples of zooplankton was collected with a net mesh size of 67 micrometer and diameter of 31cm and preserved in 5% formalin. The preserved samples were taken to the laboratory for zooplankton identification and abundance analysis. For the abundance estimation sub sample was poured in to a gridded Petri dish and counted under stereoscope microscope.

Measuring Chlorophyll "a" concentration

Chlorophyll ***a*** was measured with spectrophotometer using Chlorophyll concentration, and the algal composition abundance was determined from the reservoir water. Samples for chlorophyll were filtered on site (Whatmans GF/C filters). Measuring chlorophyll "a" concentration involved three important stages filtration, extraction and measuring absorbance at 665 and 750 nm.

Calculation of chlorophyll "a" (µg/l) was made according to Talling & Driver (1963).

$$Chl\ a\ (\mu g/l) = (13.9\ (E665 - E750) \times Ve) / Vsf \times PL$$

Where E665 and E750 are extinction at 665 and 750, respectively

Ve = Volume extract in ml
Vsf = Volume sample filtered in liters
PL = Path length of the cuvette (1cm)

Fishery

Fish samples were collected the same time with water sample using a fleet of experimental gill-nets (60mm to 120mm). The nets were set at three sites (Open water, southern shore and northern shore) over night. Captured fish were identified to species level; total length and weight of fishes were measured for each specimen. Fish were dissected to determine the sex and maturity stages. A generalized classification of stages in fishes by Nikolsky (1963) was adopted where Gonad stage I= Immature; Stage II= resting; Stage III= mature; StageIV= ripe

Result and Discussion

The water quality analysis in Table -1 gives concentration (meq/l) of major cations and anions in the reservoir. As with most lakes and rivers in the temperate region (Tudorancea *et al.*,1999) the decreasing order of the amounts of major cations in this reservoir is Ca>Mg>Na>K. The dominant cation is calcium which is usual for inland waters and other reservoirs like Koka and Finchaa (Melaku *et al.*, 1988). pH is the most important water quality parameter from the fishery point

of view, and it is 7.65 which is more neutral than for other rift valley lakes (Wood and Talling, 1988) and almost similar with high mountain lakes (Garba Guratch and Zuquala (Loffler, 1978; Baxter and Golobitsh, 1981; Wood, 1971). The electrical conductivity is very low (94µS/cm) and it is related with high dilution and productivity of the reservoir, it looks the most dilute reservoir next to Fincha which is one of the most dilute ever reported from Ethiopia (Melaku *et al.*,1988). In accordance with the classification of lakes based on conductivity (Beadle, 1981) this reservoir is fresh water as most of the Ethiopian Rift Valley lakes (K_{20} = 40-6000µScm^{-1}) (Tudorancea *et al*, 1999).The chlorophyll value for Gilgel Gibe reservoir is about 70µgl^{-1}. Transparency, as measured by Secci disc, showed average value of 7.98cm, which indicates high turbidity. This is an indication of either high productivity (lots of plankton in the water) or of a high level of suspended inorganic materials such as silt, clay or colloids (Table-2). Turbidity was not consistently or obviously mineral in character, although the reduction in water transparency accompanied rising water levels and was attributable to suspended sediment inputs associated with river inflows following summer rains. This Secci disc depth value also indicating 10% of the light intensity at the surface and the depth in which photosynthesis occurs (Euphotic zone) is 23.92cm.

Table 1. Major water quality variables and dissolved constituent

Determinant	Mean value
	7.
PH	7.65
Electrical Conductivity µS/cm	94
Ca++ Meq/l	0.4475
Mg++ Meq/l	0.2455
K+ Meq/l	0.0765
Na+ Meq/l	0.2375
Total cations	1.007
Cl- Meq/l	0.1835
SO42- Meq/l	0.176
CO3 Meq/l	trace
HCO3- Meq/l	0.724
Total anions	1.0835
B mg/l	0.098
TDS mgm/l	140
NO3 me/l	0.0395
PO4-P ppm	0.101
Fe ppm	7.36
Mn ppm	0.06
Zn ppm	0.34
Cu ppm	0.04
Chlorophyll a µgl-1	71.168

The evolution of average dissolved oxygen as a function of depth during sampling days is shown in Fig -1. The surface light intensity is too high for optimal photosynthesis by the phytoplankton species present which makes the highest dissolved oxygen concentration in the euphotic zone.

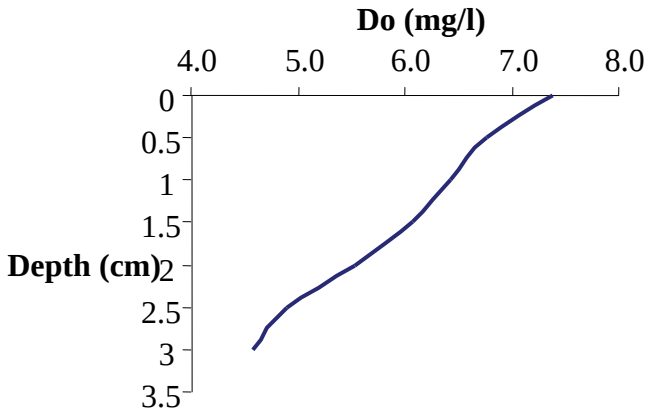

Fig-1 Dissolved oxygen in function of depth

Biological limnology

In Gilgel Gibe reservoir three groups of phytoplanktion have been identified. Nearly half were green algae (chlorophyta), and blue green algae (Cyanophyta) were the next most important group in which microcystis is the dominant one. Bacillariophyta and Cyanophyta are also important phytoplankton identified (Table 3). Determination of phytoplankton biomass as chlorophyll ***a*** concentration gave a value of 71.168μgl^{-1}, which is much higher than the previous report of (>40μgl^{-1}) (Wood and Talling, 1988) and is directly related to the productivity of the reservoir. The zooplankton of reservoirs may show certain differences from that of natural lakes. The number of rotifers is often high relative to crustaceans in new reservoirs (Potter & Meyer, 1982; Pinel-Alloul *et al.*, 1982) and rotifers highly prolific (r-selected) (Potter & Meyer**,** 1982) and thus well adapted to colonize new ecosystems. They are probably also favored by the growth of bacteria on which they may feed, in the course of the decomposition of flooded vegetation (Pinel-Alloul *et al.*, 1982). Even mature reservoirs may show unusual features that are difficult to explain. Many Spanish reservoirs contain species of copepod which appears to be absent or rare in natural waters (Margalef, 1973). The zooplankton of a Central American reservoir was found to include substantial numbers of water mites (Gliwicz & Biesiadeka, 1975). Accordingly this study shows that Rotifers, Cladocera and Coepepoda are dominant Zooplankton groups in the reservoir. Chironomid larvae, insects, and Oligocheatea were benthic animals identified in the reservoir. Plant debris (dominant) was frequently observed (Table 4), which are very important as food source for fish or more commonly in the general functioning of the aquatic eco-system.

Fishery

The estimated sustainable yield of the Gilgel Gibe River is probably in the order of 40 to 60 kg/ ha/ year. Three fish species are found in Gilgel Gibe River: two (*Barbus intermedius* and *Tilapia nilotica*) are well adapted to a lake environment. The present stock examination showed that the dominant fish species is Tilapia (*Oreochromis niloticus L.*) comprising only 38% and the remainder 62% consist of *Labeo barbus.* One Gara was also caught throughout the whole experiment period.

The length-based catch curve (Fig 2) showed that the dominant size of Tilapia and Barbus were in the interval of 24-26cm and 33-35cm length, respectively which is good quality table size and ready to catch fish. The length-weight relationship of both species in the reservoir shows that the value of ***b*** is 2.69 and 2.53, for Tilapia and Barbus, respectively which implies that as most fish, both these fish species are experiencing allometric growth in which the parameter ***b*** is approximately 3, (Wootton, 1990), and are with good body conformation or length weight relation ship (Fig 3 and Fig 4). The gear selectivity graph (Fig 5) showed that 10 cm mesh size gillnet was the

most fit and recommended fishing gear because good frequency of both species with acceptable and good quality fish size (length) that was caught with this gear type. The 6cm mesh size gillnet has the highest frequency because it was the least mesh size where fish of all sizes were entangled in the net so that it is not the recommended type of mesh size.

Table-2 Result of Secci disk depth (ZSD) measurements (cm)

	Station 1	Station 2	Station 3	Station 4	Station 5	Average
ZSD (cm)	7.9	7.9	8.1	8	8	7.98
Zeu (cm)	23.6	23.6	24.4	24	24	23.92

Table-3 Phytoplankton genera recorded in the reservoir

Chlorophyceae	Bacillariophyceae	Cynophyceae	Euglenophyta
Cosmarium	Thallasosira	Microcystis	Egulena
Scenedesmus		Anabena	

Table-4 Zooplankton and benthic animals identified from Gilgel gibe reservoir

Zooplankton	Taxon
Rotifera	Brchionus quadridantatus
Cladocera	Diaphnia barbata Diaphnia longispina
Copepoda	Cyclopoid copepods
Benthic animals	
Chironomid larvae	
Insect	
Oligocheatea	
Plant debris (dominant)	

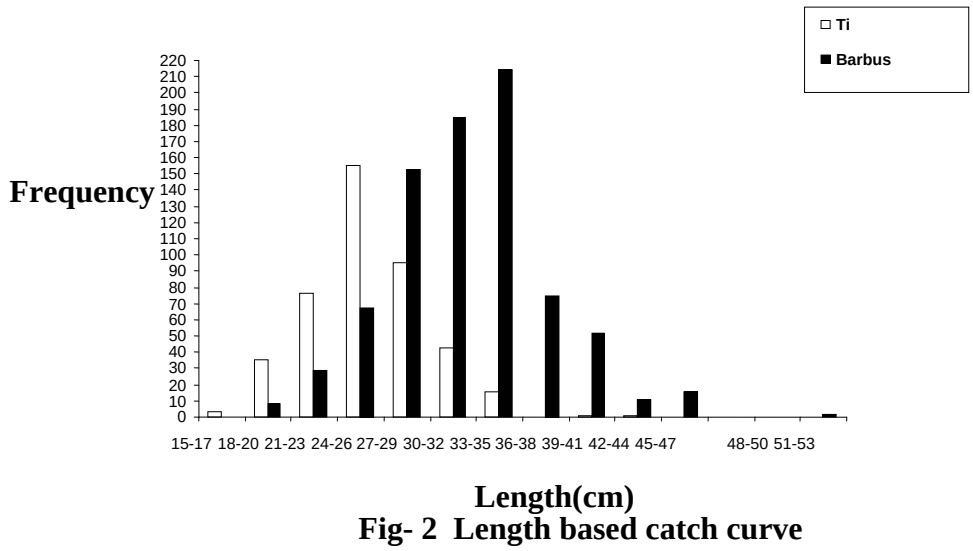

Fig- 2 Length based catch curve

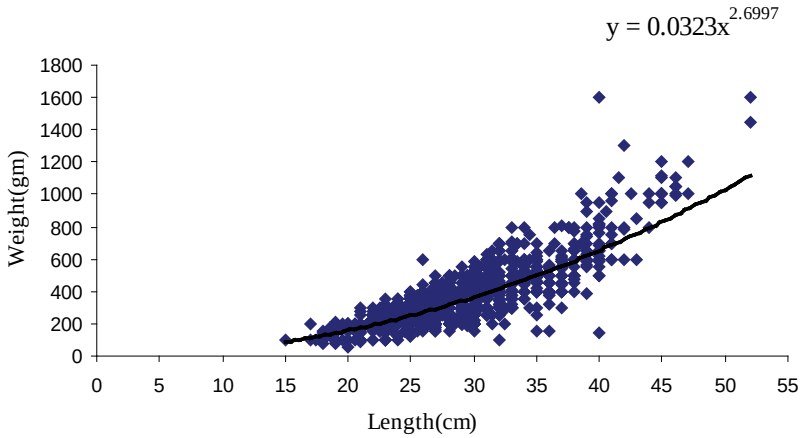

Fig- 3 Barbus length weight relationship

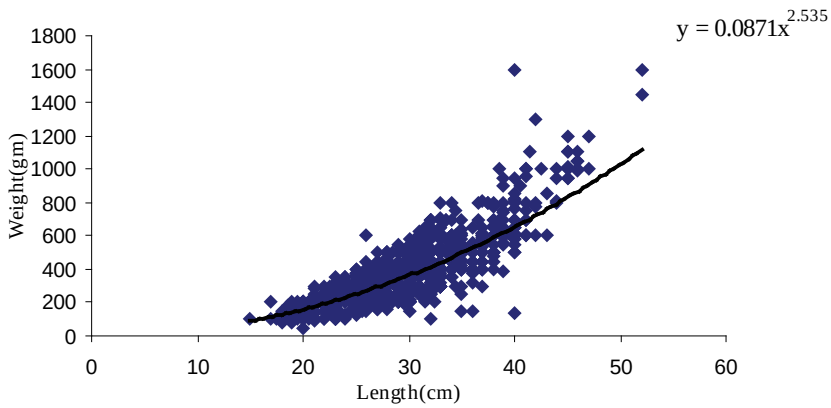

Fig-4 Tilapia length weight relationship

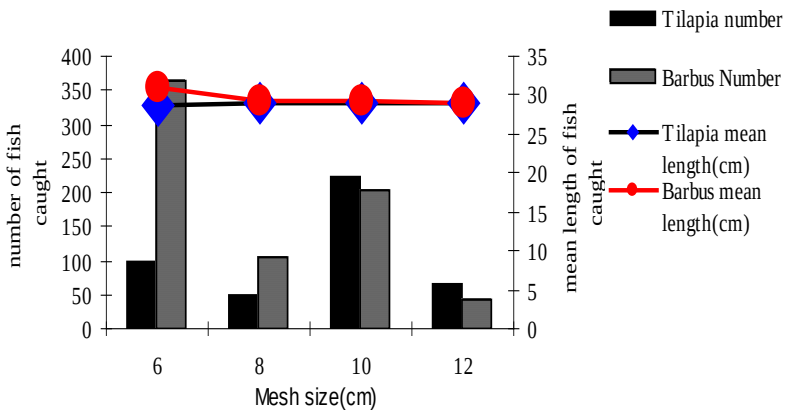

Fig-5 Gear selectivity

References

Baxter, R.M.,1985. Environmental effects of reservoirs. In D. Guunnison (ed.), Microbial processes in Reservoirs. Dr W. Junk Publishers, Dordrecht: 1-26.

Baxter, R.M.&D.L. Golobitsh, 1981. Observations on Garba Guratch, an Ethiopian mountain lake. SINET: *Ethiop.J. Sci*. 4:63 -68.

Beadle,.C.1981.The inland waters of Tropical Africa. 2nd Edition. Long man,London. 475pages.

Biswas, A.K.,1975. A short history of hydrology, p. 57-79. In Biswas, A.K.,(ed), Selected Works in Water Resources International Water Resources Association, Champaign, III.:382p.

Defaye,D.1988. Contribution a la connaissance des Crustaces Copepodes d'Ethiopie. *Hydrobiologia* 164:103-147.

FAO. Fisheries management of small water bodies in seven countries in Africa, Asia and Latin America.FAO Fisheries Circular No. 933 FIRI/C933, November 1997

Gilgel Gibe Hydroelectric project, Environmental Impact Assessment, November 1997).

Gliwicz, A.M & Biesiadka, E., 1975. Pelagic water mites (*Hydracarina*) and their effect on the plankton community in a neotropical manmade lake. *Arch. Hydrobiol*. 76:65-88.

Henderson-Sellers,B.,1979. Reservoirs. MacMillan Press Ltd.,London and Basingstocke, UK:128p.Pinel-Akkiyk, B.,Magnin, E.&Codin-Blumer, G.,1982. Efets de la mise en eau du re'servoir Desaulniers(Territoire de la baie de James)sur la zooplankton d'une rivie're et d'une tourbie're teticule'e. *Hydrobiologia* 86:271-296.

Loffer,H., 1978. Limnological and paleolimnological data on the Bale Mountain lakes(Ethiopia). Verh.int. Ver.Limnol. 20: 1131 – 1138.

Margalef, R.,1973. Plankton production and water quality in Spanish Reservoirs. First report on a research project. Paper prepared for XICongress, International Commission on Large Dams, Madrid.

Melaku Mesfin, Tudorancea C. and Baxter, R.M 1988. Some limnological observations on two Ethiopians hydroelectric reservoirs: Koka (Shewa Administrative District and Finchaa Welega Administrative District). *Hydrobiologia*. 157:45-57.

PotterPotter.D.U.&Meyer,LL.,1982. Zooplankton communities of a new pumped storage reservoir. Water Resources Bull. 18:635-642.

Talling, J.F& D. Driver, 1963. Some problems in the estimation of chlorophyll-a in phytoplankton. Proc. Conference on primary productivity measurements, marine and freshwater; held at University Hawaii, 1961, U.S. Atomic Energy Comm.,TID-7633:142-146.

Tudorancea C., Zinabu Gebre Mariam and Elias Dadebo.1999.Limnology in Ethiopia. Limnology in developing countries 2:63-118.

Wood,R.B., and Talling, J.F. 1988. Chemical and algal relationships in a salinity series of Ethiopian inland waters. *Hydrobiologia* 158:29-67.

On farm demonstration and popularization of backyard oxen fattening technologies in Dano districts, Western Oromia

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Abstract

These demonstration and popularization backyard oxen-fattening technologies were conducted at Dano districts of West shoa Zone of Western Oromia, in two peasant associations namely Gida Abu and Dano Shanan, respectively. The results indicated that supplementation oxen gave high net benefit of Birr 841.02 at Dano Shana and 1357 at Gida Abu, respectively. It was found to be economical and improve the livelihood of the participate farmers. Since the treatments were not compared against farmers' practices, MRR as low as 1% is also accepted and gave the highest net benefit. From the results of the study, it can be advised that in areas where noug cake and maize grain are available at required time and quantity and reasonable price, finishing of Horro steer with noug cake and ground maize at a level of 3kg/head/day for about 90 day is highly profitable. To make the scope higher, however, it is very important to consider strategic time of fattening. Hence, currently the price of maize grain and noug cake is very high, and it would be more advantageous if it starts fattening with maize stover, legumes forage and local available feeds.

Key words: oxen, fattening, Dano Shanan, Gida abu,

Introduction

Cattle fattening has gained prominence as an important business project of the livestock industry in the Ethiopia to make use of cheap, plentiful farm by-products such as maize stokers, teff straw, noug cake meal, maize grain and sugarcane tops, which otherwise might be wasted. Most importantly, it helps to meet the urgent demand for high-protein foods of animal origin through backyard cattle fattening or on a large scale for profitable business. Dano district is characterized by its mixed crop-livestock farming system. Maize, sorghum, teff, noug, faba bean and hot pepper are the major crops grown in the area. The area is known for its high livestock population estimated to be 74,842 cattle, 4,480 goats, 2900 sheep and 3462 equines in the district. At Bako Research center, research on fattening trials conducted both on local and crossbred animals using crop residues, forage legumes, hay, and concentrate has helped to develop profitable feeding systems to finish animals to be fattened (Mulugeta *et al*, 1995). Participatory Rural Appraisal (PRA) conducted in Dano district indicated that shortage of animal feed resources is the number one livestock production-limiting factor followed by livestock disease. Farmers of the district are not aware of the potential of improved forage crops and concentrates with substantial residues-based animal feeds to supply good quality nutrient and most crop residues are abused. Up to now there was no on farm verification of fattening technologies to complement on station work even though it is a high time to use research recommended technologies. Hence, testing the most important finding on crop residues, concentrate and forage legumes hay at farm level is highly required so that farmers adopt the most feasible management practices of finishing cattle before market and get better return from their animals. Therefore, the objective of the study is to demonstrate and popularize backyard cattle fattening technologies on farm that enhances the adoption technology and to asses the economic feasibility of on farm fattening.

Material and Methods

Study area

Demonstration was conducted at Dano Shana and Gida Abu peasant association of Dano district in West Shoa Zone of Oromia. The districts have an area of 650.2 km^2 and human population of 82522. The altitude ranges is between 1400-2500 m above sea level. The annual rainfall is between 900-1400 mm and average annual temperature between 18-30 c°. The area is characterized by mixed crop livestock production.

Criteria of farmer selection

The major criteria used to select the farmers were willingness to participate in the demonstration, owing of at least a bull to fatten and to show the technology to other farmers who were not part of the demonstration. Based on the criteria ten farmers from Dano shanan and ten fron Gida Abu were selected from the two peasant associations.

Feeding and Management

Each participating farmers had been supplementing their oxen with 3kg of concentrates and adlitum grazing. The animals were drenched for internal parasite before engagement in the experiments. The total of fattening period was 90 days and adaptation period was 15 days.

Training of farmers

A day of training and orientation was given to the selected farmers, which organized, by ILRI –BMZ Gibe valley project team on feeding, marketing, health and record keeping.

Data collection and Statistical analysis

Data were collected on initial and final prices of the oxen, prices of maize grains and noug cake. The data were analysis by using descriptive statistics.

Financial analysis

For market price assessment, three local live animal dealers made initial and final and price estimation and an average price were used for economic analysis. The economic analysis was made using partial budget analysis. In this analysis, the prices of bulls, maize grain, noug cake and salt were considered. Noug cake and maize price was taken as an average of three years market price.

Result and Discussion

The net benefits of the participating farmers is shown in (Table 1and Table 2). It gives the farmer year-round work and provides him with extra income. Similarly, study made by Mulugeta *et al.* (1995) on economics of cattle fattening on farm showed that it is a profitable enterprises. Effort should be directed towards better utilization of available crop residues, and hence reduce feed cost and optimizes profits. Given the proper care, there is less danger of diseases and parasites affecting confined animals and shorten the fattening period. Usually cattle in the area are sold for beef purpose particularly when they are too old or when there is cash shortage. Especially oxen are sold after ploughing period when they are of poor body condition with out finishing prior to market that leads to low beef production and low income of farmers. Though substantially increased production can be achieved by better use of the beef potential of bulls to satisfy the demand of an expanding population and an increased per capital consumption of beef. The traditional beef cattle production is one in which the great majority of cattle sent to market for sale /slaughter are unfinished age animals, so that the meat yield and the acquired income of farmers from the

cattle is indeed low. To alleviate this problem, the improvement of traditional beef production system through introduction of better feeding and management technologies is very important. The present study was carried out from June to August, which is coinciding with three fattening periods that were already identified by Bako Agricultural Research Center: September to December, January to April and June to August. These strategic periods coincide with social, cultural and religious ceremonies, during which both the demand for beef and selling price are high. The results indicated that supplementation of oxen gave high net benefit of Birr 841.02 at Dano Shana and 1357 at Gida Abu, respectively. There was found to be economical and improve the livelihood of the participate farmers. Since the treatments were not compared against farmers' practices, MRR as low as 1% is also accepted and gave the highest net benefit. Based on the findings of this study, it is therefore advisable and economical to plan the start of fattening program immediately after maize harvest.

Figure1. Initial and final Body condition score of steers at Dano Shanan

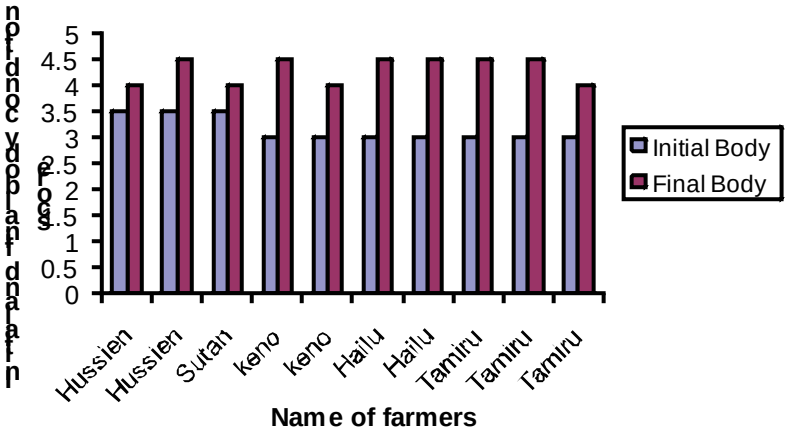

Table-1: Partial budget analysis on the fattening of Horro steers fed up on concentrate at Dano Shanan

Traits	Treatments				
	Hussein	Sultan	Keno	Hailu	Tamiru
No. steers fattened	2	1	2	2	3
Gross benefit	6066.7	3100	5133.5	5266.6	9466.30
Costs					
Maize	378	189	378	378	607.5
Noug cake	405	202.5	405	405	567
Salt	0.78	0.78	0.78	0.78	0.78
Initial price	3983.3	1866.7	3433.3	3433.4	5566.70
TCV	4767.08	2258.98	4217.08	4217.18	6741.98
Net benefit (NB)	1299.62	841.02	916.22	1049.42	2724.32
NB in ascending order	1299.62	841.02	916.22	1049.42	2724.32
TCV for each treatment	4767.08	2258.98	4217.08	4217.18	6741.98

Figure 2. Initial and final body condition score of steers at Gida Abu

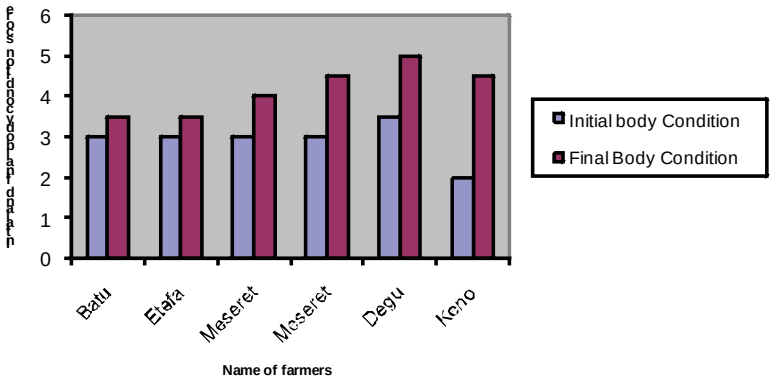

Table-2: Partial budget analysis on the fattening of Horro steers fed up on concentrate at Gida Abu

Traits	Treatments					
	Batu	Etafa	Mesert	Degu	Dinka	Keno
No. steers fattened	1	1	2	1	1	1
Gross benefit	2900	2333.3	6533.3	3600	3066.6	23666
Costs						
Maize	189	189	378	189	189	189
Noug cake	202.5	202.5	405	202.5	202.5	202.5
Salt	0.78	0.78	0.78	0.78	0.78	0.78
Initial price	1700	1433.3	3383.2	1850	1783.3	1393.3
TCV	2092.28	1825.58	4166.98	2242.28	2175.58	1785.58
Net benefit (NB)	807.72	507.72	2366.32	1357.72	891.02	581.02
NB in ascending order	807.72	507.72	2366.32	1357.72	891.02	581.02
TCV for each treatment	2092.28	1825.58	4166.98	2242.28	2175.58	1785.58

Picutre1. Fattening Performance Horro Steers at Dano Districts, Western Oromia, Ethiopia

Conclusion and Recommendation

From the results it was revealed that oxen fattening on 3 kg concentrates /head/day for about 90 days and grazing is profitable at Dano districts. To make the scope higher, however, it is very important to consider strategic time of fattening. Hence, as maize and noug cake price is comparatively high it would be more advantageous if it starts fattening with maize stover, legumes forage and locally available feeds. The fattening program should also coincide with socio-cultural and religious ceremonies when demand for cattle is high and selling price are also high. Formation of co-operatives among farmers or increased scale of production by individual farmers could be considered as means of boosting profit. Informal observations based on opinion of farmers have shown that farmers are highly attracted to the technology. However it appears that farmers lack the finance required to undertake the finishing activity. Therefore provision of adequate credit is fundamental to adoption of the technology by the smallholder farmers. Extension work to popularize the technology should also get the attention of development workers. Marketing information with regard to price of different would be of much help to make decision with regard to adoption of the current finishing technology or similar other technologies.

Acknowledgments

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Reference

Mulugeta Kebede, Tesfaye Kumsa and Abdica Gemeda. 1995. Econonics of cattle fattening at Jirma, Wellega state farms enterprise: Implications for future strategy. In proceedings of Third National Conference of the Ethiopia Society of Animal Production , Addis Ababa, Ethiopia.PP. 146-149.

SAS (Statistical Analysis System) SAS, 1998. Cary. N.C. SAS. Institute Inc.

Supplemental Value Forage Legumes, Concentrate and brewery dry grain on Fattening Performance of Horro (Zebu) Bulls

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Abstract

Study on supplemental value of different forage legumes, concentrate and brewery grain on fattening performance of Horro bulls was conducted at Bako Agricultural Research Center. Thirty growing Horro bulls, purchased from local market were brought to the center and placed in loose tie barn with cemented floor and individual pen. They had estimated age of between 2-3 years with average initial weight of 171±5 kg were systematically grouped into five treatment groups based on their initial live weight and were randomly assigned into the following five treatments: T1 = 2.4 kg of cow pea + 1.5 kg of ground maize grain, T2 = 2.25 kg of lablab + 1.5 kg of ground maize grain, T3 = 1.8 kg of L. Pallida + 1.5 kg of ground maize grain, T4 = 1.5 kg of noug cake + 1.5 kg of ground maize grain and T5 = 3 kg of brewery grain+ 1.5 kg of ground maize. These all treatments had significant ($P<0.05$) effect on final bodyweight, total body weight gain, and average daily body weight gain at 60 days of fattening periods. There was a significant ($P<0.05$) difference between legumes forage supplemented with maize grain and noug cake and brewery grain supplemented with maize grains. It was recommended from this study that in areas where noug cake is available at required time, quantity and price, supplementation of Horro bulls with 1.5kg noug cake and 1.5kg maize/head/day is economical. The inclusions of forage legumes in to diets of the animals have substantially improved the fattening performance of Horro cattle. It can be concluded that one can use legumes forage as a protein source in the place where there is shortage of noug cake especially where the farmers can easily grow legumes forage. Therefore it is recommended that the farmers develop legumes forage for enhancing the fattening performance of cattle.

Keywords: *Legumes forage, Horro bulls, Brewery grain and concentrate*

Introduction

It is well known fact that the main critical issue for livestock production and productivity is shortage of feeds and the method of utilization or formulation of available feed resources. In agreement to this fact Osuji *et al.* (1993) reported that one of the major constraints, which strongly limit livestock production in tropical countries, is unavailability of both high quality and quantity feeds so that the animals are dependent predominantly on high fibre feeds that are deficient in nutrient essential for microbial fermentation. This resulted in slow growth rate, low intake, poor fertility, weak in draught power and consequently reduces production and productivity. The major sources of animal feeds in western Oromiya are natural pasture and crop residues which are known with low protein and fermentable energy levels so that they can supply only sub-maintenance requirement of animals when they are fed alone (Alemu *et. al.*, 1991; Seyum *et. al.*, 1998). Different researchers (Nuwanyakap *et. al.*, 1987; Seyum *et. al.*, 1998; Lemma *et. al.*, 1996) recommended supplementation of crop residues by feeds of high protein and energy sources, for efficient utilization of the available feed resources. Supplementation of animals fed on fibrous feeds with forage legumes is one among many alternatives to achieve better utilization of fibrous feeds. They usually rise to supply of protein and this in turn will raise animal productivity through improving the utilization of carbohydrate energy and other nutrient from fibrous feeds (Leng, 1990). Research recommendations have been developed for sheep and cattle using maize grain as an energy source in a concentrate supplement for finishing sheep (Solomon *et al.*, 1993) and cattle (Mulugeta *et. al.*, 1995). Melese *et al.* (2001) reported average daily gain of Horro bulls fed on different proportion of forage hay and concentrate feed performed better than the group fed on *Chloris gayana*

alone (control Treatment). Tesfaye *et al.* (2005) indicated improved forage with energy sources provide ration balanced for protein-energy and supplementation with concentrates and/or forage hay increased body weight performance over the unsupplemented (control) group. The other reason might also be due to high digestibility of forages in general and Leucaena *pallida* in particular as compared to the by-product feed, which can facilitate animals feed intake. This is again similar to the report of Hennessy *et al.* (1990) in which they found high digestibility of forages for Hereford and crossbred Hereford steers. In general, *Leucaena pallida* supplementation for Horro steers as a sole supplement and as supplement with ground maize promoted better performance as compared to noug cake as a sole supplement. The feed intake was also higher for *Leucaena pallida* supplemented groups than noug cake supplemented groups (Tesfaye et al. 2005)

The conventional energy feeds for fattening animals are mainly grains, molasses, brewery dry grains, flourmill by products and the main protein sources are forage legumes, noug cake, urea, soybean meals but due to lack of appropriate formulated fattening rations and the high cost of grains it is wise to formulate the alternative cheap sources of energy and protein rations. It is obvious that limited information's on the formulation of cattle finishing rations have been addressed to under take fattening with appropriate balance and alternative sources of energy and protein rations from forage legumes, concentrate, and by-products. Formulation of fattening rations, comparing and replacing wholly or partly energy and protein sources with the alternative sources in the appropriate levels will serve as to increase growth performance and farmers income and it also helps as a sound and appropriate use of farmers' feed resources, cut feed expenses down and use of industrial by products. Hence, it is advisable to compare the growth performance and intake of Horro bulls fed up on fattening rations formulated from alternative sources of forage legumes, concentrate, and by-products. Therefore, the current study was initiated to compare the growth performance and intake of Horro bulls fed up on alternative sources of protein rations, formulate alternative fattening potential from different forage legumes, concentrates, and by-products and to assess the economic feasibility of finishing rations.

Materials and Methods

Study area

The study was conducted at Bako agricultural research centre from May 2007 to July 2007. The farm is situated at 1650 m a.s.l (09° 06´ N and 37° 09´ E) and located about 258 km west of Addis Ababa on the main road to Nekemte. Bako has a hot and humid climate and receives a mean annual rainfall of about 1219 mm, more than 80 % relative humidity of which is recorded in the months of May to September. Mean monthly maximum and minimum temperatures are about 28°C and 14°C, respectively, with 21°C of average temperature. Potential evapo-transpiration averages 62 mm per months. The dominant grass species include hyperheniya (*Hyperhenia anamesa*) and sporobolus (*Sporobolus praminidals*) grass and the legumes Neonotonia (*Neonotonia wights*). The soil type of the area is predominantly nitosols

Study animals and management

Thirty growing Horro bulls, purchased from local market were brought to the center and placed in loose tie barn with cemented floor and individual pen. They had estimated age of between 3-4 years with average initial weight of 171±5 kg were systematically grouped into five treatments based on their initial live weight and were randomly assigned to each treatment for each trial. Accordingly, the five treatments consist of the following proportion of improved forage and /or concentrate supplements:

T1 = 2.4 kg of cow pea + 1.5 kg of ground maize grain

T2 = 2.25 kg of lablab + 1.5 kg of ground maize grain

T3 = 1.8 kg of L. Pallida + 1.5 kg of ground maize grain

T4 = 1.5 kg of noug cake + 1.5 kg of ground maize grain

T5 = 3 kg of brewery grain+ 1.5 kg of ground maize grain

For the trials, all animals should be supplemented with equal amount of CP (741 gm) to provide the protein requirements of animals beside maize silage, salt and water were provided adilibtum. All animals were drenched and sprayed against internal and external parasites. The fresh leaves and juvenile steam parts of forage legumes were harvested at 10-50% flowering stage to controls nutrient contents and dried in a shade for 4-5 days. To avoid selective feeding leaves and juvenile steam parts should be grounded prior to feeding. All animals were supplemented in individual pens and fed the treatment diet for 90 days with 15 days adaptation period

Statistical Analysis

Data on daily feed intake and live body weight of the bulls were recorded fortnightly during the experimental period. The data was analyzed using the general linear model of Statistical Analysis System (SAS, 1998). During analysis treatment was considered as independent variables where as final body weight, total weight gain, daily weight gain and intake considered as dependent variables.

Economic analysis

For market price assessment, three local live animal dealers made initial and final price estimation and an average price were used for economic analysis. The economic analysis was made using partial budget, dominance and marginal rate of return analysis. In this analysis, the prices of bulls, maize grain, noug cake and salt were considered. However, the prices of cowpea, lablab, and L. pallida and brewery grain were not considered. Noug cake and maize price was taken as an average of three years market price. Besides, the stability of this recommendation was supplemented by sensitivity analysis by varying the prices of inputs

Result and Discussion

Fattening performance of Horro bulls

Initial weight, final weight, total weight gain and average daily body weight gain at 60 and 90 days of Horro bulls under different feedings were showed in (Table 1). Treatments had significant ($P<0.05$) effect on final body weight, total bodyweight gain and average daily body weight gain. Total body weight gain was significantly ($P<0.05$) higher for treatments T1 (18.7±2 kg) and T2 (19.3±2 kg) than the treatment 3, 4, and 5 at 60 days of fattening periods. Different trends were observed at 90 days of fattening. Similar trends were observed for average daily body weight gain. These results were similar with the work of Melese *et al.*, (2001) where the average daily gain of Horro bulls fed on different proportion of forage hay and concentrate feed performed better than the group fed on *Chloris gayana* alone. Also they indicated that improved forage with protein sources provide ration balanced for protein-energy. Body weight at 60 days was highest (215.5±2.4 kg), for Horro bulls in T5 followed by T4 (191.6±2.4 kg), T3 (182.8±2.2 kg), T2 (178.4±2.4kg) and lowest for Horro bulls in T1 (166.2±2.4kg). However, body weight at 90 days were (218.6±3.7 kg), for Horro bulls in T5 followed by T4 (210.7±3.7 kg), T3 (185.3±3.7kg), T2, (181.3±3.7kg) and lowest for Horro bulls in T1 (170.4±3.7kg). The reason why greater final weight of Horro bulls of the treatment T5 and T4 acheved were due to the effect of initial weight of the Horro bulls. The average daily gain and total gain of Horro bulls fed on legumes forage (Cow pea, lablab and L. pallida) performed better than the bulls fed on noug cake and brewery grains at 60 days fattening periods. Supplementation legumes forage with maize grain in the present study significantly ($P<0.05$) increased body weight performance over the supplementation of noug cake and brewery grains maize grains.

Comparisons of daily body weight gain at 60 days for T1 (0.31±0.03Kg) and T2 (0.32±0.03Kg) indicated that there was no significant ($p>0.05$) difference between two forage legumes feeding animals, however, there was significant ($p<0.05$) difference with T3 (0.19 ±0.03Kg).

Intake of Horro bulls

Daily feed intake of the Horro bulls was significantly ($P<0.05$) different among each treatment. Feed intake was high (3.9 ± 0.0kg) for Horro bulls in T1 and followed by T2 (3.75 ± 0.0kg), T5 (3.6 ±0.03 kg) and lowest (3.3 ± 0.0kg) for bulls in T3. This report is similar to the work of Hennessy *et al.* (1990) in which they found high forage intake for Hereford and crossbred Hereford steers. The other reason might also be due to high digestibility of forages in general and cow pea and D. lablab in particular as compared to the by-product feed, which can facilitate animals feed intake. This is again similar to the report of Hennessy *et al.* (1990) in which they found high digestibility of forages for Hereford and crossbred Hereford steers. Similar results were reported, Melese *et al.* (2001) they indicated that feed intake of bulls was higher for forage hay-supplemented animals than unsupplemented ones. In general, cow pea, *D. lablab* and Leucaena pallida for Horro bulls as supplemented with ground maize grain promoted better performance as compared to noug cake and brewery grain. The feed intake was also higher for cowpea, D. lablab and Leucaena pallida supplemented groups than brewery grain supplemented groups. Smilar results were reported from previous studies (O'Donovan et al., 1978; O'Donovan, 1979; Tesfay*e et al.*, 2005). All of them indicated that cattle and sheep have shown good performance by supplementing improved forage. Melese *et al.* (2001) reported similar results in which they indicated the demand for high quality animal protein along with the substitute production of cereal grains calls for improved forages which offer the best supplement so that the productivity of animals may be improved.

Economic Evaluation

The result of economic analysis indicated that had low or negative net benefit from each treatment. Since the experimental conduct from periods (May- July) were not coinciding with fattening calendar. The fattening activities were carried out during the three fattening periods that were already identified by Bako Agricultural Research Center: September to December, January to April and June to August. These strategic periods coincide with social, cultural and religious ceremonies, during which both the demand for beef and selling price are high. From these results can be advised purchase the animals between May and July when the animals are obtained from the market and low prices. Therefore, it is better economical benefit obtained from fattening animals were supplemement L.pallida, Lalba, Cow pea and brewery dry grain with maize rather noug cake with maize grains.

Conclusions and Recommendations

Cow pea, D. lablab and *Leucaena pallida* for Horro bulls as supplemented with ground maize grain promoted better performance as compared to noug cake and brewery grain at 60 days fattening. The feed intake was also higher for cowpea, D. lablab and Leucaena pallida compared with brewery grain supplemented groups. It was suggested from this study that in areas where noug cake is available at required time, quantity and price, supplementation of Horro bulls with 1.5kg noug cake and 1.5kg maize/head/day is economical. The inclusions of forage legumes in to diets of the animals in the dry period have substantially improved the fattening performance of Horro cattle. So it can be concluded that one can use legumes forage as a protein source in the place where there is shortage of noug cake especially where the farmers can easily grow legumes forage. Therefore future study should include demonstrated and popularized the legumes forage on farm and the farmers around brewery factors like Badelle use brewery dry grain as feeding for enhancing the growth performance, production and reproduction of cattle

Table 1. Least square means of initial body weight, final body weight, and average daily gain of Horro bulls fed up on forage legumes, concentrate and brewery grain.

Traits	Treatments							
	T1	T2	T3	T4	T5	Over all mean	CV%	R-square
Initials weight (Kg)	147.5±2.14e	159.2±2.14d	171.2±2.14c	178.7±2.14b	202.3±2.14a	171±5	3	0.93
Average weight for 60 days (kg)	166.2±2.4d	178.4±2.4c	182.8±2.4c	191.6±2.4b	215.5±2.4a	186±6	3	0.89
Total gain for 60 days (Kg)	18.7±2ba	19.3±2a	11.6±2c	12.9±2c	13.4±2bac	15±4.5	32	0.33
Average daily gain for 60 days (ADG) (kg)	0.31±0.03b	0.32±0.03a	0.19±0.03c	0.21±0.03bc	0.22±0.03bac	0.25±0.08	32	0.33
Average final weight for 90 days (kg)	170.4±3.7c	181.3±3.7b	185.3±3.7b	210.7±3.7a	218.6±3.7a	193±9	4	0.82
Total gain for 90 days (Kg)	22.8±2.9b	22.2±2.9b	14.1±2.9c	32.1±2.9a	16.2±2.9c	21.5±7	33	0.47
Average daily gain for 90 days (ADG) (kg)	0.25±0.03b	0.24±0.03b	0.15±0.03c	0.35±0.03a	0.18±0.03c	0.24±0.08	33	0.47

Table-2: Partial budget and marginal analysis on the fattening of Horro bulls fed up on different legumes, concentrate and brewery dry grains

Traits	Treatments				
	1	2	3	4	5
Average weight	170.4	181.3	185.3	210.7	218.6
Adjusted weight	168.7	179.5	183.4	208.6	218.4
Gross benefit	881	906	969	1226	1144
Costs					
Maize	136.7	136.7	136.7	136.7	136.7
Noug cake	0	0	0	936.6	0
Salt	0.78	0.78	0.78	0.78	0.78
Initial price	1022	1093	1125	1186	1290
TCV	1159.48	1230.48	1262.48	2260.08	1427.48
Net benefit (NB)	-278.48	-324.48	-293.48	-1034.08	-283.48
NB in ascending order	-278.48	-324.48	-293.48	-1034.08	-283.48
TCV for each treatment	1159.48	1230.48	1262.48	2260.08	1427.48
MRR (%)					

MRR: Marginal rate of return

Table-3: Sensitivity analysis for changing prices of maize and noug cake in fattening Horro bulls.

Items	Treatments				
	1	2	3	4	5
Average initial price of young bulls (Birr/kg) [2]	6.95	6.86	6.57	6.63	6.37
Average final price of young bulls (Birr/kg) [1]	5.17	4.99	5.22	5.8	5.23
Average price of maize (Birr/kg) [2]	0.16	0.16	0.16	0.16	0.16
Average price of noug cake (Birr/kg) [2]				1.15	

[1] Changes greater than the indicated figure are acceptable

[2] Changes less than the indicated figure are acceptable

Data

- Maize field price =0.16 Birr/kg
- Noug cake price = 1.15 Birr/kg
- Salt = 1.00Birr/kg
- Weight down adjusted to: 1%

Table 2. Least square means of dry matter intake of Horro bulls under different feed supplementations.

Treatments	Dry matter intake (DMI kg/day)					
	Cow Pea	Lablab	L.Pallida	Maize grain	Noug cake	Brewery grain
T1	2.4±0.0	-	-	1.5±0.0	-	-
T2	-	2.25±0.0	-	1.5±0.0	-	-
T3	-	-	1.8±0.0	1.5±0.0	-	-
T4	-	-	-	1.5±0.0	1.5±0.0	-
T5	-	-	-	1.5±0.0	-	2.1±0.03
FCE %	12.9	14	10	12-21	14	10

FCE = Feed conversation efficiency

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References

Gebregziabher Gebreyohanes and Mulugeta Kebede. 1995. Body weight changes of Horro cattle grazed wet season natural pasture. In: Proceedings of third NationalConference of the Ethiopian Society of Animal Production (ESAP), 27-29 April1995. Addis Ababa, Ethiopia. P. 161-164.

Hennessy, D.H., Barlow, R., Williamson, P.J., Murrison, R.D. and Herily, J.W. 1990.Feed intake, nitrogen retention and live weight of Hereford and crossbred Hereford steers offered forage diets differing in digestibility and nitrogen content.Aust. J. of Agric. Res. 41,421-30.

Lemma Gizachew, Abubeker Hassen and Diriba Gelete. 1996. Adaptation and yield performance of herbaceous and multipurpose tree legumes in sub humid climates of western Ethiopia. In: ESAP Proceedings of Fourth National Conference of Ethiopian Society of Animal Production 18-19 April 1996, Addis Ababa, Ethiopia. P. 187-195.

Lemma Gizachew. 1992. Comparison of different legume hay, urea, and noug cake as a protein supplement for growing Horro Sheep fed teff straw. In: Proceedings of Fourth National Livestock Improvement Conference held from 13-15 November at Addis Ababa, Ethiopia. P. 211-215.

Leng, R.A., 1990. Factors affecting the utilization of poor quality forage by ruminant particularly under tropical conditions. Nutrition research Reviews. 3: 277-303.

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D., Morgan, C.A., 1995. Animal nutrition. Longman Scientific and Technical, New York, USA.PP.607.

Melese Abdisaa, Diriba Geleti, Lemma Gizachew, Temesgen Diriba and Adane Hirpha.2001. The effect of improvement forages and/or concentrates supplementation onlive weight of Horro lambs and growing bulls. In: proceedings of the ninth Annual conference of Ethiopian Society of animal production (ESAP) held in Addis Ababa,Ethiopia, August 30-31, 2001. P. 259-265.

Nuwanyakpa, M. Y. and Butterworth, M. H. 1987. Effect of urea molasses, molasses-urea, noug cake and legume hay on the intake and digestibility of teff straw by high land sheep. Utilization of agricultural by products as livestock feeds in Africa. Proceeding of a workshop held at Ryalls Hotel, Blantyre, Malawi. September 1986.

O'Donovan, P. B. 1979. Fattening crossed and zebu cattle on local feeds and byproducts in Ethiopia. World Animal Review. 30: 23-29.

O'Donovan, P. B.; Alemu Gebre-Wold; Beyene Kebede and E. S. E. Galal. 1978. Fattening studies with crossed Ethiopian (zebu) bulls. I. Performance on diets of native hay and concentrate. J. Agri. Sci. 90:425-429.

Osuji, P.O., Nsahlai, I.V., Khalili, H., 1993. Feed Evaluation. ILCA Manual 5. ILCA, Addis Ababa, Ethiopia. 40 pp.

SAS (Statistical Analysis System) SAS, 1998. Cary. N.C. SAS. Institute Inc.

Seyoum Bediye, Ummuna, V.I., Nsahlia, I.V., Zinash Sileshi and Alemu Yami. 1996. Interrelationships of chemical properties, invitro digestibility and rumen degradability characteristics of protein sources. In: Proceedings of Fourth National Conference of Ethiopia Society of Animal Production held from 18-19 at Addis Ababa, Ethiopia. P. 129-138.

Solomon Gizaw, Solomon Abegaz and Asfaw Negassa. 1993. Growth responses of Horro sheep to different levels of maize and noug cake supplements. In: Proceedings of the 4th National Livestock Improvement Conference. Addis Ababa, Ethiopia, 13-15 November 1991. IAR, Addis Ababa. Pp. 113-118.Tesfaye Alemu Ardo. 2000. Effect of feed restriction on compensatory growth of crossbred bulls. In: proceeding of Seventh Annual Conference of Ethiopia Society of Animal Production held in Addis Abeba, Ethiopia. P. 89-95.

Tesfaye Lemma, Gebregziabher Gebreyohanes, Gizaw Kebede and Mulugeta Kebede.1999. Body weight changes of male cattle grazing natural pasture at Bako. In: Proceedings of seventh National Conference of the Ethiopian Society of Animal Production (ESAP), 27-29 August 1999,. Addis Ababa, Ethiopia.

Tesfaye Lemma, Gebregziabher Gebreyohannes, Chala Merera, Jiregna Desalegn ,Girma Aboma and Diriba Gelet.2005. Comparative Feeding Values of *Leucaena Pallida* and Noug Cake (*G. Abyssinica*) for Fattening Horro Steers. Ethiopia Journal of Animal Production (EJAP). Vol.5.No.1.

Animal Production

Age and Growth determination of Tilapia (*Oreochromis niloticus* L.) on Lake Zeway

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Abstract

This Study was done on fundamental concept of fishery management. Tilapia (Oreochromis niloticus) is the most important fish in the Ethiopian fisheries. Knowledge on the age and growth of this fish is absolutely basic, because the knowledge is central to develop and manage its fishery. This study dealt with adult fish of Lake Zeway. The main objective was to design appropriate management options and the specific objectives were first to examine the length at different ages of this fish and secondly to observe maturity stages, in relation to length. Sample fishes were collected from the experimental fishing and were dissected to collect the otolith. The otoliths were polished and the translucent zones were counted under the microscope to determine the age of the fish. Age at different length shows that smaller size of fish at respective age. Length at average maturity stages of both sexs indicates that early age sexual maturity or smaller size of fish at maturity that is fish are stunted. Both the above situations are characteristics of highly exploited populations, which the policy makers should wake up to design management policies and plans.

Key words: *Oreochromis niloticus*, tilapia, age determination, biannulus, Lake Zeway

Introduction

Tilapias make up the genus Tilapia in the family Cichlidae, order Perciformes. Tilapia genus of tropical fishes belongs to the cichlid family. There are 14 species of tilapias, all native to tropical fresh waters of Africa, but some commercially important species and cultivated in Israel and in several Asian countries, including Indonesia, Malaysia, Thailand, and the Philippines have been introduced. Several species are popular aquarium fishes because of their interesting behavior and attractive coloration. In Africa the tilapia harvest is an important component of subsistence fisheries Nile tilapia, *Oreochromis niloticus* constitutes the major portion of cichlid catch in Africa (Fryer & Iles, 1972). This species is found in almost all the inland waters of Ethiopia (Shibru, 1973) and contributes the entire landed catch from most of the Ethiopian waters.

They feed on a wide variety of food, including insect larvae, crustaceans, juvenile fish, worms, various plants, and detritus. Some species can survive in waters with oxygen concentrations as low as 0.1 parts per million, and one species inhabits hot springs with water temperatures as high as 40° C (104° F). However, most species of tilapia are not so tolerant.

The determination of fish age and growth is fundamental in fisheries biology and management. Such age-determined parameters as mortality and growth underlie the population dynamics models used in fishery analyses. Age studies can furnish other basic data such as stock age structure, age at first maturity, spawning frequency, individual and stock responses to changes in the habitat, recruitment success, etc. Age and growth data also permit the determination of population changes due to fishing rates.

The anatomical approach (Oesseochronometry) is the most commonly used method to determine fish age (Casselman,1987).This method involves microscopic examination or counting the regular growth marks formed in hard tissues such as scales, otholiths, vertebrae, spines and tail bones. This technique is referred to as macrosturure or macrozone analysis (Campana & Neilson, 1985; Yosef, 1990).

The deposition of annual growth rings (annulae) in the calcified tissues of bony fishes is at least partly caused by seasonal changes in the environment. These periodic changes (Temperature cycles, available food) are less regular and less severe in tropical than in temperate zones. Ageing tropical fishes was until recently assumed to be virtually impossible due to continuous spawning and the absence of growth cycles (Mohr, 1921), making the application of the anatomical method and of length-frequency analyses difficult if not impossible. It has been demonstrated, however, that though tropical fish have a longer spawning period than temperate fish (Lowe-McConnell, 1987), recruitment is limited to one or two seasons of the year. This limitation may arise out of spawning fluctuations or out of the juvenile and larval mortality which governs and limit recruitment to specific periods (Bakun *et al*., 1982; Victor, 1982).

Many authors have reported the presence of seasonal growth rings (annulae) in tropical fish otoliths (Brothers, 1979; 1982; Sainbury and Whitelaw, 1984) although ring deposition in some species is irregular (Mathews, 1974). Once the annual ring periodicity has been determined, age reading is rather simple. Indeed, seasonal changes are much less drastic in the tropics than in the temperate regions. However, regular climatic fluctuation, associated primarily with fainfall and winds, exists in many tropical freshwaters (Lowe-McConnell, 1987). This fluctuation may follow either a uniannual or multiannual cycle, resulting in the annual formation of one or more macrozones or checks in the calcified structures of the fish (Willoughby, 1974: Blake & Blake, 1978: Brothers, 1979; Lecomte et al., 1989; Yosef & Casselman, 1995). Some of the factors which reportedly appear correlated with macrozone or check formation in the tropics include changes in temperature (Willoughby, 1974; Blake & Blake, 1978; Nekrasov, 1980; Yosef & Casselman, 1995) and changes associated with the cycle of wet- dry seasons (Holcik, 1974: Wurburton, 1978). In addition fluctuation in body condition associated with spawning activity has also been considered an important factor (Garrid, 1959; Nekrasov, 1980; Booth et al., 1995). This study dealt with adult Tilapia of Lake Zeway. The main objective was to design appropriate management options and the specific objectives were first to examine the length at different ages of this fish and secondly to observe maturity stages, in relation to length.

The study area

Lake Ziway lies 08 0 01' N and 38 0 47' E within the Ethiopian rift valley system at an altitude of 1636 meters above sea level in the Oromia region of the country. Lake Zeway has open water area of 422 km^2 and shoreline length of 137 km. The lake is fed by two major rivers, i.e. Ketar and Meki River, and has one outflow in the south, the Bulbula River which flows into Lake Abiyata (LFDP 1993). Five bigger islands are situated in Lake Zeway: Tulu Gudo (4. 8 km^2), Tsedecha (2.1m^2), Funduro (0.4 km^2), Debre Sina (0.3 km^2) and Galila (0.2 km^2). While the latter two have only a few inhabitants, the three bigger ones are populated with several hundreds of people (Anon. 1999).

It is the shallowest of the Rift Valley lakes with maximum and mean depth 8.95m and 2.5m, respectively. Lake Ziway is the most northerly of the four interconnected rift valley lakes, Ziway, Abijata, Langano and Shalla (Fig.1) that forms the Ziway-Shala basin (Van Damm and Edmond, 1984). The weather of Lake Ziway region is semi-arid for most of the year. It is frequently windy and stormy. The rainy season of the region is between mid June and mid September, followed by a dry season from October to February and there is a small rainy season with occasional precipitation in the month of March (Schroder, 1984).

The lake (Fig. 2) contains extensive areas of littoral vegetation. A large portion of its littoral zone falls within the draw- down area, which is dried out during the dry season and inundated during the rainy season. The shore of the lake is covered with reeds and papyrus in the north and with submerged vegetation and reeds in the south. The upper shore zone in the south is grassland dotted with big *Ficus sycomora* trees.

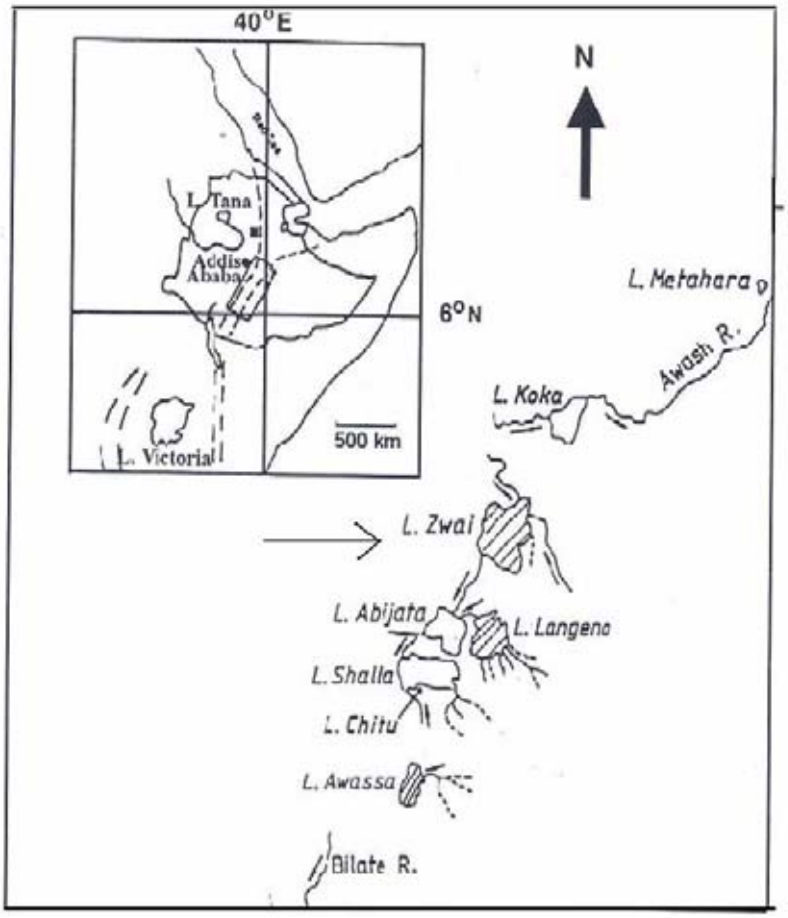

Fig. 1. Map of Ethiopia (inset) and the Rift Valley Lakes with their drainage basin pattern. the arrow indicates Lake Ziway

Fig. 2. Map of Lake Ziway showing its perenial rivers, islands and the sampling sites (Source: LFDP, 1998)

mis niloticus, Barbus Ethiopica, Barbus ., Carassius caracius, and Cyprinus car- 02). There is a number of landing points or trucks and brought to the major land- keting Enterprise, FPME (a semi-auton- ng from the capital city, Addis Ababa and

k and line. Fishing has seasonal pulse on with high fishing activity and increased he high demand for fish during the fast- rease in catch rate. The increase in the pawning aggregation of the tilapia to the he beach seine fishing practices (Schoder exploited are lake Ziway and lake Awas- heir vicinity to the capital of the country ch is highly preferred by consumers (for ake Ziway, due to high number of fishers otures juveniles & breeding stocks, is in

Table 1.Morphometric and physical characteristics of Lake Ziway

Characteristics	Value
Altitude (m)	1636
Surface area (Km 2)	442
Maximum depth (m)	8.95
Mean depth (m)	2.5
Volume (Km 3)	1.6
Secchi depth (cm)	10.75 -19.25

Source: Wood and Talling (1988).

Materials and Methods

Sampling

Monthly, approximately 100 fishes, 50 from both sexes were sub sampled from the experimental fishing on Lake Zeway, during the period from February 2000 to January 2001. 100m long fleet of gillnet was used, which was constructed by connecting four gillnets of stretched mesh size ranging from 6cm to 120cm by increments of 2cm. The net was diploid overnight in the lake at three different locations shallow area, center of the lake and river mouth. After each collection the sex, maturity stage, total length, total weight of each fish was measured. As soon as the fish dies, fishes were dissected on the head part of the body and both the right and the left otolith were removed and cleaned with water and stored in dry labeled paper bag until microscopic examination.

Microscopic analysis

Prior to microscopic examination, otoliths were socked in 70% ethanol for three days and then transferred in to 40% glycerol for seven days to enhance the appearance of the macrozones. Bigger sized otoliths from larger fish were grounded on the external (concave) side and polished using 400 & 600-grit sand paper and sliced again with12-µm lapping film.

For microscopic interpretation, the polished Otoliths were immersed in a dense clarifying liquid 45% glycerol in a dark container. Binocular microscope was used for the reading. Slow growth rings appeared dark through the dark transparent background of the container, whereas fast or opaque growth rings appeared light. Translucent zones were counted at least twice for each otolith without knowledge on fish size. To determine the period of translucent zone formation and to estimate age based on seasonal deposition cycle of otoliths, the type and relative width of the macrozone at the edge of each otolith was noted.

It is generally believed that interpretation of annulus (macrozones) from tropical fish calcified tissues (scales, otholiths, etic) is a problem. However, methods used to interpret annulus for temperate fish can be used for some tropical fish, such as tilapia, if they are applied by systematic and detailed examinations than before (Demeke, 1989: Yosef, 1990).

Interpretation of otoliths and age estimation

The second translucent zone was associated with the first annulus. The first annulus was considered as juvenile marks and which did not follow the seasonal pattern. As described in Yosef (1990), this annulus is located close to the otolith nucleus and it is covered by heavy calcareous material so the otholit was thinned by grinding on carborundum paper to locate the juvenile marks. Therefore, the number of translucent zones associated with annulus for each fish did not include the juvenile mark.

Average length-at-age and Average maturity stage Vs length were then calculated, by using previously estimated Von Bertalanffy growth parameters..

Results and discussion

The age and growth data is basic information for management and used also as a reference from which the effects of fishing, environmental changes and future management practices may be evaluated. NTBA (number of total biannulus) at different length in Fig -3 shows O.niloticus of Lake zeway is getting smaller in its size with respect to the age. In Fig -4 the length at average maturity stages of both sexs indicates that early age sexual maturity or smaller size (stunted) fish at maturity. The growth pattern of the fishery is changing from time to time. According to this study, length at age data and length at maturity stages shows that length at first maturity and length at respective age is decreasing. This is the sign of stunted fish and early age maturity, in the lake. Fishing pressure is assumed to be the major cause for stunted tilapias in Lake Zeway. Both the above situations are characteristics of highly exploited populations which needs an urgent management rules& regulations of the lake.

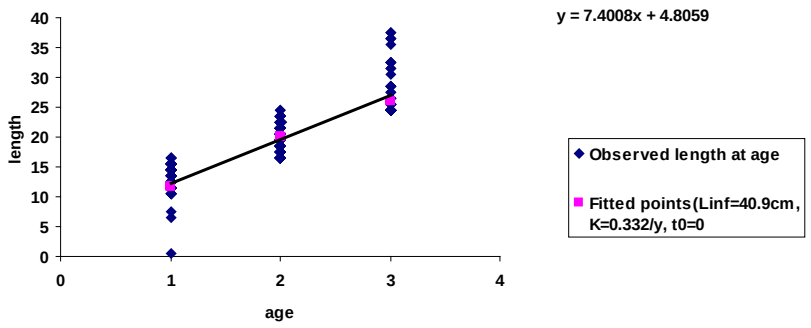

Fig 3 Length (cm) at age

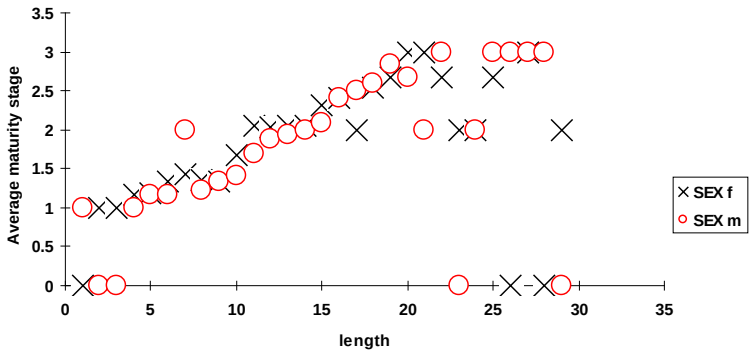

Fig 4- Average maturity stage Vs length

Throughout the year there were otholits with their translucent zone at their margin but their frequency varied at some season. The frequency was highest (25-45%) in January, February, July and September (Fig 5), compared to the other months. Accordingly this study showed that annually two translucent zones are formed in the otoliths of O.niloticus of Lake Zeway, which is in agreement with the study done on the same species of Lake Awassa (Admassu, 1989): One is between February to March while the other between July and September. Biannual growth -check formation in calcified tissues of fish in the tropics has been reported by several authors (Garrod, 1959; Willoughby, 1994; Blake & Blake, 1978). Cold water temperature of the lake, the quality and quantity of food available in relation to the spawning season in the lake during these months may be are the possible reasons for the translucent zones formation in these seasons of the year.

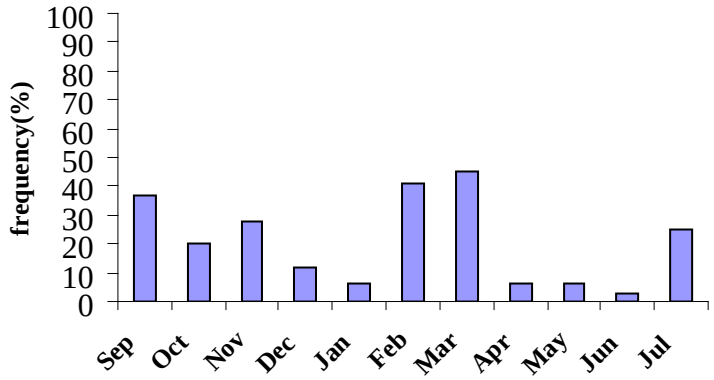

Fig -5 Seasonal frequency (%) of otoliths with translucent zone at the edge

Otolith size depends on the age of the fish, which is closely correlated with length. Increment thickness will reflect bodily growth (Campana and Nielson, 1985; Gutierrez and Morales-Nin, 1986). Accordingly on this study the otolith radius and the total fish length were linearly related (Fig 6).

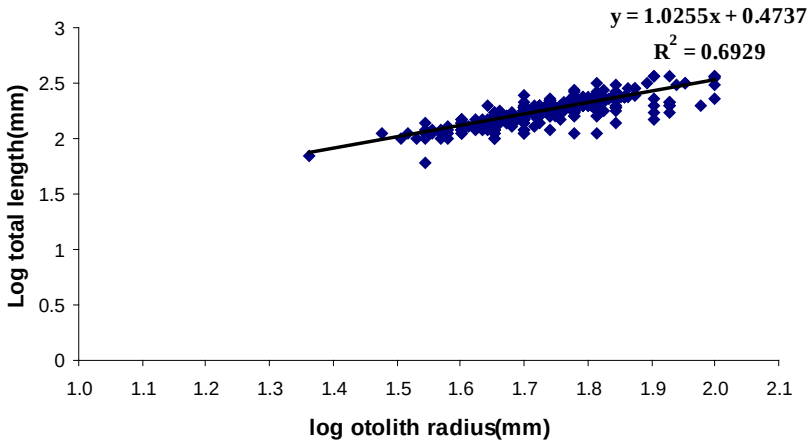

Fig 6 Relation ship between total length of fish and maximum posterior radius of otoliths in Oreochorms niloticus from Lake Zeway

The age of each fish is estimated based on the fact that, the first biannulus formation for the February-March cohort on average will be 6 months old and for july-September cohort it will also be 6 months old. That is there is on average 6 months gap between the two times of biannulus formation, there fore the formula *Age = 6.5+((NTBA-1)x6.0)months (*Admassu, 1989) is used to estimate the age related to NTBA is as in Table 2.

Table-2 Length at age estimates in year for Oreochromis niloticus

NTBA	n	Mean length	Estimated age(months)	In year
1	125	15	6.5	0.5
2	334	19.2	12.5	1.0
3	54	22.5	18.5	1.5

Conclusions and recommendations

Intact inland fishery ecosystems in the rift valley system are in great problem of poor management of the recourse due to luck of environmental protection measures. Lake Zeway fishery is characterized by patterns overexploitation and environmental degradation. Luck of information on minimum harvestable age, age at sexual maturity and year class composition of catch and rate of mortality obtained from age and growth studies is absolutely a gap to design appropriate fishery management policies in the rift valley lakes.

The commercial net at Zeway catches significant number of immature Tilapia. Decrease in the size of fish caught is reported which is inline with this study. Nets removing immature fish result in over fishing (Pauly, 1983). Therefore, it should remain the legal minimum mesh size, and must be enforced.

Management measures should be encouraged and commercial fishing gears should be monitored regularly to check if management decisions are being enforced. Further detailed and continues studies on age and growth of commercially important fish species of Lake Zeway is required in combination with the resource monitoring activities of the lake, to estimate the level of fishing, the status of the fishery and the maximum sustainable yield. The resource is expected to decline as long as possible measures are not undertaken. The direct resource users should agree with management solutions and should be motivated and willing to share management responsibilities.

Strong management rules and regulations are recommended, to properly use the resource. Otherwise the fishing activity with unlimited fishing effort is damaging the resource

References

Admassu D, 1989. A study on the age and growth of adult Oreochromis niloticus Linn. (Pisces: Cichlidae) in L. Awassa, Ethiopia. M.Sc thesis, AAU, 90 pages 37: 255–267

Admassu D. and Ahlgren I., 2000. Growth of juvenile tilapia, *Oreochromis niloticus* L. from Lakes Zwai, Langaeno and Chamo (Ehiopian rift valley) based on otolith microincrement analysis. *Ecology of Freshwater Fish* 2000: 9: 127-137.

Alemayehu Negassa, 2002. The status of introduced exotic fish species, *Tilapia zillii*

Gervais (piscesi *Cichlidae*) and its relation with native *Oreochromis niloticus* in

Lake Ziway, Ethiopia. M.Sc. Thesis. Addis Ababa University, 76p.

Anon. 1999. Regional Government of Oromia, Oromia Economic Study Project

Bakun A., J. Beyer D. Pauly J.F. Pope and Shrp, 1982. Ocean Science in relation to living resources. Canadian Journal of Fisheries and Aquatic Sciences 38: 1 059-1 070.

Blake. C. & B, F. Blake, 1978 . The use of opercular bones in the study of age and growth in Labeo senegalensis from Lake Kainji. Nigeria. *J. Fish Biol.* 13: 287-295.

Booth A.J.G.S. Merron & C.D. Buxton, 1995. The growth of *Oreochromis andersonii* (Pisces:Cichlidae) from the Okavango Delta,. Btswana and comparison of the scale and otolith methods of ageing. Envir.Bio. Fishes 43: 171-178

Brothers E.B., 1979. Exogenous factors and the formation of daily and sub daily increments in fish otoliths. *American Zoologist* 18: 631-632.

Calender K.D., 1974. Difficulties in ageing fish in relation to inland fisheries management, pages 100-250, in Proceedings of the national seminar on fisheries policy and strategy , 22-25 June 1993, pages 74-82.

Campana S.E. & Neilson J.D., 1985. Microstructure of fish otoliths. *Canadian Journal of Fisheries and Aquatic Sciences* 42: 1014–032.

Campana, S.E. 1990. How reliable are growth back-calculations based on otoliths? *Canadian Journal of Fisheries and Aquatic Sciences* 47: 2219–2227.

Casselman J.M., 1987. Determination of age and growth . In Weatherly, A.H. & H.S. Gill (eds). The biology of Fish Growth . Academic Press, London: 209-242.

Francis R.I.C.C. 1990. Back-calculation of fish length: a critical review.

Journal of Fish Biology 36: 883–902.

Fryer G. & T. D. Iles, 1972. The Cichlid fishes of the Great Lakes of Africa. Their Biology and Evolution. Oliver & Boyd. Edinburgh.

Garrod D. J., 1959. The growth of Tilapia esculenta Graham in Lake Victoria. *Hydrobiologia* 174: 195-200.

Healey M.C. 1980. Growth and recruitment in experimentally exploited lake whitefish (Coregonus clupeaformis) populations. Canadian Journal of Fisheries and Aquatic Sciences.

Holcik J., 1974 The green bream, Sargochromis codringtoni (Boulenger. 1908) In Balon, E. K & A.G. Coche (eds). Lake Kariba. A Man-Made Tropical Ecosystem in Central Africa. Dr W. Junk Publishers. The Hague: 280-298

Lecomte F., F. J. Meunier & R. Rojas-Beltran. 1989. Some data on the growth of Arius Proops (Ariidae. Siluriforms) in the estuaries of French Guyana.Aquatic Living Resourecs 2:63-68.

LFDP, 1993. Lake Fisheries Development project working paper.

Lowe-McConnell R.O., 1987. Ecological studies in tropical fish communities. Cambridge University Press. London; 382 pp.

Nekrasov. V. V., 1980. The causes of annulus formation in tropical fishes. Hydrobiological journal 2: 35-39 Office, Agricultural Sector Study draft final report. Addis Ababa.

Pauly,D.(1983). Some simple methods for the assessment of tropical fish stocks. FAO Fish.Tech. Pap. (234):52 pages.

Sainsbury, K. J. and A.W. Whitelaw, 1984. Biology of Peron's threadfin bream, Nemiterus peronii (Valenciennes) from the North West Shelf of Australia. Australian Joournal of Marine and Freshwater Research 35:167-185.

Schroder R. 1984. An attempt to estimate the fish stock and sustainable yield of Lake

Shibru. T, 1973. Fresh water fishes of Ethiopia. Haile Selassie I University, Addis Ababa

Victor, B.C., 1982. Daily otolith increments and recruitment in two coral-reef wrasses, Thalassoma bifasciatym and Halichoeres bivittatus. *Marine Biology* 71: 203-208.

Warburton K., 1978. Age and growth determination in marine catfish using an otolith check technique. J. *Fish boil*. 13: 429-434.

Willoughby N. G., 1974. The ecology of the genus Synodontis (Pisces: Silluroidei) in Lake Kainji. Nigeria, Ph.D. thesis, University of Southampton, U.K.

Wood R.B and Talling, J.F. (1988).Chemical and algae relationships in a salinity series of Ethiopian inland waters. *Hydrobiologia* 158:29-67.

Wudneh.T. 1998. Biology and management of Fish stock in Bahir Dar gulf, Lake Tana.

Yosef , T., 1990. Age determination and growth estimation of immature *Oreochromis niloticus* L. (Pisces: Cichlidae) in Lake Awassa, Ethiopia. M.Sc thesis, University of Waterloo. Waterloo, Canada.

Yosef, T. & J. M. Casselman, 1995. A procedure for increasing the precession of otolith age determination of tropical fish by differentiating biannual recruitment. In Secor. D. H.,J.M.Dean & S.E. Campana(eds). Recent Developments in Fish otolith Research. University of South Carolina, Columbia: 247-269.

Zenebe Tadesse. (1988). Studies on some aspects of the biology of *Oreochromis niloticus* in Lake Zway, Ethiopia. M.Sc. Thesis. Addis Ababa University 78 pp.

Effect of fish meal processing on feed quality for livestock in Zeway, Oromia (Ethiopia)

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Abstract

The experiment was conducted at Ziway Fishery Resources Research Center from November 2003 to June 2004 using two commercially important fish species, Nile tilapia (*Oreochromis niloticus*) and cat fish (*Clarias gariepinus*) offal collected from processing shade of Fish Production and Marketing Enterprise (FPME). The offal was cooked at about a temperature of 70- 75^{0}C for 35 - 40 minutes. In this study drying rack which was made from locally available material was used with laminated tin for complete drying. The rack with laminated tin was placed in an open sunny area away from the shade. To accelerate the drying process, the rack was situated away from forest and or high buildings which reduces, air movement or cast shadows. The sun dried tilapia and cat fish offal was of good quality and marketable products. The offal was hard and well dried and the products had a pleasant odor. The product can be stored for one year without being affected by mold or bacteria. The time taken to dry the offal to the moisture content of 12.81- 15.44% using this technique was 5-6 days. The dried fish offal were also free from either insect or mold contamination. Finally it was concluded that freshly processed fish offal dried on rack with laminated tin under natural and sunny condition, would be expected to dry 5-6 days to achieve final lower moisture content.

Key words: Fish offal, drying rack, moisture content, laminated tin and natural drying

Introduction

Livestock play a major role in Ethiopian Agriculture: produces milk, meat and hides for the farming community. Currently many livestock produce little meat or milk for farmer and his family due to lack of nutritional supplement. For example, if poultry are often so poorly fed with out protein supplement they are unable to give enough eggs. Therefore, the provision of increased quantities of high quality fish meal is one of the best options needed to improve livestock performance

Fish meal and oil industry started in northern Europe and North America at the beginning of the 19th Century (FAO, 1986). Historically fish meal was a by-product of oil production and away of utilizing surpluses and small fishes that could not be used for human consumption (Karimi, 2006).

In the early days, fish oil was produced for the leather and soap industries, and the solid residual was sold as a high nitrogen and phosphorous fertilizer. More recently, the solid residue, or meal, has become too valuable for use as a fertilizer as high protein content makes it suitable for animal feed (Clucas I.J and Ward, A.R, 1996). Fish meal has been used as a livestock feed for many years. Even now it is widely used in Latin America and south East Asia. Good quality fishmeal demands a high price than other high protein feedstuffs.

Fish meal is a high protein supplement which can be mixed with other supplements to produce a balanced diet for livestock (Clucas I.J. and Ward A.R., 1996). MLAY M.L. and M.K. WIZU, B.L. (1982) reported that in other part of the world, fish meal often processed at the village level. ETO, (1982) has also said that fish meal may be manufactured on small scale in many tropical countries, fish are simply air or sun dried on the beach, or concrete floors and then pulverized. Fish meal development is very important to the success of other livestock activities. The contribution of fish meal as animal feed compare to other by products such as oil seed cakes and floor mill is high.

Fish meal is finding their greatest use with simple stomached animal. They are used mostly in diet for which the growth promoting effects of animal protein factor (APF) are valuable. Fish meal is also very important for young animals, whose demand for protein and amino acids is high and important for actively growing pregnant lactating animals. Fish meal is also important in aquaculture production, primarily as a method of utilizing waste from fish processing. It is also used in pet, particularly cats' food and in ration for milking cows. Meal produced from cat fish processing waste sometimes fed back to other cat fish as part of their ration.

The protein in fish meal is a good source of essential amino acids. Of the essential amino acids, lysine is the most critical; it can be present in large quantities in fish meals. The cereal based livestock diets used in feed rations are deficient in lysine, so that the use of fish meal as part of the ration can safely balance the diet. Fish meal is also a good source of minerals and vitamins particularly calcium, phosphorus, sodium, magnesium, potassium, iron, copper, zinc, manganese, iodine, selenium, and B group vitamins such as choline, B_{12} and riboflavin, and growth factors known as the Animal Protein Factor (APF)which can be deficient in a mixed diet.

Traditional way of fish meal processing was started at Ziway 10 years ago. They were used contaminated raw materials (offals) for processing and the final product was inferior in quality due to high level of lipids, ash, and others because they spread the cooked offal on mat on the ground for drying where it can easily get contaminated by dogs, cat and birds. At the same time during processing time they do not control the amount of heat (the temperature and the boiling point) which is the most important part in the preparation of fish meal. Fish meal produced by this traditional way was having extremely bad smell (not fishy smell)

According to Dirk and Tesfaye (1998) the importance of fisheries sector in Ethiopia is difficult to evaluate for the simple reason that at national level the productivity of fish and it's by – product is not recorded. However the total landing from fresh water, rift valley and Tana lakes, of Ethiopia in 1996/ 97 was 10400 tones with an effort of 3000 fisher men. Information is lacking on the amount of fish meal and oil produced in our country

Lake Ziway, with the total area of 434 km^2 is one of the productive and the third biggest rift valley lakes of the country. There is fish processing shade and a freezing unit at Ziway which run by Fish Production and Marketing Enterprise (FPME). Empirical models show the potential yield of all species combined in range of 3000 to 6680 tones per year which can potentially produce 1800-4676 tones of fish meal annually (FAO, 1982, Wel comme, 1979). Therefore, the objectives of this study are developing efficient methods of processing that minimizes losses, and improves the quantity and quality of fish meal, and to maximize the benefit of the fisher men in terms of income and employment.

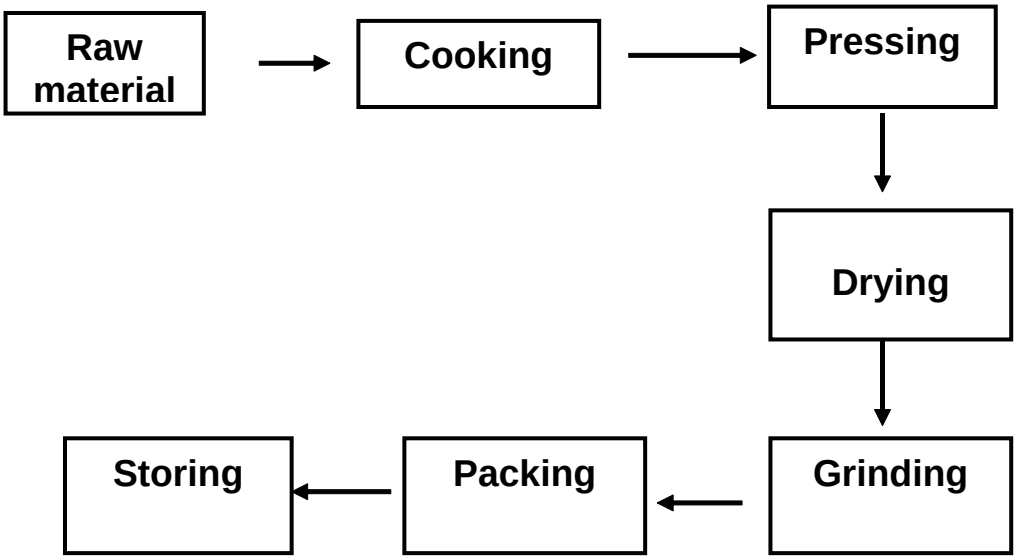
Materials and Methods

The study was conducted at Zeway Fishery Resource Research Center. It is located in mid rift valley at an altitude of 1500 meter above sea level. The average annual rainfall of the area is about 700mm and its mean maximum and minimum temperatures are 27 and 14°C, respectively. Its mean relative humidity and wind speed are55 % and 1.66m/ second, respectively. Data was obtained from Zeway metrological station recorded from November, 2003 to July 2004.

Fish offal and wastes were collected from Fish Production Marketing Enterprise (FPME) and different landing site of Lake Zeway for experimental purpose. Thus offal and wastes were chopped to increase surface area for further process and bulked. The cooking barrel was purchased from the market for cooking offal and divided into two equal parts. Its covering part at the top was made from sheet metal .The capacity of each barrel was 50 kg of offal. The barrel is open at the top. 15 liter of water was added to the barrel and right at the start of boiling, the offal was transferred to the barrel. The offals were stirred gently at intervals and cooked from 35-40 minutes. At the end

of cooking, temperature reading was taken. The final temperature was 70-75^{0}C. The cooked offal was left to settle in the barrel over night. That is from 6 pm to 8 am (morning) to separate the oil, water and solid components. The pressed by-products were spread on the laminated tin on rack for drying in the sun and after the drying process is over it was grinded to produce a powdered new fish meal product ready for use as animal diet. Then, the final product packed in bags normally contains 50 kg paper or polyethylene laminated sacks and stored for one year in a cool and well ventilated areas. The quality of the product was evaluated at Pasture and ILRI laboratory in Addis Ababa for toxicology and their nutrient content.

Flow chart of the process



Heating (cooking)

Heating or cooking is one of the most important steps in the successful operation of fish meal. If the cooking time and temperature are too low the fluid (oil and water) will not be released from the protein and pressing out will be difficult. However if the offal are over cooked the fish will become a soft mush and there will be difficulty in pressing. New experiments however have shown that the walls of the fat cells are broken down before the temperature reaches 50°C (FAO, 1986). The oil is free and theoretically it should be pressable to separate it from the solid materials. Another important observation from recent investigations is that coagulation of the fish protein is completed at 75°C and, further more the process is very rapid. This new experience leads to the conclusion that there is very little, if any thing, to be gained by heating the material beyond 75°C or by using prolonged heating time. But the most common practice of cooking fish offal was to heat to 95-100°C within 15-20 minutes (FAO, 1986). The temperature was regulated by thermometer using the given time (that is 35-40).

Pressing

The purpose of the press is to squeeze out as much liquids as possible from the solid phase. This helps to accelerate the drying process. This is also important to improve the quality of the meal and to reduce the moisture content there by reducing the fuel or energy consumption of the drier. But in the present study this pressing was done by settling the liquid according to FAO (1986).

Drying

The purpose of the drying process is to convert the wet and unstable mixture of press cake and concentration into a dry and stable fish meal. This drying was done by heating to the temperature where the rate of evaporation of the water is considered satisfactory. Increasing the temperature will speed up the drying process. The drying temperature of the present experiment was on an average about 28°C under natural condition. This will help to maintain the nutritional value of the meal (FAO, 1986).

Grinding (milling)

Before milling the meal, it is necessary to remove or check extraneous matter like pieces of wood, clothe, fish hooks and nails, which might still be present. The purpose of milling is to facilitate uniform incorporation in feeds. Properly milled meal has attractive appearance and is readily mixed into feed rations which require homogenous blending. The size of the miles meal was a 10 mesh screen (FAO, 1986).

Bags and storage

Meal is stored and transported in bags. The capacity of fish meal bags used was normally 50 Kg. In tropical areas, the bags are often of Hessian. This is open structured materials allows for the passage of water vapor and oxygen. Under humid condition the hygroscopic meal may absorb moisture. If the moisture content rises above 15%, moulds and bacteria may become active and the meal can compact into solid lump in the bottom of the bag (FAO, 1986).

In the current study polyethylene laminated sacs were used, because

1. they prevent the rapid movement of oxygen and water
2. the meal protected to some extent from insect attack and from contamination by moulds and bacteria
3. the meal can not seep from the sack as it can through hessian

Moisture content

Samples of all fish meal products were analyzed for moisture contents. Moisture content of 5 gm meals were determined relative to the oven dried fish meal at 105^{0}C for 24hrs (Bastock *et al.*, 1987).

Chemical analysis

Samples were analyzed for dry matter (DM) ,ash, organic matter(OM), Nitrogen crude protein(CP), phosphorus(P), ether-extract(EE), potassium(K), calcium(Ca), sodium(Na)and magnesium(Mg). Total Nitrogen was determined by kaladh method (AOAC, 1990). Dry matter content was determined by oven drying all samples at 105^{0}C. Ash was determined by igniting the samples in muffle furnaces at 550^{0}C over night (AOAC, 1990). Nitrogen and phosphorus (P) were determined by auto analysis (Chemlab, 1978and 1984) and crude protein (CP) was calculated as N×6.25. Calcium (Ca), potassium (K) and magnesium (Mg) were determined by AOAC Elmer, (1992) method. Ether extract (EE) was determined by AOAC (1990) method and the difference between dry matter (DM) and ash gives organic matter (OM).

Statistical analysis

Moisture content of sun dried fish meal (Tilapia and Catfish) were statistically tested using system of analysis (SAS, 2001).

Result and discussion

In the present study fresh offals were used for the preparation of quality meal which was high in protein content and low level of lipids, ash and other contaminations. Because the processing steps were well controlled .The meal was dried on raised rack which was covered by net and plastic sheet to prevent pests such as "Abaa koda" bird, dogs, rates etc., and the rain during rainy season. The end product was having only fishy smell. This makes the quality of the newly produced fish meal high and acceptable to users.

The chemical composition of fish offal is indicated in Table 1. As shown in the table below crude protein contents of *Oreochromis niloticus* offal was higher than that of *Clarias gariepinus.* This may be attributed to differences in the feeding habits of fish (Zenebe Tadesse, *et al.,* 1998). *Clarias gariepinus* are carnivores fish feeds on fish, insect, zooplankton, which are rich in protein where as *Oreochromis niloticus* are herbivores feeding mainly on phytoplankton or algae. Hence, food of animal origin contain more protein than algae and this is turn may reflect on the tissue of the consumed fish (Zenebe Taddesse, 1998). Another reason why Clarias gariepinus offal was low in CP content was due to seasonal variations.

Table1: Chemical composition of fish offal.

Type of samples	DM %	Ash %	OM %	P %	CP %	AIA %	Ether %	Na %	K %	Ca %	Mg %	Fe %
Tilapia	92.43	29.52	70.48	0.66	50.77	1.24	9.21	5706.89	0.77	7.63	0.20	1511.8
Cat fish	92.89	37.56	62.44	0.82	45.61	4.42	8.76	6043.16	0.50	9.09	0.24	2497

Fish offal which was heated to the temperature of 70- 75°C has lower moisture content (Table 2). The water content of offal was low comparing to the whole fish. That was about 55%. If this is reduced to 15% spoilage bacteria and moulds can not survive because lower moisture content that inhibits growth of bacteria and moulds (Abera Degebassa, 2004).

The result obtained from the present study shows that lower final moisture contents obtained and the average moisture content of the finally produced fish was 12-15%. It was also observed that to dry fish offal (Tilapia and cat fish) to the final moisture content under natural drying method (sun and wind) it required 5-6 days. The produced meal was well dried free from contamination by dust, sand, animals and others. Therefore it has longer shelf life and less susceptible to spoilage caused by bacteria and moulds.

Table 2: Mean ± SE moisture content of final dried fish o7ffal

Drying method	Fish species	Number of observable	Mean ± SE	P value
natural	Tilapia	8	12.81± 0.74	0.0001
	Catfish	8	15.44 ± 0.44	

Freshness of raw material is important in its effect on the protein in the end product. Minimizing the time between catching fish and processing and of keeping is very important as a means of reducing the spoilage.

Process control is necessary for producing of high quality fish meal. Excess temperature for prolonged periods in the cooking, evaporating and drying should be avoided since fish protein is sensitive to excessive heat. It has been shown that the rate of loss in the availability of lysine is less than 1% per hour at temperature below 120°C and above this as the temperature rises to 140°C the rate increases very rapidly to 10% per hour (Carpenter and Booth, 1973). Under the present studies the offal were cooked from 70- 75°C and the loss of lysine was minimized. During cooking and drying care was taken to avoid contamination of fish meal and was produced with good quality at all stage in handling and storage.

In Lake Ziway a minimum of three species of fishes are found. However, the most economical fish species are Nile tilapia (*Oreocromis nilotcus*) and African cat fish (*Clarias gariepinus*). Korokonch (Ziway) and Menafesha are the major fish landing as well as marketing site of the lake. Wooden and motorized boats are the major vessels used on Lake Ziway.

The most economical fish species used for consumption from Lake Ziway shows that tilapia is the dominant of the catch and cat fish is the second. The average offal from 100 kg of tilapia and cat fish amount to about 70% and 60% by weight of the total fish caught for consumption. When processing 100 kg of each fish (tilapia and cat fish) they give 20% and 22% of dry weight, respectively. However, over 70% of the offal is water (FAO, 1986). It needs urgent research attention on fish offal which is not properly exploited as animal feed resource. So the production of fish meal could be the solutions that can urgently solve the problem of increasing price of animal feeds to encourage more people to go in to animal farming and thus increasing animal production by increasing protein supply.

Composition and quality

The chemical compositions of fish offal (tilapia and catfish) are shown in table 1. Fish meal is a rich source of protein. Fish meals have relatively high energy content and rich in important minerals such as phosphorus in vitamin B and essential fatty acids. The constituent of the meal vary according to the raw materials and processing methods. The protein content is on average about 65% but it can vary from 50- 75%; fat content between 5 to 10%; mineral content depends on the raw material and varies between 12 and 33% (Clucas, I.J. and Ward, 1996). In the present study the crude protein content of tilapia and cat fish was about 50.77% and 45.61%, respectively. The fat content was 9.21 and 8.76%. The ash or mineral content was 29.52% and 37.56 %, respectively. The moisture content was between 12.81% and 15.44%, respectively. Fish meal is evaluated in the market on the basis of crude protein content. Prices are often set per unit protein (the unit protein being percentage of protein in the meal). There fore, the produced meal by the present study contain 50.77% CP and at present its price in Ethiopia is about 4.00 birr/kg.

Poulter *et al*., (1982) reported that the product could have free shelf life over one year for offal dried to below 15% moisture content. The present study showed that with moisture content of 12 – 15% the dried offal can be stored for one year without being spoiled by mould and bacteria. However, Sidewell *et al.,* (1974) stated that for high fat content fish offal (cat fish) the actual shelf life of the dried fish offal may be shorter due to the envitable onset of rancidity.

During the drying process and storage of the dried meal infestation was a major problem. In addition to this it causes loss in quality and quantity, insect pests are carriers of pathogenic bacteria and thus represent a serious health hazard (Proctor, 1977; Wood, 1978). There fore care was taken at all stages of fish handling and processing in order to control insect infestation such as flies and blow flies. No evidence of beetle attack was found on any of the bathes of fish at the end of drying period, because all the fish were well dried and checked during the experiment.

Conclusion and recommendation

The product obtained during and at the end of the experiment was good and marketable product. After one year storage it was in good condition and free from insect and pest attack. Therefore it can be concluded that freshly processed fish offal dried on rack under natural and sunny condition, would be expected to dry in about 5 days to achieve final lower moisture content. Hence, it can be recommended that fresh fish offal processed under local condition using locally available materials and dried on rack are appropriate and good in feed quality for livestock. Because the energy from the sun is free and also the product is free from contamination by animals and insect.

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References

Abera Degebassa. (2004) Solar drying of fish fillet using tent in ziway .Proceedings of the 12th annual conference of the Ethiopian Society of Animal Production (ESAP} held in Addis Ababa, Ethiopia, August 12-14, 2004.

AOAC (Association of Analytical Chemists) 1990. Official method of analysis (15th ed.). AOAC Inc. Arlington, Virginia, USA.

AOAC (Association of Analytical Chemists) 1980. Official method of analysis (13th ed.). AOAC Inc. Washington DC, USA.

Bostock, T. W., Walker, D. J. and Wood, C. D., 1987, Reduction of losses in cured fish in the tropics. Guide to extension workers.

Carpenter, K.J. and V.H. Booth 1973, Damage to lyasine in food processing: its measurement and significance. Nutr. Abstr. Rev., 43(6):423- 511

Chemlab. 1978. Continuous flow analysis. Method Sheet No. W2-075-01. Determination of Orthophosphate in water and waste water. Chemlab Instruments Ltd. Horn church, Esex, UK.

Chemlab 1984. Continuous flow analysis system 40. Method Sheet No. CW2-008-17 (Ammonia (0-1 and 0-50 PPM. N). Chemlab Instruments Ltd. Horn church, Essex,UK.

Clucas and AR Ward 1996. Post-Harvest Fisheries Development : A guide to handling preservation, processing and quality. Chatham Maritime, Kent ME4 4TB, United Kingdom

Dirk, R. and Tesfaye Wudneh. 1998. Fisheries management : A review of current status and working paper 26. Minstry of Agriculture. Addis Ababa. Ethiopia.

Etoh, S. (1982) Fish meal from by-catch on a cottage industry scale. Info fish marketing Digest, No.S:24-28.

FAO ,1982.Data book on land use and Agriculture in Ethiopia vol. 1 : 254 p , vol. 11 pp. 255- 472 ,Rome, FAO publ. (AG : DP / ETH/78/oo3

FAO , 1986. The production of fish meal and fish oil. Fishery industries division. FAO fishery technical paper 142.

Karimi , A. 2006. The effect of varying fish meal inclusion levels on performance of broilert

chicks. International Journal of poultry science 5 (3) , 255-258.

Mlay, M. L. and Mkwizu, B. L. (1982) The production of fish meal at the village level.

Paper presented at the FAO expert consultation on Fish Technology in Africa, Casablanca and Morocco. June, 1982.

Perkin Elmer 1992. Analytical methods for atomic absorption Spectrophotometer. Perkin Elmer Coorporation, Norwalk, Connenticut, USA.

Poulter, R.G., Doe, P.E. and Olley, J. 1982 Isohalic sorption isotherms 2. Use in prediction of

storage life of dried salted fish. Journal of food technology, 17,201-210

Proctor,D.L. 1977. The control of insect infestation of fish during processing and storage in the tropics. Processing of the conference on handling, processing, and marketing of tropical fish,pp.307_311.London Tropical Products Institute.

SAS.2001. SAS users guide version 8.2. Stastitical Analysis System (SAS). INC. ,Cary North Carolina , USA.

Sidwell, V.D. , Foncannon,P.R. ,Moore...,N.S. and Bonnet, J.C. 1974. Composition of the edible portion of raw (fresh or frozen) Crustaceas, fin fish and molluscus.1.protein,fat, moisture ,ash ,carbohydrate ,and colesterol. Marine Fisheries Review, 36(3), 21-35.

Welcomme , R. L , 1979. The inland fisheries of Africa. CIFA OCC. Pap (7): 69p.

Wood C.D. (1981) The preservation of losses in cured fish. FAO Fisheries Technical Paper, No.219, 87 pp

Zenebe, T. (1988) Studies on some aspects of the biology of *Oreochromis* in lakes of Ethiopia, Msc. Thesis, Addis Ababa university, 78pp

Zenebe Tadesse, Ahlgren, G, Gustafsson, I-B and Boberg, M. 1998. Fatty acid and lipid content of *Oreochromis niloticus* L. in Ethiopia lakes dietary effects of phytoplankton. Ecol. Fresh. Fish 7:146-158

Evaluation of Chorkor smoker and Altoona oven for smoking Nile tilapia (*Oreochromis niloticus*) fish at Ziway, Ethiopia

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Abstract

Fish is an important source of food and income to many people in the developing world. The high moisture content of fish renders it extremely perishable. One attractive way to help fishing communities is to improve the technology they use by introducing new or better ways of processing and preserving of fish. Fish smoking prolongs its shelf life; enhance flavor and increases utilization in soups and sauces. It also increases protein availability to people through out the year and makes fish easier to pack, transport and market. The study was conducted at Zeway Fishery Resource Research Center (ZFRRC) from September, 2005 to June, 2006 using commercially important fish species, Nile tilapia (*Oreochromis niloticus*) in two treatment combinations that is salted and unsalted. The main objective of the study was to compare the fish preserving efficiency of chorker and altona ovens and prolong the shelf life of smoked fish. Improved chorkor and the Altoona ovens were measured 0.85m high, 1.70m long, 0.9m width, 0.6m thick and 1.70m high, 1m long, 1.28m width, and 0.6m thick with the carrying capacity of 1 kg of prepared fish per tray, respectively. The ovens were placed in the shade which was constructed from locally available materials to protect them from the rain, sun and strong air movement or wind. The consumption of firewood (fuel) of the improved chorkor smoker was compared with that of the Altoona oven. Thirty-seven kg of fire wood was used to smoke 100 kg of gutted fish using Chorker smoker, while forty kg of firewood was used to smoke the same amount of fish. The time taken to smoke the prepared fish using both ovens to the moisture content of 14-40% was 3-4 days, respectively. All smoked fish in the chorkor oven had acquired good quality, consumed low fuel and less time to be smoked. The smoked fish using Altoona oven was also good in quality but consumed more fuel and took longer smoking time comparing with chorkor oven. The final product obtained can be stored for "wet hot smoked" under -5^{0}C for 3 months and for "dry hot" smoked fish from 6 to 9 months with out being affected by bacteria and moulds. Hence, it is concluded that chorkor smoker is appropriate and convenient for small scale fisher men in the humid areas of Ethiopia.

Key words*:* Nile tilapia, salt, moisture content, chorkor and Altoona ovens

Introduction

Fish is an important source of food and income to many people in the developing world. The high moisture content of fish renders it extremely perishable. One attractive way to help fishing communities is to improve the technology they use by introducing new or better ways of processing and preserving of fish. It has been estimated that in the high ambient temperatures of the tropics, fish spoils with in 12-20 hours of being caught depending on species and size (Geoff Ames *et.al.*, 1991)

Smoking is a good method of drying and preserving fish where there is no cold facility for frish fish handling. However, it requires skill and experience to produce a high quality end product that will keep long shelf life. Hot smoking of fish involves temperature of more than 80^{0}C and the fish is cooked during processing. The reason for smoking fish are varied but, as far as Ethiopia is concerned, the process has proved to prolong its shelf life, enhance flavor and increase utilization in soups and sauces, reduce wastage times of bumper catches, store for the lean season and increase protein availability to people through out the year (Clucas and Ward, 1996)

For smoking of fish fruits trees and residual of corn are best if available. Wood or plants which have been impregnated, colored, gummed or painted are not used for smoking. The raw material used for the generation of smoke should be free from extraneous material such as plastic. In Ethiopia we use all kinds of trees except true man trees and eucalyptus trees which are not suitable for smoking fish as they give the fish unpleasent smell, taste and flavors. It is not necessary to salt or brine the fish before smoking however, this depends on the local tradition. The use of salt does, however, improve the storage life and inhibits the growth of micro-organisms. The fish can be smoked whole, filleted, cut etc., (Clucas, 1982).

There fore, in search for improved smoking techniques, the use of chorkor smoker has been investigated at Ziway Fishery Research Center as an alterative to traditional ovens. Thus, the objective of this study was to test fish preserving efficiency of the two ovens and prolong the shelf life of smoked fish.

Materials and Methods

The study area: This experiment was conducted at Zeway Fishery Resource Research Center (ZFRRC), located in mid-rift valley at an altitude of 1840 m.a.s. l. The average annual rain fall is rarely exceeds 700mm.and its mean maximum and minimum temperature is 27 and 14^0C, respectively.

Description of the ovens

Altoona oven

The oven consists of a firing chamber (combustion) constructed from mud bricks, with a stoke hole at the bottom of the front wall. The smoking unit, which is fixed by mud brick on top of the combustion chamber, was enclosed and has a chimney .The fish was skewered through the eyes with metal roads and hung in the enclosed chamber for smoking. The holding capacity of Altoona oven is10 kg of prepared fish at a time. The cost of construction of Altoona oven is estimated to be…. than that of chorkor oven.

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Figure 1. Diagram showing Altoona oven used in the study

Chorkor oven

The chorkor smoker (oven) was constructed from locally available materials at low cost. It consists of a combustion chamber and a smoking unit with a set of trays. The combustion chamber is rectangular, twice as long as it's wide and divided by a wall down the middle and with two stokes holes in the front. The combustion chamber is the base of the smoker and was generally constructed from mud. The top of the oven wall is square, level and flat so that the trays fit flush

and no smoke or heat can escape through the gaps. The smoker was designed in such a way that the woods frame of the trays rest along the middle line of the base walls so that they were firmly supported and do not catch the fire .The capacity of chorkor smoker was 10 kg of prepared fish per trays. The distance of the fire from the base to the last tray was 50cm.

Figure 2. Diagram showing Chorkor oven used in the study.

Experimental design and data analysis:

Fish preparation

A total of 12 smoking experiments were carried out using freshly caught fish, Nile tilapia (*Oreochromis niloticus*). Only high quality fish were used for the smoking experiments. The range of preparation method and pretreatments were as follows.

Treatment 1

Dry salted Nile tilapia: the scale of each fish was removed, gutted and washed before salting by soaking in 10% brine for 40 minutes and then packed in fine dry salt using 1 kg salt to every 10 kg of prepared fish by weight and left over night (approximately for 12 hrs). The number of observation was 12 for each.

Treatment 2

Brined Nile tilapia: After being prepared in the same manner as for treatment one except that the fish is not packed in the dry salt, the fish were placed in saturated brine for 60 minutes.

Treatment 3

Unsalted prepared tilapia: the fish were gutted according to local customs. That is the guts were removed from each fish but after washing with clean water were kept to smoke without salting.

During the experiment, locally produced salt was used for dry salting. After salting, the fish were carefully washed to remove excess crystals from the surface and were allowed to drain before smoking the capacity of the chorkor smoker was up to 10 kg of fish per trays.

The trays filled with fish were stacked on top of each other in the ovens (up to 10 trays was used on one oven for one smoking cycle) with a total of 100 Kg of wet fish. The fire was set in the fire pit of each chamber of the oven with small amount of hard wood. Hard woods burn slowly, producing plenty of heat and a minimum of soot, and they impart a sweet taste to the fish.

The fire is closely watched, and as soon as it becomes too intense, some sticks of wood were removed. For the final stage (drying) and also for re-smoking the fish after several weeks of storage

only small amount of wood is used. In this case the fuel may be straw or saw dusts that have been moistened to produce plenty of smoke.

In order to ensure even smoking the fish were turned and the orientations of the trays were changed 2-4 times during the smoking cycle. The upper trays were placed closer to the fire, while the lower ones were moved higher. After 2-3 hours of hot smoking, the contents of two or three trays of partly smoked fish can be combined in one tray. Then it can be smoked over the moderate fire (below 60^0C) to continue the drying process. If the fish show brown color that it is completely smoked and removed from the oven and allowed to cool for 10 minutes, packed and stored in the storage.

Moisture content

Samples of all smoked salted and unsalted products were analyzed for moisture content. Moisture contents of 5 grams of smoked fish were determined relative to the weight of oven dried fish at 105^oC for 24 hours (Bostock et al, 1987)

Statistical analysis

Moisture content of salted and unsalted smoked fish (Nile tilapia) was statistically tested using the GLM procedure of SAS (SAS, 2001).

Result and discussion

Depending on the type of fish to be smoked (species, thickness, way of cutting), what it will be used for and the length of time it may have to be stored the smoking process can take one hour to two days. The consumption of fire wood (fuel) of the improved chorker oven was compared with that of Altoona one. 37 asnd 40 Kg of fire wood was used to smoke 100 Kg of prepared fish using the two ovens to the moisture content of 14-40 % in 3 and 4 hours, respectively. All smoked fish in the chorker oven was good in quality and marketable products. It took less time and fuel .The smoked fish using Altoona oven was good in quality, but it took more fuel and time than the chorkor oven .Under chroker smoker “wet hot smoking fish would require 3 hours but under Altoona oven it required 4 hours. For hot dry smoked fish it took 10 hours for chorkor oven and 18 hours for Altoona oven. The final product obtained by “wet hot ”smoked fish can be stored for 3 months under -5^0C and from 6 to 9 months for” dry hot” smoked fish without being affected by bacteria and moulds.

Nile tilapia treated with salt and smoked hot dry have significantly lower moisture content ($P<0.05$) than unsalted smoked tilapia in chorkor oven, but in Altoona oven no significant difference was observed (Table 1). This indicates that the total fish smoked treated with salt and unsalted were similar for all treatments. Spoilage bacteria can not survive the reduction of water content of fish from 80% to 25% because lower moisture content inhibits growth of bacteria and moulds (Abera Degebasa, 2004).

The result obtained from the study using both ovens show that lower final moisture content were achieved and the average moisture content for dry hot smoked fish and wet hot smoked fish were 14 to 40%, respectively. The recorded data indicated that the difference in moisture content between salted and un salted fish was relatively small .This is due to the combined effect of the smokers and the presence of salt in the fish .Therefore, salted hot dry smoked fish has longer shelf life than “wet hot” smoked fish and less susceptible to spoilage caused by bacteria and moulds.

The store of smoked fish should be a clean, dry, well ventilated room which has been, protected against the entry of animals and insects which are the major problem. The smoke-dried fish should be placed on shelves that allow good air circulation. Insect infestation causes losses in quality and quantity, insect pests are carrier of pathogenic bacteria and represent a serious health hazard (Procter, 1977; Wood, 1981).Therefore, care has to be taken at all stages of fish handling

and processing in order to control insect infestation such as flies and blow flies. Depending on the storage life required, it is necessary to re-dry (re-smoke) at some intervals during storage. This is particularly relevant during the rainy season when the relative humidity is high. Bostock, *et al.*, (1987) reported that it is very important to ensure that the skin of smoked fish is completely dry before the fish are stored in order to reduce the risk of mould growth , because fish which are not cooled properly before being stored are more likely to be attacked by moulds. Wood, (1983) stated that the smoked dried fish are brittle, losses and breakage often occurs when the products are packed and taken to the market. Hence, careful handling when packing can reduce losses.

Table 1 Mean ± SE moisture content of smoked salted and unsalted fish using chorkor smoker and Altoona oven.

treat-ment	product	n	smoking method	Mean dry weight ± SE
1	Dry salted tilapia	4	chorkor	14.075c ± 0.72
			altoona	18.325 a ± 0.12
	Brined Nile tilapia	4	chorkor	40.075a ± 0.77
2			ltoona	33.050a ± 0.41
3	Unsalted Nile tilapia	4	chorkor	26.825 b ± 0.48
			altoona	27.100a ± 0.85

Treatment mean bearing the same letter are not significantly different ($p < 0.05$)

The chorker smoker has proved to be useful innovation in fresh water fisheries, because it is easily adjusted to local needs and conditions. In Ziway it was built from mud made bricks with teff straw. These bricks are more durable and have better heat retention properties, which further improves fuel efficiency.

The smoker is user-friendly, easily to operate and time saving, thus alleviating drudgery. It has reduced labor requirements by about 30% and fire wood use by about the same. It has contributed immensely to the production of high quality smoked fish, as it can smoke about 100 kg of fresh fish, about ten times the capacity of the traditional cylindrical mud/metal oven.

Conclusion and recommendation

The chorkor smoker helps to create job opportunities and generate incomes for rural fisher men. It also encourages younger women to take up fish smoking as a profession. Hence, it can be concluded that fish smoked using chorkor and Altoona oven would be expected to smoke in 3 and 4 hours, respectively to achieve final lower moisture content. But in case of hot dry smoked fish it would take 10-18 hours.

It was also observed that fish smoked using chorkor smoker consume less fuel and time. Therefore, it is recommended that chorker oven is appropriate and convenient for fisher men of humid area in Ethiopia where fish drying is not possible.

References

Abera Degebassa, 2004. Solar drying of fish fillet using tent in ziway .Proceedings of the 12th annual conference of the Ethiopian Society of Animal Production held in Addis Ababa, Ethiopia, August 12-14, 2004.

Bostock, et al . (1987) Reduction of losses in cured fish in tropics. Guide for extension workers. Report of the Tropical Development and Research Institute.G204,v+47pp

Clucas I.J., 1982. Fish handling, Preservation and Processing in tropics. Part II. Report of the tropical development and research institute,G145,vii +144pp

Clucas I.J and Ward A.R., 1996. Post harvest fisheries development. A guide to handling, preservation processing and quality. Chatham Maritime, Kent ME4 4TB, United Kingdom.

Geaff Ames, Ivor clucas and Susan Scott Paul, 1996. Post harvest losses of fish in the tropics.

Proctor, 1977.

Wood,1981. The control of insect infestation of fish during processing and storage in the tropics .Proceeding of the conference on handling, processing and marketing of tropicalfish,pp307-311.London Tropical Products Institute.

Wood C.D., 1983. Losses of traditional cured fish .A case study .In proceeding of the work shop on the production and storage of dried fish .Universiti Pertaniam Malaysia,Serdang.(Malaysia),2-5 November 19982. FAO Fish Report.

Participatory Evaluation of Gillnet and Long Line on Lake Beseka, Ethiopia

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Abstract

Evaluation of gillnet and long line was conducted on lake Beseka from April 2005 to march 2006 using 75 m long gillnets of 60, 80,100 and 120mm stretched mesh each and long line having 60 branch line of hook size 5,6,7,and 8 each. Gillnet with stretched mesh size of 80 mm has got maximum catch (58.35 %) by weight of the total catch recorded from gillnet. Hook size No. 5 has got maximum catch (34.7%) by weight of the total catch recorded from long line. *Oreochromis niloticus* and *Claries gariepinus* are the two fish species recorded from the catch but *Oreochromis niloticus* has low market demand in the area for its poor body condition (b value 2.367) compared with *Claries gariepinus*. 50.40% by weight of the gillnet catch was *Oreochromis niloticus* whereas 99.2% of the long line catch was *Claries gariepinus*. On the other hand, long line catches live *Claries gariepinus* where as gillnet caught claries gariepinus was found died, which is prone to spoilage.

Key words: Lake Beseka, Gillnet, Long line, Oreochromis niloticus, Claries gariepinus, Evaluation

Introduction

Currently, fishing is a potential field serving as job opportunity, source of animal protein, and recreation (Zenebe, 1988). Fish farming was started many years ago and currently culture fishery is leading capture fishery in different corners of the world.

Ethiopia has a number of international rivers, beautiful Lakes, and reservoirs which have political, ecological and economical importance. Estimated potential of these water bodies ranges from 30,000 - 40,000 metric tones per year. However, only 20-30% of this resource is utilized due to different reasons (FAO, 1995). Some of the reasons include lack of technical skill, cultural, market, infrastructure and other socio-economic conditions.

Fishery resource utilization requires better infrastructure as it is the most perishable agricultural commodity. This nature of the item resulted over exploitation of few accessible lakes like Zeway, Langano, and Awasa whereas those found in inaccessible areas are not yet exploited (Alem, 1993).

Lake Beseka is one of the rift valley lakes showing continuous expansion in volume. As sited in (MWR, 1998) the lake has increased from 3 km^2 to 42 km^2 in the last 30 years. Run of, under ground water influx from sugar cane irrigation and more than forty submerged springs are the probable causes for sharp increase in volume (MWR, 1999). Fishing activity has been started before 1976 on this lake by organized fishermen, but there is series problem of appropriate fishing gear for this particular water body. Being in area where food security is series issue, lake Beseka has an estimated fish potential of 205 tons per year (FAO, 1995) where as, the current production is not greater than 15-17 tons per year. Beach seine fishing is impossible due to volcanic rocks and submerged woods that made the fishing ground irregular. Moreover, net fishing has got problem due to interference of crocodile. Hence, most of the fishermen are forced to use long line and few use gillnet. However, fishermen have crucial problem in fishing gear durability and selectivity for the target fish.

Fishing gear is one of the essential components in fishery and use of appropriate fishing gear ensures sustainable resource utilization. The over all objective of this experiment was to evaluate gillnets and long lines of different size in participatory way with the local fishermen and recommend the best fishing gear that is economically and ecologically friendly.

Description of the study area

Lake Beseka is found in East shoa Zone Fentale district 200km from Addis Ababa on the way to Djibouti, 955 meters above sea level (Mamo& Getaneh, 2003). The mount Fantalle which is 2007 m high is found few km north of the lake and the largest sugar factory Metehara is also found south east of the lake. Both the high way and the rail way from Addis Ababa to Djibouti and Dire Dawa cross the North part of the Lake. Lake Beseka holds one large Island having an area of 3-4km^2. This island is the most protected area harboring wild life. The south west of the lake has three active hot springs which are used as thermal therapy for the surrounding community. Lake Beseka is accessible both by rail way and high way and also adjacent to Awash national park which increases its value for eco-tourism.

Materials and methods

Three local wooden boats, 4 gillnets of 60, 80, 100, 120mm each 75 m long each, 240 hooks of hook size 5,6,7,8 each 60 in number was constructed. Five fishermen were selected from the existing fishery cooperatives on voluntary bases to participate on the data collection. Filwuha, Jamaica, Gimel meda, Deset, Wacho, and Hadid are randomly selected as sampling site.

Sampling

Both gillnet and long line was set overnight (from 5:00pm to 7:00am) at a depth of 3-6 m. Soap known as Zap was used as bait for line fishing as that of local fishermen. Sample from each fishing gears under evaluation was recorded separately and measured for total length (TL) and total weight (TW) to the nearest 0.1 cm and 0.1g, respectively and sexes of most specimen were determined by pressing the abdomen and/or dissected the gonads.

Result

From 35 settings done in the experimental period a total of 1066 fish were collected from all gill nets under evaluation. Catch composition of the gillnet shows that 186 (17.44%) fish were *Claries gariepinus* whereas the remaining 880 (82.55%) was *Oreochromis niloticus*. On the other hand 49.6% of the catch by weight was *Claries gariepinus* whereas 50.4 % was *Oreochromis niloticus*. Compared with other gillnets, Gillnet with stretched mesh size 80mm has got maximum catch which is 622 fish (58.35 %) by weight of the total catch from gillnet.

Table1. Catch summery of different Fishing gears under evaluation

Gear type	Fish spp	No of setting	Mean L(cm)	Mean weight(gm)	N
Gillnet 60mm	*Oreochromis niloticus*	35	18.35	128.23	350
Gillnet 80mm	*Oreochromis niloticus*	35	19.98	154.65	508
Gillnet 100mm	*Oreochromis niloticus*	35	19.17	134.28	21
Gillnet 120 mm	*Oreochromis niloticus*	35	19	100	1
Gillnet 60mm	*Claries gariepinus*	35	42.35	539	20
Gillnet 80mm	*Claries gariepinus*	35	42.28	547.1	114
Gillnet 100mm	*Claries gariepinus*	35	49.94	812.77	47
Gillnet 120mm	*Claries gariepinus*	35	81.9	2022	5
Hook no. 5	*Claries gariepinus*	35	54.25	1409.17	20
Hook no.5	*Oreochromis niloticus*	35	17.5	120	1
Hook no. 6	*Claries gariepinus*	35	59.22	1735.56	9
Hook no. 7	*Claries gariepinus*	35	60.67	1821.67	6
Hook no.8	*Claries gariepinus*	35	45.26	767.88	33
Hook no. 8	*Oreochromis niloticus*	35	24	275	2

Catch composition from this gillnet showed 508 *Oreochromis niloticus* and 114 *Claries gariepinus* with mean length of 19.98cm and 42.28cm, respectively. Mean weight of the former species were 154.65gm whereas that of the later is 547.10gm.

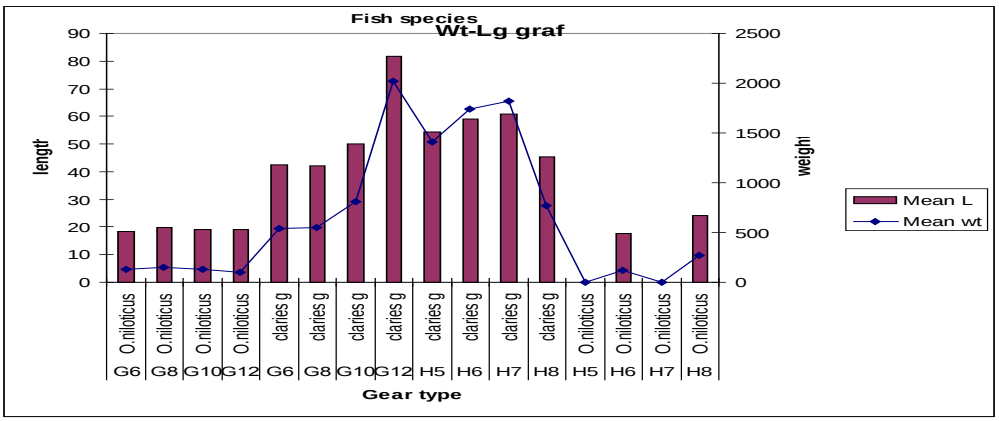

Fig 1. Length weight graph from all gear type under evaluation

Ninty nine percent by weight of long line catch were *Claries gariepinus* which indicates that long line is selective than gillnet. Comparison between hooks of different size revealed that hook number 5 has got maximum catch (34.7% by weight) n=20 followed by hook number 8 which has got 31.19%, n=33. Mean weight of Claries gariepinus caught by hook number 5 was 1409.17gm while mean length was 54.25cm and that of number 8 was 767.88gm and 45.26cm, respectively.

Oreochromis niloticus was found in excess, but with poor body condition (b=2.367) compared with the same species found in other lakes. Fishermen were observed collecting fingerlings of *Oreochromis niloticus* using mesh wire from shore to use as bait.

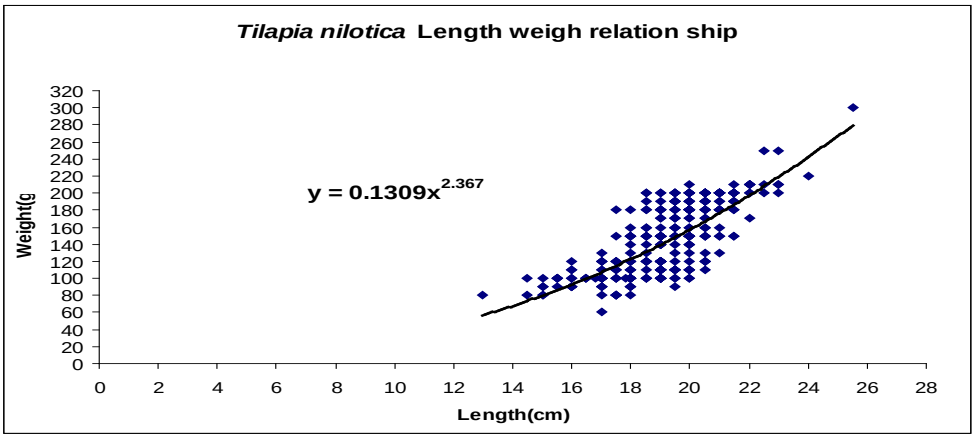

Fig. 2 Oreochromis niloticus Length weight relationship

However, fishermen preference was *Claries gariepinus* to *Oreochromis niloticus* for that the later has low market demand in the local market despite its abundance. Moreover, *Claries gariepinus* collected from all gillnets has less preferred by fishermen compared to those collected from long line for the reason that it was found to be easily spoiled. In addition, maximum catch recorded

by gillnet highly attracted crocodile and the most efficient gillnet was seriously damaged by the crocodiles. A number of fish were eaten from gillnet before sampling and ten (10) crocodiles were died entangled in gillnet during the whole experimental period.

Discussions and recommendations

As the lake size is increasing from time to time there may be changes in water chemistry. This change will favor or disfavor the fish and other aquatic biodiversity. Car washing using lake water, for its bleaching power, became a common practice on the rim of the lake and currently organized local communities are highly involved in this activity. As different vehicles and heavy trunks involved in oil, chemical and other substances transportation are washed in to this lake, there might be risk of pollution which will be fatal for the inhabiting biodiversity and the local community as well. Hence, car washing should be stopped and limnological parameters should be carried out periodically.

Fishermen suggest that crocodiles are increasing from time to time and their increase in number is becoming the major obstacle for fish resource utilization. The study has also confirmed that use of net fishing destructs both the non target fish (*Oreochromis niloticus*) and the crocodile resource. So that there has to be a method by which both crocodiles and the fish are sustainable utilized. Long line fishing is the best environmentally friendly and selective to catch commercially important *Claries gariepinus*.

Oreochromis niloticus found in the lake are not yet utilized due to their small size. Elderly fishermen say that the size of *Oreochromis niloticus* is decreasing compared to the time when the lake size were small and beach seine fishing was present. This might be stunting due to excessive breeding supported by low phytoplankton and zooplanktons in the water. Evaluation of the varity under feeding condition (aquaculture) and distocking *Oreochromis niloticus* population will be the researchable gaps to know the reason for stunting. Introduction of Claries gariepinus fingerlings to boost production can be the best solution if the above methods failed.

Reference

Alem M., 1993. Overview of fishery sector in Ethiopia. Proceedings of the National Seminar on fishery policy and strategy. pp45

FAO, 1995. Review of the Fisheries and Aquaculture Sector. Ethiopia. FAO, Rome.

Mamo T. and Getaneh E., 2003. The geology and surface alteration mapping of Fantale geothermal Prospect, intern report of Geological Survey of Ethiopia, Hydrogeology, Engineering Geology and Geothermal Departement, 29P.

MWR, 1998. Study of Lake Beseka (Inception report, vol.1). Ministry of Water Resources, Addis Ababa, Ethiopia, 2003.

MWR, 1999. Study of Lake Beseka (main report, Vol. 1). Ministry of Water Resources, Addis Ababa, Ethiopia.

ZenebeT., 1998. Food and feeding ecology of tilapia (Oreochromis niloticus L.) and effect of diet on lipid quality of fish in some lakes of Ethiopia. . Ph.D. dissertation, school of Graduate Studies, Addis Ababa University, Addis Ababa, 139 pp.

Labour availability and use pattern in smallholder livestock production system in Yerer watershed of Adaa Liben district

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Abstract

The study was carried out in 'Yerer watershed' of Adaa Liben district which comprises two peasant associations namely Yerer Silassie and Gende Gorba, with an objective to identify the labour use pattern, availability and gender labour division in different livestock production activities of mixed farming system of the study area. A total of 150 sample farmers or 10 percent of household heads in the watershed were included in the study.

Among the different livestock activities milking, barn cleaning and animal product marketing were the responsibilities of female members of the family. On the other hand, live animal marketing, livestock herding and watering, and feed collection were the responsibilities of males. Except animal herding and watering which were the responsibilities of age group of 10-14 years, all the other activities are mainly the responsibilities of the productive age group (15-64 years) within the family. The household heads themselves were responsible for herding, watering and feed collection. Labour shortage was a problem for about 46.3 percent (n=62) of the farmers. Feed collection and livestock herding, respectively were the first and second important activities for which most farmers have labour shortages and give priority for labour allocation. Due to year round demand of labour for herding, most farmers in the area hire additional labour for herding at first.

Key words: Division of labour, livestock activities, herding,

Introduction

Labour is an essential household resource in most African livestock production systems. The availability of labour within the household is determined by size, sex and age composition of the family. As reported by Getachew *et al.*, (1993) in some selected vertisol Ethiopian highlands, family sizes per farm are large and it amounts to five persons at Dogollo, and 5.6 persons at Ginchi and Inewari. The use of labour is often closely related to the use of other resources (e.g., land and capital) by the households and the production system, thereby influencing management practices, enterprise combinations, labour hiring/sharing strategies and overall levels of technical and economic performance (ILCA, 1990).

Gender within the household is an important dimension in labour allocation in mixed crop–livestock production systems. Gender division of labour varies across regions. Both men and women take part in livestock management. However, women generally contribute more labour inputs in areas of feeding, cleaning of barns, milking, butter and cheese making and sale of milk and its products than men and children. Children herd animals (Tangka *et al.*, 2000).

Adult males and females are normally assumed to be different in terms of the amount of effective work they can do, though there may be some tasks (e.g. in cropping) where their work output will be equivalent. Children's work output will depend on their age and the nature of the task performed. For some tasks (e.g. herding), a child of 14 years, for example, can perform as effectively as an adult (ILCA, 1990). However, the major source of farm labour comes from members of 15 to 65 years of age (Getachew *et al.*, 1993).

In the traditional crop–livestock systems in the Ethiopian highlands, women milk, process and sell milk and dairy products. Revenue from the sale of butter and cheese is the main source of income for women (Whalen, 1984). Incomes collected by men are largely spent on food and other items for the family (Shapiro *et al.*, 1998). This implies that there are different responsibilities and shared tasks and a lot of flow or exchange of resources and outcomes among family members in the Ethiopian highlands (Tangka *et al.*, 2000). In Debre Berhan, the average daily amount of time women spend on livestock-related activities are: 23 minutes in milking, 1.25 hours in cleaning the barn, 1.5 hours in collecting dung, one hour in making dung cakes and 1.75 hours every other day in processing milk (Giglietti and Steven, 1986). The same study noted children spending an average of nine hours a day herding and watering animals and collecting dung.

With all these backgrounds, this study was carried out to identify the labour availability status, labour use pattern, and gender labour use in different livestock production activities of mixed farming system of the study area.

Material and Methods

Description of the study area

This study was carried out in Adaa Liben district of the east Showa administrative zone of Oromiya Regional State (ORS). The specific study area "Yerer watershed" comprises two peasant associations (PAs) namely Yerer Silassie and Gende Gorba. These two PAs are part of the 45 PAs in the district. Yerer Silassie and Gende Gorba PAs share common boundaries and are totally part of the watershed, and cover a land mass of about 3372 and 3820 ha., respectively (WOA, 2003) and are located at $8^{o}50$ to $8^{o}53$ latitude and $38^{o}55$ to $38^{o}59$ longitude.

The overall farming system in Adaa Liben district in general and in the study area in particular is characterized by mixed crop-livestock production system, and the system is well integrated. The crop production is a dominant system over the livestock system in the district in general and in the watershed in particular. Livestock production is a second important system next to crop for the overall farming system in the study area. The major contribution of livestock production for the farming community is provision of draft power, transport and as a means of security. According to WOA (2003) report, the specifically studied PAs (Yerer Silassie and Gende Gorba) has a total livestock population of 5,269.4 and 6,777.2 TLU, respectively. The livestock classes held by farmers in the study area include; cattle (oxen, cows, heifers, bulls and calves), equines (donkey, mule and horse), small ruminants (sheep and goat) and poultry (WOA, 2003).

Sampling methods

The two peasant associations in the Yerer watershed namely Yerer Silassie and Gende Gorba were used for the study. All the three villages from each PA: Buti, Korke and Makana for Yerer Silassie, and Goditi, Dedema and Worko for Genda Gorba were included in this study. Due to shortage of time and resource, about 10 percent of the household or total of 150 sample household farmers were randomly selected based on the proportion of total households in the two PAs using Probability Proportional to Size (PPS) approach. Therefore, out of the total households (525) in Yerer Silassie and (950) in Gende Gorba, proportion of 54 and 96 household were included in the study, respectively. At village level, in Yerer Silassie 12, 15, and 27 households were selected randomly for Buti, Korke and Makana, and at Gende Gorba 28, 39, and 29 households were selected randomly for Goditi, Dedema and Worko, respectively. Moreover, in order to capture gender of household head effect in family labour availability and gender division of labour in different livestock production activities, the sample households on each village were stratified to female and male headed households. At this level the numbers of female (22) and male (128) headed households were determined using Proportional Probability to Size (PPS) approach.

Data collection and analysis

In the study two methods/approaches namely discussion with key informants for baseline information and formal (diagnostic) survey using well structured questionnaire were used.

In the primary phase of the study, group discussion was held with key informants to investigate and have an overview about the type of activities and gender division of labour in livestock production sub-system. The information generated in the key informant discussion phase was used for the preparation and development of the questionnaire for the formal survey. The questionnaire was pre-tested on sample households. Single visit multiple subject survey method was employed in diagnostic survey. Detail about household family size, labour unit, gender division of labour, seasonal labour availability and demand, solutions to overcome labour shortage and priority of livestock activities in labour allocation were investigated through interview with the head of household. The labour unit within the family was estimated using coefficient to convert family size under different sex and age groups into a standard labour unit as given in Table 1.

Table 1. Coefficients used in the study for converting household labour to a standard labour unit

SEX CATEGORY	AGE CATEGORY	WORK CONDITIONS	LABOR UNIT
Both Sex	<8 or >75years	All	0
Children of both sex	8-14years	Full time Part time	0.5 0.25
Adult Male	15-65	Full time Part time	1.0 0.5
Old Male	66-75	Full time Part time	0.5 0.25
House wives	15-65 66-75	Part time Part time	0.5 0.25
Adult Female	15-65	Full time Part time	0.7 0.35
Old Female	66-75	Full time Part time	0.35 0.18

Source; Bekele Shiferaw (1991).

The raw data collected from the formal survey were entered in Excel for data arrangement and cleaning. Finally, cleaned data were analyzed by a computer using person chi-square test and logistic regression of SPSS release version 12.0.1 (SPSS, 2003).

Results and Discussions

Available labour unit in the family

The average labour unit within the family was 3.27 ± 0.12 (Mean ± SE). The total mean labour unit in the family was higher ($P<0.01$) for households headed by men (3.40 ± 0.13) than households headed by women (Table 2). The average labour unit per household in this study is found to be higher than 2.5 adult equivalents (2.5 labour units) reported by Mukasa-Mugerwa (1981) in Adaa district. Therefore, due to family size increment the average labour unit per household in this study was higher than his estimate.

Table 2. Family labour unit difference between the two PAs and households headed by men and women in Yerer watershed.

VARIABLE	GROUP	N	$\overline{X}$	SE	P-VALUE
OVERALL		150	3.27	0.12	
PA	YERER SILASSIE	54	3.14	0.20	0.456
	GENDE GORBA	96	3.34	0.16	
HOUSEHOLD HEAD SEX	MALE	128	3.40b	0.13	0.008
	FEMALE	22	2.48a	0.34	

Means in the column within variable followed by different superscript letters were significantly (P<0.01, T-test) different.
PA= Peasant association

The available labour unit within the family was stratified by different age groups and is presented in Table 3. The mean available labour unit for the productive age group of 15-64 years was higher (P<0.01) for male than female headed households.

Table 3. Family labour unit difference within age groups between the two PAs and households headed by men and women in Yerer watershed.

AGE GROUP	VARIABLE	GROUP	N	$\overline{X}$	SE	P-VALUE
BETWEEN 10-14 YEARS.	OVERALL		150	0.59	0.05	
	PA	YS	54	0.67	0.08	0.204
		GG	96	0.55	0.05	
	HHSEX	MALE	128	0.61	0.05	0.302
		FEMALE	22	0.48	0.11	
BETWEEN 15-64 YEARS.	OVERALL		150	2.60	0.11	
	PA	YS	54	2.45	0.17	0.321
		GG	96	2.69	0.15	
	HHSEX	MALE	128	2.73b	0.12	0.006
		FEMALE	22	1.86a	0.30	
ABOVE 64 YEARS.	OVERALL		150	0.07	0.01	
	PA	YS	54	0.03a	0.01	0.012
		GG	96	0.10b	0.02	
	HHSEX	MALE	128	0.06	0.02	0.053
		FEMALE	22	0.14	0.04	

Means in the column within variable followed by different superscript letters were significantly (P<0.01 and P<0.05, T-test) different.
PA= Peasant association, YS= Yerer Silassie, GG=Gende Gorba, HHSEX=household head sex

Therefore, this result shows that male household heads have better family labour unit than female household heads. This has direct relation with higher average family size of male household heads. Moreover, the higher average labour unit in male headed household also relates with higher average family holding of 15-64 years age groups in the household. Furthermore, due to high proportion of family member within age group of >64 years in female headed households resulted in less labour unit in the household.

Quantifying the detailed labour input in to various livestock production activities was not possible through farmers interview. According to Mukasa-Mugerwa (1981), with an average family labour unit (2.5 adult equivalents[9]) the accurate division of family labour is very critical. This is true with the average labour unit of 3.27 from this study. Because of the dominance of crop production, most of the family labour unit is used for crop related activities, and labour input for livestock activities is limited.

9 1 adult equivalent= 1 adult man, 0.75 adult female, 0.5 child of 10-15 years and 2 children of less than 10 years (Jahnke, 1980 as cited in Mukasa-Mugerwa, 1981).

Gender division of labour in livestock activities

Milking

Out of the total 69 farmers having milking cows, 73.9 percent (n=51) of the farmers indicated that females are responsible for milking and this division of labour for milking was the same for both the PAs and both the households headed either by men or by women (Tables 4 and 5). About 65.2 percent (n=45) of the farmers indicate that females within age groups of 15-64 years were responsible for milking (Table 6). Whalen (1984) also indicated that women are responsible for milking and milk processing in most smallholder ruminant livestock production system in Africa.

Livestock herding and watering

It is evident that in both the PAs male members of the family are responsible for herding and there was no difference between the two PAs (Table 4). However, in households headed by women about 25 percent indicated that herding is also done by female members of the family. Thus, there was difference (P<0.01) between the gender of household heads in division of family labour for livestock herding. A similar trend was observed in watering animals (Table 5).

In general, based on farmer's opinion, about 50.4 and 50.7 percent of farmers said that herding and watering, respectively are done by the age group of 15-64 years, and 27.8 and 22.4 percent of the farmers assigned these works to 10-14 year age group, respectively (Table 6). The role of children in livestock herding and watering has been reported in Debre Berhan (Giglietti and Steven, 1986). Moreover, Tangka *et al*. (2000) reported that children of both sexes are responsible to herd animals in smallholder livestock production system in Africa.

Table 4. Farmers response on division of labour for livestock activities based on sex between the two PAs of Yerer watershed

ACTIVITIES TYPE	PA	TOTAL HH (N)	GENDER			X2 P-VALUE
			MALE	FEMALE	BOTH	
			%	%	%	
MILKING	YS	30	26.7	66.7	6.7	0.345
	GG	39	12.8	79.5	7.7	
	TOTAL	69	18.8	73.9	7.2	
HERDING	YS	52	96.2	3.8	0.0	0.603
	GG	81	92.6	6.2	1.2	
	TOTAL	133	94.0	5.3	0.8	
WATERING	YS	52	98.1	1.9	0.0	0.348
	GG	82	92.7	4.9	2.4	
	TOTAL	134	94.0	3.7	1.5	
BARN CLEANING	YS	52	9.6	90.4	0.0	0.479
	GG	82	7.3	90.2	2.4	
	TOTAL	134	8.2	90.3	1.5	
LIVE ANIMAL MARKETING	YS	52	88.5	11.5	0.0	0.685
	GG	82	85.4	13.4	1.2	
	TOTAL	134	86.6	12.7	0.7	
ANIMAL PRODUCT MARKETING	YS	54	31.5	66.7	1.9	0.035
	GG	91	18.7	69.2	12.1	
	TOTAL	145	23.4	68.3	8.3	
FEED COLLECTION	YS	52	96.2	3.8	0.0	0.695
	GG	82	93.9	4.9	1.2	
	TOTAL	134	94.8	4.5	0.7	

YS= Yerer Silassie, GG=Gende Gorba, PA.= Peasant associations, HH= Household heads

Barn cleaning

About 90.3 percent of the farmers indicated that barn cleaning is the responsibility of female member of the family in both the PAs and households headed by men and women. Thus, this division of labour for barn cleaning holds true for both the PAs and households headed by men or women (Tables 4 and 5). This is in agreement with Tangka *et al*. (2000) who reported that women generally contribute more labour inputs in barn cleaning. Moreover, Getachew *et al*. (1993) reported that women are responsible in milking cows (at times assisted by men), barn-cleaning and dung cake-making at Dogollo, Ginchi and Inewari. Like other activities, the productive age groups (15-64 years) were also responsible for barn cleaning (Table 6).

Table 5. Farmers response on division of labour for livestock activities based on sex between male and female household heads

ACTIVITIES TYPE	HOUSEHOLD HEAD SEX	TOTAL HH (N)	GENDER			X2	P-VALUE
			MALE %	FEMALE %	BOTH %		
MILKING	MALE	59	18.6	74.6	6.8		0.925
	FEMALE	10	20.0	70.0	10.0		
	TOTAL	69	18.8	73.9	7.2		
HERDING	MALE	117	96.6	2.6	0.9		0.001
	FEMALE	16	75.0	25.0	0.0		
	TOTAL	133	94.0	5.3	0.8		
WATERING	MALE	118	95.8	1.7	1.7		0.003
	FEMALE	16	81.3	18.8	0.0		
	TOTAL	133	94.7	3.8	1.5		
BARN CLEANING	MALE	118	6.8	91.5	1.7		0.235
	FEMALE	16	18.8	81.3	0.0		
	TOTAL	134	8.2	90.3	1.5		
LIVE ANIMAL MARKETING	MALE	118	94.1	5.1	0.8		0.000
	FEMALE	16	31.3	68.8	0.0		
	TOTAL	134	86.6	12.7	0.7		
ANIMAL PRODUCT MARKETING	MALE	124	26.6	65.3	8.1		0.091
	FEMALE	21	4.8	85.7	9.5		
	TOTAL	145	23.4	68.3	8.3		
FEED COLLECTION	MALE	118	97.5	1.7	0.8		0.000
	FEMALE	16	75.0	25.0	0.0		
	TOTAL	134	94.8	4.5	0.7		

HH= Household heads

Table 6. Distribution of family and hired labour for livestock activities based on sex and age group in Yerer watershed

ACTIVITIES TYPE	FAMILY MEM-BERGENDER GROUP	TOTAL HH		FAMILY MEMBER AGE GROUP							HAIRED LABOUR	X2 P-VALUE
				0-10yrs	11-14 yrs.	15-64 yrs.	>65yrs.	11-14 & 15-64yrs.	15-64 yrs. & HAIRED	15-64 & >65yrs.	15-64 yrs.	
		N	%	%	%	%	%	%	%	%	%	
MILKING	MALE	13	18.8	0.0	0.0	17.4	0.0	0.0	0.0	0.0	1.4	
	FEMALE	51	73.9	0.0	4.3	65.2	4.3	0.0	0.0	0.0	0.0	0.369
	BOTH	5	7.2	0.0	0.0	7.2	0.0	0.0	0.0	0.0	0.0	
	TOTAL	69	100.0	0.0	4.3	89.9	4.3	0.0	0.0	0.0	1.4	
HERDING	MALE	125	94.0	3.0	27.1	46.6	0.0	5.3	0.8	0.0	11.3	
	FEMALE	7	5.3	0.0	0.0	3.8	0.8	0.0	0.0	0.0	0.8	0.021
	BOTH	1	0.8	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	
	TOTAL	133	100.0	3.0	27.8	50.4	0.8	5.3	0.8	0.0	12.0	
WATERING	MALE	126	94.8	4.5	21.6	49.3	0.0	7.5	0.7	0.0	11.2	
	FEMALE	5	3.7	1.5	0.0	1.5	0.7	0.0	0.0	0.0	0.0	0.000
	BOTH	2	1.5	0.0	0.7	0.0	0.0	0.0	0.0	0.7	0.0	
	TOTAL	133	100.0	6.0	22.4	50.7	0.7	7.5	0.7	0.7	11.2	
BARN CLEANING	MALE	11	8.2	0.7	0.7	6.0	0.0	0.7	0.0	0.0	0.0	
	FEMALE	121	90.3	0.0	8.2	70.1	3.7	7.5	0.7	0.0	0.0	0.263
	BOTH	1	1.5	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	
	TOTAL	134	100.0	0.7	9.0	77.6	3.7	8.2	0.7	0.0	0.0	
LIVE ANIMAL MARKETING	MALE	116	86.6	0.0	0.7	85.1	0.0	0.0	0.0	0.7	0.0	
	FEMALE	17	12.7	0.0	0.0	10.4	2.2	0.0	0.0	0.0	0.0	0.002
	BOTH	1	0.7	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	
	TOTAL	134	100.0	0.0	0.7	96.3	2.2	0.0	0.0	0.7	0.0	
ANIMAL PRODUCT MARKETING	MALE	34	23.4	0.0	0.0	22.8	0.7	0.0	0.0	0.0	0.0	
	FEMALE	99	68.3	0.0	0.7	64.1	3.4	0.0	0.0	0.0	0.0	0.855
	BOTH	12	8.3	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	
	TOTAL	145	100.0	0.0	0.7	95.2	4.1	0.0	0.0	0.0	0.0	
FEED COLLEC-TION	MALE	127	94.8	0.0	0.7	86.6	2.2	0.7	0.7	0.0	3.7	
	FEMALE	6	4.5	0.0	0.0	3.7	0.7	0.0	0.0	0.0	0.0	0.925
	BOTH	1	0.7	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	
	TOTAL	134	100.0	0.0	0.7	91.0	3.0	0.7	0.7	0.0	3.7	

HH= Household heads

Feed collection

According to 94.8 percent farmers in both PAs, feed collection is a routine work of males. However, in households headed by women about 25 percent household heads stated that females are also responsible for this job. Thus, there was difference (P<0.001) between the households headed by men and women (Table 5). Moreover, based on farmers opinion about 91 percent of them indicated that the productive age groups (15-64 years) was responsible for feed collection (Table 6). Other studies show that men are involved in forage collection and feeding livestock (Getachew *et al.*, 1993). Tangka *et al.* (2000) also stated that women are responsible to cut the grass and supervise feeding and grazing of cows.

Live animal marketing

Based on the response of farmers, it can be concluded that live animal marketing is done by the males in both the PAs. However, among the households headed by females, 68.8 percent of heads of family responded (Table 5) that the female members were responsible for live animal marketing (P<0.001). Thus, heads of household have access for income from live animal selling which is used for major expenses of the family. Again live animal marketing is the responsibility of the productive age groups (15-64 years) as per the response of over 96 percent of the farmers (Table 6). As indicated by Tangka *et al.* (2000), in most smallholders farming system live animal marketing is

the responsibility of head of the family. However, joint decisions by husband and wife are made on the purchase and sale of livestock (Tangka *et al.*, 2000).

Animal product marketing

Gender role are different (P<0.05) in animal products marketing in the two PAs. In Yerer Silassie, more number of males take part in animal products marketing compared to Gende Gorba. The long distance of major marketing places for Yerer Silassie may result male family members to be responsible for animal products marketing as compared to Gende Gorba. In general, about 68.3 percent (n=99) farmers in the study area indicated that female members were responsible for marketing of animal products than male member of the family (Tables 4 and 5). Therefore, females of the family within age groups of 15-64 years were more responsible for animal product marketing than male member of the family (Table 6). According to Tangka *et al.* (2000) report in the traditional crop–livestock systems in the Ethiopian highlands, women milk, process and sell milk and dairy products. Revenue from the sale of butter and cheese is the main source of income for women. Also this result indicates that women within the family have access to petty cash which may be used to the daily expenses of the family as whole. These authors also reported that women are also responsible to distribute the milk to different users.

As far as the overall livestock activities were concerned, male members of the family shoulder more responsibilities within the age groups of 15-64 years. This is in agreement with Getachew *et al.* (1993) who indicated that the major source of farm labour comes from members of the family who are 15 to 65 years of age. However, for major livestock activities the responsible gender of the family members is also determined by sex of household heads. Thus, this result indicates that household heads themselves are responsible for major livestock activities in the area such as livestock herding, watering and feed collection.

Labour supply and demand in livestock activities

The labour allocation, shortage and hiring priority for different livestock activities were investigated in the area (Table 7) and the priority difference among the activities were tested. The priority difference in labour allocation, shortage and hiring were significant (P<0.001) among the different activities. Hence, about (59.0 and 53.7%) and (48.8 and 66.7%) of the farmers in the study area ranked feed collection and herding as first and second in labour allocation and for which labour was scarce, respectively (Table 8). Due to more labour requirement for herding throughout the year, over 65.8 and 55.0 percent of the farmers ranked herding and feed collection as first and second priority, respectively for hiring additional labour (Table 8). Herding and feed collection are the most labour intensive activities in livestock production, due to this fact children in the highland mixed farming system spend about 9 hours in animal herding and watering (Giglietti and Steven, 1986). As a result most farmers in crop dominated mixed farming systems where labour allocation priority is given for crop production face labour shortage for these activities in livestock production.

The difference in labour allocation priority for feed collection and livestock herding between the two PAs and genders of household heads were not significant. However, about 63.7 and 60.0 percent of the farmers gave first and second rank for feed collection and herding, respectively in labour allocation (Table 7).

Table 7. Priority in labour allocation, shortage and hiring for feed collection and livestock herding in Yerer watershed.

PRIOTITY IN LABOUR	TOTAL HH (N)	FEED COLLECTION			TOTAL	HERDING		
		1st	2nd	3rd		1st	2nd	3rd
		%	%	%	N	%	%	%
ALLOCATION	124	63.7	31.5	4.8	120	34.2	60.0	5.8
SHORTAGE	40	72.5	25.0	2.5	49	42.9	53.1	4.1
HIRING	20	45.0	55.0	-	34	73.5	23.5	2.9

HH= Household head

Table 8. Farmers response on labour allocation, shortage and hiring priority among different livestock activities in Yerer watershed

ACTIVITY TYPE	PRIORITY IN LABOUR ALLOCATION				PRIORITY IN LABOUR SHORTAGE				PRIORITY IN LABOUR HIRING			
	HH	1st	2nd	3rd	HH	1st	2nd	3rd	HH	1st	2nd	3rd
	N	%	%	%	N	%	%	%	N	%	%	%
All	2	1.5	0	0	11	17.7	0	0	1	2.6	0	0
Brncln	56	0.7	9.7	31.3	8	0	7.7	38.5	4	2.6	5	66.7
Clfcar	7	0	0	5.2	3	0	0	23.1	-	-	-	-
Fedcol.	124	59	29.1	4.5	40	46.8	25.6	7.7	20	23.7	55	0
Hrd.	120	30.6	53.7	5.2	49	33.9	66.7	15.4	34	65.8	40	33.3
Milking	13	8.2	0.7	0.7	1	0	0	7.7	2	5.3	0	0
None	76	0	4.5	52.2	-	-	-	-	-	-	-	-
Promark.	1	0	0	0.7	-	-	-	-	-	-	-	-
Takvet.	3	0	2.2	0	2	1.6	0	7.7	-	-	-	-
X2 P-VALUE		0.000				0.000				0.000		
Total (N)	402	134	134	134	114	62	39	13	61	38	20	3

Brncln= Barn Cleaning, Clfcar=Calfcare, Fedcol. = Feed Collection, Hrd. =Herding, Promark.= Product Marketing, Takvet.= Taking Animals To Vet., HH= Household heads

The labour shortage status of farmers between the two PAs and genders of household heads were significantly ($P<0.05$) different. Hence, farmers at Gende Gorba had more shortage of labour compared to those in Yerer Silassie. Households headed by women experienced greater extent of labour shortage than male headed households (Table 9).

Table 9. Variation in labour shortage and hiring condition between the two PAs and genders of household heads in Yerer watershed.

VARIABLE	GROUP	TOTAL HH (N)	LABOUR SHORTAGE		HIRED	
			N	%	N	%
PA	YS	52	18	34.6	13	25.0
	GG	82	44	53.7	25	30.5
X^2 P-VALUE			0.035		0.558	
HHSEX	MALE	118	50	45.4	31	26.3
	FEMALE	16	12	75.0	7	43.8
X^2 P-VALUE			0.017		0.152	
	TOTAL	134	62	46.3	38	28.4

YS= Yerer Silassie, GG=Gende Gorba, HHSEX=household head sex, HH= Household head, PA= Peasant association.

According to farmers response, farmers at Gende Gorba had more ($P<0.05$) labour shortage through out the year for both feed collection and herding compared to those in Yerer Silassie. Due to the closeness of Gende Gorba to Debre Zeit town, farmers in the area spent more time in off-farm activities and this resulted labour shortage for farmers at Gende Gorba in livestock activities as compared to farmers in Yerer Silassie. However, the labour shortage was more critical during

the dry (*Bega*) and the main rainy season (*Kiremt*) at Yerer Silassie for feed collection and herding, respectively (Table 10). The labour shortage for feed collection may resulted due to the seasonal labour demand for feed collection during the dry season on which majority of the family labour involved in crop harvesting and threshing. Moreover, the labour shortage in herding during the main rainy season may result from the demand of labour to control the animals from damaging the cropped farm lands.

Table 10. Seasonal variation in labour shortage for feed collection and livestock herding between the two PAs and genders of household heads in Yerer watershed.

GROUP	TOTAL HH (N)	SHORTAGE SEASONS IN FEED COLLECTION				TOTAL HH (N)	SHORTAGE SEASONS IN HERDING		
		ALL	DSE	SRS	MRS		ALL	DSE	MRS
		%	%	%	%		%	%	%
PA									
YS	13	69.2	15.4	7.7	7.7	15	73.3	6.7	20.0
GG	27	100.0	0.0	0.0	0.0	34	91.2	8.8	0.0
X^2 P-VALUE			0.026					0.027	
HHSEX									
MALE	33	90.9	3.0	3.0	3.0	40	87.5	7.5	5.0
FEMALE	7	85.7	14.3	0.0	0.0	9	77.8	11.1	11.1
X^2 P-VALUE			0.592					0.724	
TOTAL	40	90.0	5.0	2.5	2.5	49	85.7	8.2	6.1

YS= Yerer Silassie, GG=Gende Gorba, PA= Peasant association, HH= Household head HHSEX=household head sex, All= all year, DSE= Dry season, SRS=Short rainy season, MRS= Main rainy season.

Therefore, the overall labour demand and supply for livestock production activities of the area indicated that feed collection and livestock herding were the most important activities which demand more labour and there is labour shortage problem in the production system.

Conclusion

The division of labour within a family differed between the two household head sex groups in major livestock activities such as herding, watering, animal marketing and feed collection. As the result of this study indicates, there was division of labour within the household for activities such as (milking, barn cleaning and animal product marketing) which were the responsibilities of women and (herding and feed collection) which were the responsibilities of men. Labour was found to be a scarce resource in livestock production for about 46.3 percent of the farmers in the area. Among the different activities, feed collection and livestock herding were the major labour demanding activities for which most farmers in the area face labour shortage problem. Therefore, priority was given for feed collection and livestock herding in allocation of available labour and hiring additional labour.

Reference

Bekele Shiferaw, 1991. Crop-livestock interaction in the Ethiopian highlands and effect on sustainability of mixed farming: A case study from Ada district. An MSc. Thesis presented to the Agricultural University of Norway. 163p.

Getachew Asamenew, Haily Beyene, Workineh Negatu and Gezahegn Ayale, 1993. A survey of the farming system of vertisol areas of the Ethiopian highlands. In: M. Tekaligne, A. Abiye, K.L. Srivastava and D. Asegelil (eds.). Improved management of vertisols for sustainable crop-livestock production in the Ethiopian highlands: Synthesis report 1986-92. Technical Committee of the joint vartisol project. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia.

Giglietti, R. and R. Steven, 1986. Labour requirements in livestock enterprises among ILCA sample farmers in Debre Berhan area: Highlands Program. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 44p.

ILCA., 1990. (International Livestock Centre for Africa). Livestock system research *manual*, ILCA Working Paper No. 1, Volume 1. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 287p.

Mukasa-Mugerwa, E., 1981. A study of traditional livestock production in Ada district of Ethiopia. Mimeograph. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 154p.

Shapiro, B.I., J. Haider, Alemu Gebre-Wold and Abebe Misgina, 1998. Crossbred cows and human nutrition and health in the highlands ecoregion: Evidence from Ethiopia, Mimeograph. International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia. 22p.

SPSS., 2003. Statistical Program for Social Study. Version 12.0.1, release of 2003 Chicago, Illinois, USA.

Tangka, F.K., M.A. Jabbar and B.I. Shapiro, 2000. Gender roles and child nutrition in livestock production systems in developing countries: A critical review. ILRI Socio-economics and Policy Research Working paper 27. International Livestock Research Institute (ILRI), Nairobi, Kenya. 64p.

Whalen, I.T., 1984. ILCA's Ethiopian highlands program: Problems and perspectives in expanding the participation of women. Paper prepared for IITA/ILCA/Ford Foundation workshop on Women in Agriculture in West Africa, Ibadan, Nigeria, 7–9 May 1984. 24p.

WOA, 2003. (Woreda Office of Agriculture Adaa Liben). General characteristics of Adaa Liben Woreda. Debre Zeit, Ethiopia. (Unpublished data)

Lactation performance of dairy cows in the Yerer watershed, Oromiya region, Ethiopia

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Abstract

The study was conducted in the Yerer watershed located in Ada Liben Woreda of East Shoa Zone of Oromiya Region from August 2003 to September 2004. The objectives of the study were to characterize the overall lactation performance of local and crossbred dairy cows in the watershed and to understand, lactation yield, daily yield, lactation length of local and crossbred dairy cows and their influence on production.

The major livestock kept by the farmers were cattle, equine, poultry, sheep and goats with an average holding of 5.45 ± 2.7 Tropical Livestock Unit (TLU) per household. The proportion of oxen over female cattle was high.

The overall milk yield per lactation in the watershed area was 506.78 liters, made up of 238.35 liters for local and 1558.12 liters for crossbred. In the Yerer watershed, considering average lactation yield and average lactation length of local cows, the average estimated daily milk off take from local cows was 1.09 liters. The average estimated daily milk yield of crossbred cow was 5.97 liters. The overall lactation length of both local and crossbred cows in the watershed was 7.52 ± 1.64 months as per farmer's statements.

In the watershed, the estimated overall average milk production per household consumption unit was 84.18 liters. Again considering average milk production from local dairy cows, the average consumption was much less than the expected to be consumed by household consumption unit per year.

Though in Yerer watershed the average milk produced per farm was 835.97 liters most of the households produced hardly 180 to 240 liters of milk per farm per year. Out of this, 82.2 percent of milk or milk products were consumed and rest was marketed. Selling price of fresh milk in the watershed ranged from 1.65 to 1.85 Birr per liter.

Farmer's perception to have crossbred dairy cows and to increase exotic germplasm in the reproductive herd was highly positive, for the purpose of generating income.

Introduction

Ethiopia is one of the least developed countries in the world with per capita income of 130 US Dollars (World Bank, 1996). Poverty and food insecurity are the two major problems in the country. As in many developing countries, agriculture is the mainstay of the Ethiopians and about 85 percent of the total population is engaged in the sector. The contributions of the sector to the country's Gross Domestic Product (GDP) and exports are about 60 % and 90 %, respectively (World Bank, 1995). Animal production plays a significant role in the countries economy. The livestock sub sector contributes approximately 12- 15 percent to the GDP (McDaC, 1999).

The estimated number of indigenous milk cows in Ethiopia is about nine million and are in the hands of smallholder farmers and pastoralists under traditional management systems. In Ethiopia about 300,000 crossbred or upgraded cows are used for milk production under relatively improved management conditions in urban and peri-urban areas. The total milk production per year from cattle is 0.8 million tons out of 1.0 million tons from all the species put together in Ethiopia (Azage *et al.,* 2000). The traditional management systems, which have evolved over the years, are characterized by low input feeding and management with indigenous genotypes. This system

can be classified in to nomadic (pastoral) production system, livestock crop mixed system (agro-pastoral) and crop livestock mixed system.

As cited by Azage *et al,* (2000) a study undertaken by the Addis Ababa Agricultural Development Bureau in 1996 indicated that the per capita consumption of milk is as low as 16 liters. Considering an estimated minimum consumption of 250 ml of milk per head per day, the current demand supply variance is about 170 million liters per year. At a national level, by the year 2025, the total human population is estimated to reach 140 million with about 40 million living in urban areas. Given the current number of milk cows and lactation yield, the projected demand-supply variance for milk in the urban sector is about 2.74 billion liters per annum. In order to fulfill the increasing demand, at least a consistent four percent annual increase in milk production will be required (Azage *et al.,* 2000).

Lactation performance

Despite the large livestock population, livestock productivity in Ethiopia is below the average compared to most countries in eastern and sub-Saharan Africa. For example, the annual growth rate of cow milk was 1.4 percent for Ethiopia compared to 2.9 percent for eastern Africa 2.4 percent for sub-Saharan Africa (SSA) (FAO, 1995). Similarly, in 1994 average milk yield were 209 kg/animal for Ethiopia compared to 350 kg/animal for eastern Africa and 376 kg/animal for SSA (FAO, 1995).

Table 1. Lactation yield of local cows

Breed	Lactation yield in liters	Country	Source
Arsi	377	Ethiopia	Schaar et al. (1981)
Zebu	929	Ethiopia	Kiwuwa (1983)
Horro	508	Ethiopia	IAR (1991)
Zebu	450	Ethiopia	Yitaye (1999)

Table 2. Lactation length of local cows

Type	Lactation length in days	Country	Source
Boran	139 to 313	Ethiopia	Wahid (1976)
Arsi breed for 1st lactation	148	Ethiopia	Schaar et al. (1981)
Arsi breed for 2nd lactation	227	Ethiopia	Schaar et al. (1981)
Arsi breed for 3rd lactation	237	Ethiopia	Schaar et al. (1981)
Fogera	175	Ethiopia	Schaar et al. (1981)
Boran	172 to 185	Ethiopia	Schaar et al. (1981)
Barka	185	Ethiopia	Schaar et al. (1981)
Zebu cows	303	Ethiopia	Kiwuwa (1983)
Horro	229	Ethiopia	IAR (1991)

Table 3.Daily yield of crossbred cows in some places of Ethiopia

Cross bred type	Daily yield in (kg)	Country	Source
Arsi and Friesian crosses*	6.4	Ethiopia	Kiwuwa et al. (1983)
50% Arsi-Friesian	5.7	Ethiopia	Kiwuwa et al. (1983)
50% Zebu-Friesian	6.3	Ethiopia	Kiwuwa et al. (1983)
75% Friesian-Arsi	6.0	Ethiopia	Kiwuwa et al. (1983)
75% Friesian- Zebu	6.2	Ethiopia	Kiwuwa et al. (1983)
50% Friesian-Zebu crosses	5.1	Ethiopia	Gashaw (1992)

* Unknown blood level

Table 4. Lactation yield of crossbred cows in Ethiopia

Cross bred types	Lactation yield in liters	Location	Source
Friesian and local crosses*	1800	Debre Zeit	Gryseels and Anderson, (1983)
Friesian and local crosses,1st lactation*	1769	Debrezeit	Gryseels and Anderson, (1983)
Friesian and local crosses, 2nd lactation*	2347	Debrezeit	Gryseels and Anderson, (1983)
Friesian and local crosses*	1600	Debreberhan	Gryseels and Anderson, (1983)
50 % Friesian-Zebu crosses	1800	Arsi	Kiwuwa et al. (1983)
50 % Friesian-Zebu crosses	1291.8	Selale	Gashaw (1992)
Friesian and local crosses*	3357	Ada Berga	Mureja (1994)
Jersey-local crosses*	1820	Ada Berga	Yimam (1994)
75 % Friesian - Arsi crosses	1540	Arsi	Teferi (1994)
Friesian and local crosses*	1581	Agarfa	Keberu (2000)

* Unknown blood level

Table 5.Lactation length of crossbred cows

Crossbred	Lactation length in days	Country	Source
50 % Friesian and half Arsi crosses	313	Ethiopia	Kiwuwa et al. (1983)
Friesian and Boran crosses 1st lactation at Debre Zeit ILCA*	439	Ethiopia	Gryseels and Anderson (1983)
Friesian and Boran crosses 2nd lactation at Debre Zeit ILCA*	304	Ethiopia	Gryseels and Anderson (1983)
Crossbred cows in Selale area*	327	Ethiopia	Gashaw (1992)
Crossbred cows*	300	Ethiopia	Yitaye (1999)
Crossbred cows*	330.7	Ethiopia	Keberu (2000).

***Unknown blood level**

Objectives of the study

The objectives of the study were to characterize the overall Lactation performance of local and crossbred dairy cows in the watershed

- Lactation yield of both local crossbred dairy cows
- Daily yield of local crossbred dairy cows
- Lactation length of local crossbred dairy cows

Materials and methods

The study was conducted in Yerer watershed of Ada Liben Woreda of the Eastern Shoa Administrative Zone of Oromiya Regional State.

Location and climate of the area

Ada Liben Woreda is located 45 km south east of Addis Ababa, at an altitude of 1600 to 2400 m above sea level. Situated at 8° 44' N and 38° 58' E. Mean minimum and maximum temperatures are 10.6 and 25.0 °C, respectively. The rainfall pattern of the area is bimodal with the small rains (short rainy season) occurring between February and April and main rains (long rainy season) between mid June and mid September. The mean annual rainfall is 800 mm (WBOA, 2003). The long term mean annual rainfall shows that the short rains contribute 30 percent of the annual precipitation (Astatke *et al.,* 1995).

The Woreda has a total land of 161,056.3 ha of which about 119,449.5 ha and 6461.83 ha of land is being used for crop cultivation and as pasture land, respectively (WBOA, 2003). Also about 10,632.5 and 1630 ha of land is supposed to be covered by forest, bushes and shrubs, and lakes (water lands), respectively (WBOA, 2003). The particular study area "Yerer Watershed" found in Ada Liben Woreda some about 14 km north of Debre Zeit and consists of two Peasant Associations (PAs), namely Yerer Silase and Gende Gorba which covers about 3,372 and 3,820 ha of land, respectively (WBOA, 2003). Total watershed area covers about 4.5 percent of the Woreda. The human population of Yerer Silase and Gende Gorba peasant associations is estimated to be 4,104 and 7,427 with population density of 121.7 and 194.4 person per sq. km, respectively (WBOA, 2003). The number of households in Yerer Silase and Gende Gorba are 525 and 950, respectively. In Yerer Silase PA, out of the total number of households 19.32 percent (101) are female headed and the rest 80.76 percent (424) are male headed. In the Gende Gorba PA, female headed households account for 13.7 percent (130) and male headed are 86.3 percent (820) (WBOA, 2003).

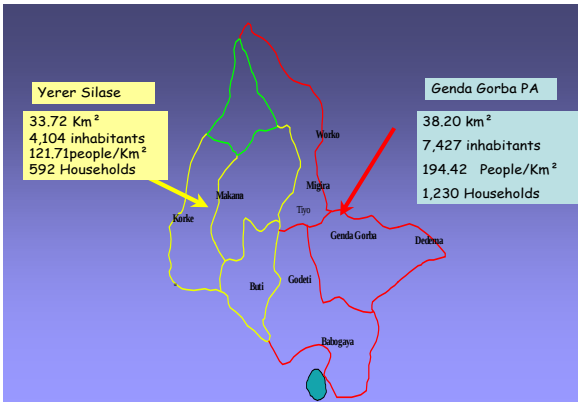

Figure 1.Map of the study area

Although rain fall is bimodal, it is the big rains that are mainly used for crop production. Rains during the months of July to September are very intense. Cropping operations are not carried out during the small rains, but it helps to grow grasses for livestock and is also used for preparation for cultivation during the main rains. The Yerer watershed has one of the peak of the woreda (3100 m.a.s.l.) as one gets over mountain (WBOA, 2003). Because of the sloppy topography, and clearing of forests for expanding of cultivated land and accelerated the soil erosion gradually destroying the soil resource in the study area (Hurni, 1990).

The average minimum and maximum air temperature data at 1.5 m from ground for twenty seven years (1977-2003) ranged from 7.9 (1985) to 28.2ºC (1987). However mean annual temperature for this period was 18.5ºC (Kahsay, 2004). Highest temperature was observed for the months of March, April, May, and June, while the months October, November and December had the lowest temperatures.

Data for the study

Both qualitative and quantitative data were used for the study using exploratory and diagnostic survey. The data that were obtained through secondary information were included. The study covered six villages of the two PA's. Using Participatory Rural Appraisal (PRA) and rapid survey, attempts were made to take inventories of the present dairying in all villages, and to understand the overall situations, type of resources, present situations for the development.

Sampling procedure

Both the PAs of the watershed area formed the first level of stratum for this study. In each PA three villages, Buti, Korke and Mekana for Yerer Silasa, and Goditti (Babogaya and Goditti), Dedema and Worko for Gende Gorba were considered in the study as second level of stratum.

Resource constraints were decided from PRA and rapid survey. Based on the inventory taken at the time of rapid survey it was estimated that there were 368 households having dairying. Of these, 120 households or 32.6 percent of the total dairying households were considered in the formal survey. The methodology used was a formal survey of a representative sample of dairy production units within the dairy shed. Farmer-recall (over one year) techniques were used for collecting production data.

Data collection

Based on the information generated through PRA, a questionnaire was used and record sheets were developed for the formal interview /diagnostic survey (Jabbar and Mullins 1997; Rey *et al.,* 1999). Before starting the actual formal survey, the developed questionnaires were pre-tested for the suitability of the study. Enumerators (two) were trained and used to collect the data for formal survey. Field observation was taken in the sampling area.

Statistical methods

The statistical analysis used in this study varied depending on the type of variables and information obtained. However, quantitative data were analyzed using descriptive statistics (percentage, mean comparison, mode, median, standard deviation, coefficient of variation etc.). Computer software SPSS 12.1 were used for data management and analysis.

Results and discussion

Lactation yield of local cows

The first and most important purpose of dairy cattle production is to provide milk for family use and for sale. However milk yield of indigenous cattle is very low. The overall average estimated lactation yield was 506.78 liters, of which average 238.35 liters for local cows which is very low due to poor genetic makeup, shortage of feed and poor management conditions (Table 6).

The milk yield for the local cows is undoubtedly very low compared to breeds like Boran (454-1818 liters) as estimated by Wahid (1976). The unimproved cattle normally have very low milk yield of about 200-300 kg per lactation (Brannang and Persson, 1990). The present results strengthen the finding of the others.

Table 6.Average lactation yield of cows based on farmers estimation in liters in Yerer watershed

Genotype	N	Mean	SD	Minimum	Maximum
Crossbred	24	1558.1	1490.15	240.0	4500.0
Local	94	238.35	73.73	56.0	480.0
Average	118	506.78	851.74	56.0	4500.00

Similarly, FOA in 1995 reported on average milk yield of 209 kg/animal for Ethiopia compared to 350 kg/animal for Eastern Africa and 376 kg/animal for sub-Saharan Africa. Yitaye (1999) reported that milk off-take from zebu cows was around 450 liters per cow per lactation. The lower milk yield per lactation of Yerer local cattle might be because of feed and water shortage or breed/ type characteristics.

Lactation length of local cows

The overall lactation length of both local and crossbred cows in the watershed was 7.52 ± 1.64 months as per farmer's statements. The estimated mean lactation length for local cows in the watershed was 7.2 ± 1.44 months short lactation length was due to shortage of feed and water in the area (Table 7).

Which is within the range 4.63-10.43 months reported for Boran cows (Wahid, 1976). Schaar *et al.* (1981) calculated lactation length of 148, 227 and 237 days for 1 st , 2nd and 3rd lactation for Arsi zebu and 175, 172 and 185 days for first lactation of Fogera, Borena, and Barka breeds, respectively in Ethiopia.

Daily yield of local cows

In the Yerer watershed, considering average lactation yield and average lactation length of local cows, the average estimated daily milk off take from local cows was 1.09 liters.

This is in agreement with Degena and Adugna (1999) who reported national average of 1.09 liters/day/cow. However, many reports indicate slightly higher than yields for local cows. Yitaye (1999) reported amount of 1.5 liters ranging from of 0.5 to 2 liters of daily milk yield for local cows. According to FAO (1993) average daily milk off take per cow ranged from 1.5 to 2 liters over a 150-180 days lactation period for Ethiopian local cows. Getachew (2002) estimated in the Ginchi watershed the average milk production as 1.76 liters per day.

Lactation performance of crossbred cows

Lactation performances in addition to genetic causes are affected by some environmental factors influencing milk production (Bhatnagar *et al.,* 1982). The genotype of the animals which are raised in smallholdings must be compatible with the environment and available resources, including the knowledge and skills of the farmers.

Table 7 shows that there is seven months gap between minimum and maximum lactation lengths of the cows. It is likely be due to variation in feeding, watering, and management conditions. Gryseels and Anderson (1983) estimated the average length of first lactation for Friesian x Boran crosses at Debre Zeit ILCA station to be 14.6 months or 439 days, falling to 10.13 months or 304 days for the second lactation. The overall lactation length of crossbred dairy cows in Agarfa was 330.7 ± 2.0 days (Keberu, 2000). The difference in lactation length could be due to variation in feeding and management condition.

Table 7.Lactation length of dairy cows in months as estimated by farmers of Yerer wateshed

Genotype	N	Mean	SD	Minimum	Maximum
Crossbred	24	8.63	1.89	6	13.0
Local	94	7.24	1.45	5	12.0
Total	118	7.52	1.64	5	13.0

Lactation yield of crossbred cows

The average estimated milk yield per lactation of crossbred cows was 1558.1 liters (Table 6). This may be due to better inputs offered to them and exotic inheritance. The reported difference between the minimum and maximum yield which was 4260 liters for crossbred cows indicates the differences in management and may be the level of exotic inheritance.

This result is in agreement with Teferi (1994) who reported that 3/4 Friesian crosses with Arsi give 1540 liters per lactation yield. Keberu (2000) obtained an overall mean annual milk yield of 1581 ± 15.3 kg for crossbred cows kept in Agarfa. Gryseels and Anderson (1983) in their study

using 40 smallholder farms obtained an average milk yield of around 1800 liter/cow per year at Debre Zeit and 1600 liter/cow per year at Debreberhan. These yields were obtained with little use of purchased concentrates. Kiwuwa *et al.* (1983) reported that crossbred ½ Friesian x ½ zebu cows under smallholder dairy farms produced annual milk yield of 1800 kg/cow in Arsi region. Gashaw (1992) reported that mean annual milk yield for crossbred dairy cows in Selale was 1291.8 kg. IAR (1991) reported 1621 liters yield in 241 lactation length days.

The production of crossbred cows is about five times more when compared with zebu cattle in present study. One of the report indicates that milk yield can increase seven folds and lactation length was more than double in crossbred cows (Schaar *et al.,* 1981).

Lactation length of crossbred cows

In the Yerer watershed, the estimated mean lactation length of crossbred cows was 8.6 ± 1.9 months (n = 24). This result is in agreement with the 8.03 months (229 days) of lactation length reported for IAR (Institute of Agricultural Research) herd (IAR, 1991). However, lactation length as reported by the farmers is much lower compared to Friesian crosses with recognized breeds like Arsi and Boran (Kiwuwa *et al.*, 1983, Gryseels and Anderson, 1983, Keberu, 2000)

Daily milk yield of crossbred cows

In the watershed, considering average lactation yield and average lactation length of crossbred cows, the average estimated daily milk yield of crossbred cow was 5.97 liters. This means one crossbred cow can replace five local cows provided the crossbred males can be used for draught and infrastructures such as feed, health coverage and good market for milk are available.

Similar studies undertaken by Gashaw (1992) indicated that the mean milk yield per day of lactation for ½ Friesian x ½ zebu crosses in Selale was 5.1 kg. Kiwuwa *et al.* (1983) also reported an average of 6.4 kg milk yield per day of lactation for Arsi region from crossbred cows under smallholder dairy farm conditions. The small difference may be, due to differences in exotic blood, feed, ecology and management conditions.

Conclusion and recommendations

Overall, 51.3 percent of the farmers allocated no land for forage cultivation or had land for grazing. This was because of shortage of land and priority for crop production. Land size allocated for grazing and fodder to land suitable for cropping was at an average ratio of 0.057: 1. Out of these, 53.6 percentage of the households had less than 0.053:1 ratio and there was highly significant difference between households ($p < 0.01$). Communal grazing land to feed livestock was used by 75.8 percent of the households in the watershed. The main feed for cattle was crop residue according to 95.8 percent of the farmers. Secondary feed resources were grazing cattle on aftermath followed by hay and purchased feed. Feeding priority was given to oxen. Seasonal shortage of feed in the area was severe during July to September. Main measures taken to overcome the seasonal feed shortage was utilizing stored crop residue. Uncontrolled mating was practiced for local cattle. The estimated average land holding with exclusive right of use by the household was 1.88 ± 1.07 ha and average crop productivity was 9.42 ± 3.56 quintal per hectare. Due to shortage of water, no irrigated land was owned by 91.7 percent of the households. Land was rented all year round by 15 percent of the households to the extent of 0.14 ± 0.48 ha on average.

In the watershed, the average estimated household consumption unit was 6.02 ± 2.17 and mean family labour force was 3.59 ± 1.49 per household, the mean hired labour force was 1.9 ± 1.24. With an average land labour ratio of 0.37:1 per household, 53.3 percent of the households employed one labourer (*Eregna).* The major food crops produced in the Yerer watershed were teff, faba bean and wheat. The major cash crop in the watershed was /*Gesho*/ and was grown by 38.39 percent of the

households. The cash crop to food crop ratio in the area was very low at an average of 0.057:1. In the cattle herd, the average sex ratio (M/F) was 1.77:1 indicating the importance of oxen for traction. Mean mortality rate of cattle was as high as 9.85 percent. Off-take rate was 7.01 percent for cattle.

Three categories of constraints in the watershed were identified and each of these constraints has to address in order to promote the dairy production system in the area. Among the non-technical constraints, the human population pressure has lead to shortage of land for cultivation and every land is utilized to grow food crops. Further lack of education hinders the farmers to adopt new technologies in dairy and agricultural production. Thus there is need to adopt family planning and offer training in dairying.

Among technical constraints, problems related to disease, shortage of feed, water and better genotype need to be addressed. For control of disease regular vaccination, de-warming and spraying for ectoparasite of dairy cows should be practiced. The feed resource in the area was crop residue and enhancing nutritive value of crop residues by urea treatment would be one of the solutions to be focused. The watershed is located near to accessible market for milk production but dominated by local cattle. To improve their production potentiality efficient AI service or bull stations should initiated. To solve the problem of water shortage construction of community water points may be the solution. Of the institutional constraints, lack of marketing organization, dairy extension, credit institutions for dairying are important factors. In order to solve these problems starting of milk collection centers and strengthening milk co-operative societies in the area, appointment of *Kebela* development agents (extensionist) for dairy and livestock development promotion of micro finance credit, and insurance for dairy cows should be given priority in development agenda

Generally, in order to promote the dairy production system in the area integrated type of development program will be very important and by doing, so dairying is likely to become one of the main occupations of the farmers of Yerer watershed.

Reference

Astatke, A., Mohamed Saleem, A. M. and EI Wakeel, A. 1995. Soil water dynamics under cereal and forage legume mixtures on drained vertisols in the Ethiopian highlands. Agric. Water Management, 27:17-24.

Azage Tegegne, Tsehay Reda, Alemu Gebrewold and Hizkas Ketema. 2000. Pastoralism and agro-pastoralism which way forward. Milk recording and herd registration in Ethiopia: An essential step towards genetic improvement for milk production. In: Pro. of 8th Annual Conference of Ethiopian Society of Animal Production (ESAP) 24-26 August 2000. Addis Ababa, Ethiopia.

Bhatnagar, D. S., Taneja, V. K. and Basu, S. B. 1982. Estimation of genetic parameters for first lactation performence in Tharparkar cattle. Ind. J. Anim. Sci. 52 (1): 1-3.

Brannang, E. and Persson, S. 1990. Ethiopian Animal Husbandry. A handbook. Swedish University of Agricultural Science, Uppsala.

Degena Aredo and Adugna Lemi. 1999. The crop livestock systems and contributions to the economy: A review of empirical evidence. Economics of integrated crop and livestock system in Ethiopia. In: Proc. of the 3rd conference of the AESE (Agricultural economic society of Ethiopia). pp. 1-34.

FAO. 1993. (Food and Agriculture Organization of the United Nations). The state of Agriculture 1993, FAO, Rome. Italy.

FAO.1995 (Food and Agriculture Organization of the United Nations). Production Yearbook 1994. Food and Agriculture Organization, Rome, 1995. FAO, Rome, Italy.

Gashaw Geda. 1992. Assessment of feed resource base and performance of crossbred dairy cows distributed to smallholder in the Selale Dairy Development Project area. M. Sc. Thesis, Alemaya University of Agriculture, Dire Dawa, Ethiopia.

Getachew Eshete. 2002. Assessment of feed resource, their management and impact on livestock productivity in the Ginchi watershed. M. Sc. Thesis, Alemaya University, Dire Dawa, Ethiopia.

Gryseels, G. and Anderson, F. M. 1983. Research on farm and livestock productivity in the central Ethiopian highlands; Initial results, 1977-1980. ILCA Research Report No. 4. International Livestock Canter for Africa. Addis Ababa, Ethiopia.

Hurni, H. 1990. Degradation and conservation of the soil resources in the Ethiopia highlands. In: African Mountains and Highlands: Problems and Prospective. B. Messerli and H.Hurni (ed). Marceline, Missouri (USA). Pp 51-64

IAR. 1991. (Institute of Agricultural Research).In: Proc. of 4th National Livestock Improvement Conference. 13-15 Nov., 1991, Addis Ababa, Ethiopia.

Jabbar Emmanuel Tambi and Mullins Gary. 1997. Market-oriented smallholder dairying research working document No. 3. A methodology for characterizing dairy marketing systems. ILRI (International Livestock Research Institute). Nairobi, Kenya.

Kahsay Berhe, 2004. Land use and land cover changes in the central highlands of Ethiopia: The case of Yerer mountain and its surroundings. . M. Sc. Thesis, Addis Ababa University, Addis Ababa, Ethiopia.

Keberu Belayneh. 2000. Milk production and lactation performance of crossbred (Friesian x Arsi) cattle at Agarfa Multipurpose Training Center, Bale, Ethiopia, M. Sc. Thesis, Alemaya University of Agriculture, Dire Dawa, Ethiopia.

Kiwuwa, G. H., Trial, J. C. M., Kurtu, M. Y., Getachew, W., Anderson, F. M. and Durkin. J. 1983. Crossbred dairy cattle productivity in Arsi Region, Ethiopia. ARDU and ILCA. Research Report No. 11. ILCA Addis Ababa, Ethiopia.

McDaC. 1999. Survey of the Ethiopian economy: Review of past reform development (1992/93-97/98). Addis Ababa, Ethiopia, pp157.

Mureja Shibru. 1994. Milk production and persistancy characterstics of Holstien Friesian cattle on the Holeta Government Dairy Farm, Ethiopia. M.Sc. Thesis, Alemaya University of Agriculture, Dire Dawa, Ethiopia.

Rey, B., Agyemang, K., Thorpe, W., Mullins, G., Diedhiou, M., Nokoe., S. and Shapiro, B. 1999. Market-oriented smallholder dairy research working document no. 4. A research methodology for characterising dairy production systems, ILRI (International Livestock Research Institute) Nairobi. Kenya.

Schaar, J., Brannang, E. and Meskel, L. B. 1981. Breeding activities of the Ethio-Swedish integrated rural development project. Part II. Milk production of zebu and crossbred cattle. Wld. Anim. Rev. 37: 31-36.

Teferi Dina. 1994. Reproductive and milk yield performance of crossbred dairy cattle at the Co-operative farm in the Arsi Region, Ethiopia. M.Sc. Thesis, Alemaya University of Agriculture, Dire Dawa, Ehiopia.

Wahid, A. 1976. Livestock Resources of Pakistan Sahiwal Cattle. Monograph 6. University of Karachi. Pakistan.

WBOA. 2003. (Woreda Bureau of Agriculture Ada Liben). Annual report. Debrezeit, Ethiopia.

World Bank. 1995. World Development Report 1995. Oxford University Press. New York. USA.

World Bank. 1996. African Development Indicators 1996. The World Bank Washington, D.C. USA.

Yimam Hassen. 1994. Evaluation of the performance of Danish Jersey cattle at Ada Berga state farm, Ethiopia. M.Sc. Thesis, Alemaya University, of Agriculture Dire Dawa, Ethiopia.

Yitaye Alemayehu. 1999. A study on livestock production systems, feed resources and feed allocation practices in the Awassa Woreda Sidama Zone, Southern Ethiopia. M.Sc. Thesis, Alemaya University, Dire Dawa, Ethiopia.

Livestock ownership status and flock/herd structure in mixed production system of Yerer watershed of Adaa Liben district.

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Abstract

The study was carried out in 'Yerer watershed' of Adaa Liben district which comprises two peasant associations namely Yerer Silassie and Gende Gorba, with an objective of identifying the livestock holding, ownership pattern and herd/flock structure in relation with the production objective of farmers live in the area. A total of 150 sample farmers or 10 percent of household heads in the watershed were included in the study.

Due to importance of oxen for draught power, donkey for transportation and poultry for income, 84.0, 76.0 and 74.0 percent of the farmers posses these animals, respectively with average size of holdings 2.32, 1.69 and 5.31, respectively. Female animals and animals above 1 year of age, respectively account for higher proportion of (70.1 and 43.6%) sheep and (60.0 and 37.3%) goats flocks. The cattle herd comprises 48.3 and 17.2 percent of oxen and cows above 4 years of age, respectively.

Key words: Livestock ownership, livestock holding, flock structure, herd structure.

Introduction

Livestock ownership varies depending on the wealth status and the overall farm production objectives. In mixed farming systems of the highlands of Ethiopia where crop production is important cattle are the most important livestock species for cultivation, threshing and to provide manure (Getachew *et al*., 1993). Gryseels and Goe (1984) also reported that most farmers in the central highlands of Ethiopia own two oxen, a cow, a few sheep and a donkey. Cattle (Zebu type) are kept mainly for draught power and manure. Available data for the Debre Berhan area indicate that half of the farmers owned two or more oxen, around 30 percent had one and 20 percent owned no oxen. In the Debre Zeit area relatively more farmers had two or more oxen, but around 25 percent of the smallholder had none or only one ox (Gryseels *et al*., 1984). In less accessible highlands, donkeys are used extensively to transport agricultural inputs and farm produce (Gryseels and Goe, 1984).

According to Zelalem and Lendin (2000), Debre Zeit is one of the major teff growing areas in the country and the farmers therefore need more draught power for teff cultivation. Hence farmers around Debre Zeit, keep more oxen and fewer cows as compared to those around Holetta and Selale. Brokken and Senaite (1992) also reported that the number of cows per household around Debre Zeit ranges from 1 to 5, with an average of 2.5. These authors also indicated that easier management and lower disease risk as major reasons for keeping local (Zebu type) cattle around Debre Zeit.

In the Ethiopian highlands (above 2500 m.a.s.l.) the flock sizes tend to increase per household although there exists a higher population density. In a survey work made by MOA, Dega sheep flocks per farm on average were significantly larger than Woina-dega sheep flocks (Zelalem and Fletcher, 1991). Similarly results of a survey work covering 226 households around Debre Berhan area also indicated that 69 percent of the farmers hold five or more sheep, at an average flock size of 10.69 animals (Gryseels and Anderson, 1983). Moreover, in the high altitudes of Menz area the majority of the house holds possessed a minimum of five sheep, the maximum of about 150 sheep and the average flock size is 12 to 15 animals with either none or one to two heads of cattle (Sheno

Research Center, 1997). However, the results of ILCA (1979), Wilson (1982) and Bayer (1986) were supported by the findings of Mukasa-Mugerwa *et al.* (1986) in the Adaa district who reported that the flock size of 4.1 animals per household, and Berhanu (1995) who reported that the flock size of 4.2 animals per household in the south western part of the Ethiopian highlands.

By the expression ' flock/herd structure' it means that the proportion (in terms of number of head) of the herd of a single species which is formed by different age and sex classes of animals, e.g., breeding females, calves, mature bulls, mature oxen etc (ILCA, 1990). In mixed production systems where animals are used for draught and transport, the proportion of mature oxen or donkeys in herds tends to be relatively high (ILCA, 1990).

The age and particularly the sex composition of a flock/herd are regulated to a great extent by the main flock/herd functions (Wilson, 1986). This structure is a reflection of the system of management that explains, to some extent, the management objectives and strategies. The objective could be to cope with constraints placed upon the system so as to ensure a constant availability of animals and their products spread over the production year (Niftalem, 1990). Therefore, with this background this study was carried out to assess the livestock holding, ownership, composition and flock/herd structure of the smallholder mixed farming community at "Yerer watershed" of Adaa Liben district of Oromyia Regional State (ORS).

Material and Methods

Description of the study area

This study was carried out in Adaa Liben district of the east Showa administrative zone of Oromiya Regional State (ORS). The specific study area "Yerer watershed" comprises two peasant associations (PAs) namely Yerer Silassie and Gende Gorba. These two PAs are part of the 45 PAs in the district. Yerer Silassie and Gende Gorba PAs share common boundaries and are totally part of the watershed, and cover a land mass of about 3372 and 3820 ha., respectively (WOA, 2003) and are located at $8^{o}50$ to $8^{o}53$ latitude and $38^{o}55$ to $38^{o}59$ longitude.

The overall farming system in Adaa Liben district in general and in the study area in particular is characterized by mixed crop-livestock production system, and the system is well integrated. The crop production is a dominant system over the livestock system in the district in general and in the watershed in particular. Livestock production is a second important system next to crop for the overall farming system in the study area. The major contribution of livestock production for the farming community is provision of draft power, transport and as a means of security. According to WOA (2003) report, the specific study PAs (Yerer Silassie and Gende Gorba) has a total livestock population of 5,269.4 and 6,777.2 TLU, respectively. The livestock classes held by farmers in the study area include; cattle (oxen, cows, heifers, bulls and calves), equines (donkey, mule and horse), small ruminants (sheep and goat) and poultry (WOA, 2003).

Sampling methods

The two peasant associations in the Yerer watershed namely Yerer Silassie and Gende Gorba were used for the study. All the three villages from each PA: Buti, Korke and Makana for Yerer Silassie, and Goditi, Dedema and Worko for Genda Gorba were included in this study. Due to shortage of time and resource, about 10 percent of the household or total of 150 sample household farmers were randomly selected based on the proportion of total households in the two PAs using Probability Proportional to Size (PPS) approach. Therefore, out of the total households (525) in Yerer Silassie and (950) in Gende Gorba, proportion of 54 and 96 percent household were included in the study, respectively. At village level, in Yerer Silassie 12, 15, and 27 households were selected randomly for Buti, Korke and Makana, and at Gende Gorba 28, 39, and 29 households were selected randomly for Goditi, Dedema and Worko, respectively. Moreover, in order to capture house-

hold head gender effect in the livestock holding, ownership and herd/flock structure, the sample households on each village were stratified to female and male headed households. At this level the numbers of female and male headed households were determined using Proportional Probability to Size (PPS) approach.

Data collection and analysis

In order to address the objectives of the study, formal (diagnostic) survey was used using well structured questionnaire. All required parameters to quantify livestock holding, ownership pattern and herd/flock structure were included in the questionnaire used in formal survey of the study. The questionnaire was pre-tested on sample households. Single visit multiple subject survey method was employed in diagnostic survey.

The raw data collected from the formal survey were entered in Excel for data arrangement and cleaning. Finally, cleaned data were analyzed by a computer using descriptive statistics, person chi-square test and logistic regression of SPSS release version 12.0.1 (SPSS, 2003).

Results and Discussions

Livestock holding

The number of animals owned for the different livestock species is presented in Table 1. The average holding of each livestock species in this study is more than double as compared to the average holding of oxen (1.86), cows (0.93), sheep (1.55) and goats (1.00) reported before 25 years at Debre Zeit (Gryseels and Goe, 1984). The average holding for sheep in this study is far lower than the average flock size of 10.69 around Debre Berhan area for 226 households reported by Gryseels and Anderson (1983) and 12 to 15 animals in the high altitudes area of Menz reported by Sheno Research Center (1997). However, the average sheep holding observed in this study is almost similar to the average flock sizes of 4.1 reported in the Adaa district (Mukasa-Mugerwa *et al*., 1986) and 4.2 animals per household in the south western part of the Ethiopian highlands (Brehanu, 1995).

Table 1. Mean, minimum and maximum number of holdings for different livestock species and classes in Yerer watershed.

LIVESTOCK SPECIES	NO OF HH	NO OF ANIMALS	LIVESTOCK HOLDING			
			MIN.	MAX	$\overline{X}$	SE
SHEEP	29	117	1	13	4.03	0.56
GOAT	20	110	2	12	5.50	0.69
CATTLE	132	559	1	12	4.23	0.21
Y. BULL	63	88	1	3	1.40	0.08
OXEN	126	292	1	6	2.32	0.09
NM. COW	69	90	1	5	1.30	0.08
M. COW	71	89	1	5	1.25	0.07
DONKEY	114	193	1	5	1.69	0.09
POULTRY	111	589	1	30	5.31	0.42

MIN. = Minimum holding, MAX.= Maximum holding, HH= Household head, NM= non milking, M=milking, Y.BULL=young bull.

The average number of holdings for each class of animals was not significantly different between the two genders of household head. However, farmers at Yerer Silassie have significantly ($P<0.01$) higher mean number of sheep (6.13 ± 1.54) and oxen (2.55 ± 0.15) than those at Gende Gorba. However, no difference was found for mean holding of other livestock classes between the two PAs (Table 2).

Table 2. Livestock holding difference between the two PAs in Yerer watershed.

LS SPECIES	PA	NO OF HH	$\overline{X}$	SE	P-VALUE
SHEEP	YS	8	6.13b	1.54	0.018
	GG	21	3.24a	0.42	
GOAT	YS	12	6.25	0.94	0.193
	GG	8	4.38	0.94	
Y.BULL	YS	26	1.35	0.12	0.600
	GG	37	1.43	0.11	
OXEN	YS	49	2.55b	0.15	0.042
	GG	77	2.17a	0.12	
NM. COW	YS	28	1.18	0.07	0.215
	GG	41	1.39	0.13	
M. COW	YS	30	1.20	0.07	0.526
	GG	41	1.29	0.11	
DONKEY	YS	47	1.62	0.12	0.464
	GG	67	1.75	0.12	
POULTRY	YS	45	5.98	0.74	0.183
	GG	66	4.85	0.48	

Means in the column within PA followed by different superscript letters were significantly (P<0.05, T-test) different.
YS= Yerer Silassie, GG=Gende Gorba, PA.= Peasant association, Y. = Young, NM= Non milking, M= Milking, HH= Household head

The average oxen and milking cows holdings observed in this study is lower than values reported by Zelalem and Lendin (2000) and Bekele (1991) who reported that mean holdings of oxen as 3.2 and 2.29 and milking cows as 1.7 and 1.43, respectively in the same area. Moreover, the average holding for cows observed in this study is lower than 1.45 reported in Debre Berhan (Gryseels and Goe, 1984).

Livestock ownership status

Small ruminant ownership status

Out of the 150 farmers in the watershed, about 8.7 and 1.3 percent owned only female and male sheep, respectively. There was no difference between the two PAs and the two sex of household heads. More number of farmers at Yerer Silassie owned goats than Gende Gorba (P<0.05). However, there was no difference between households headed by men and women (Table 3). The larger number of households of Yerer Silassie owning goats may have direct relation to their access for browsing area at the bottom land of mount Yerer and better grazing land ownership than those in Gende Gorba.

In general, about 19.3 percent (n=29) and 13.3 percent (n=20) of the farmers at both PAs possessed sheep and goats, respectively. This figure was far lower than that reported by Gryseels and Anderson (1983) who indicated that 69 percent of the 226 households around Debre Berhan hold five or more sheep. However, relatively higher proportion of the farmers in the study area owned sheep than goats. This may relate with better market value of sheep than for goats.

Table 3. Difference in number of farmers owned sheep and goat between the two PAs and genders of household heads in Yerer watershed.

VARIABLE	GROUP	TOTAL HH (N)	SHEEP			GOAT		
			BOTH SEX	ONLY FEMALE	ONLY MALE	BOTH SEX	ONLY FEMALE	ONLY MALE
			%	%	%	%	%	%
PA	YS	54	11.1	3.7	0.0	18.5	0.0	3.7
	GG	96	8.3	11.5	2.1	6.3	2.1	0.0
X^2 P-VALUE				0.259			0.016	
HHSEX	MALE	128	10.2	9.4	1.6	10.2	1.6	0.8
	FEMALE	22	4.5	4.5	0.0	13.6	0.0	4.5
X^2 P-VALUE				0.611			0.454	
TOTAL		150	9.3	8.7	1.3	10.7	1.3	1.3

YS= Yerer Silassie, GG=Gende Gorba, PA.= Peasant associations, HHSEX=household head sex, HH= Household head.

Cattle ownership status

Out of the 150 farmers in the study watershed, about 19.3 and 43.3 percent owned only milking cows and oxen, respectively (Table 4). This result indicates that more farmers owned oxen than cow which is mainly because of the demand for draught power in the area. The ownership difference for different age groups of cows and oxen were not significant between the two PAs and genders of household heads. According to Gryseels *et al.* (1984) half of the farmers in Debre Berhan area owned two or more oxen, around 30 percent had one and 20 percent owned no oxen. In the Debre Zeit area, relatively more farmers had two or more oxen, but around 25 percent of the smallholders had none or only one ox (Gryseels *et al.*, 1984). Therefore, the proportion households that owned oxen in this study were higher than other highland areas as indicated earlier.

Table 4. Difference in number of households owning cow and oxen between the two PAs and genders of household heads in Yerer watershed.

VARIABLE	GROUP	TOTAL HH (N)	COW			OXEN		
			ONLY NM. COW	ONLY M. COW	BOTH	ONLY Y. BULL	ONLY OXEN	BOTH
			%	%	%	%	%	%
PA	YS	54	20.4	24.1	31.5	1.9	44.4	46.3
	GG	96	16.7	16.7	26.0	1.0	42.7	37.5
X^2 P-VALUE				0.227			0.274	
HHSEX	MALE	128	19.5	21.1	26.6	1.6	44.5	41.4
	FEMALE	22	9.1	9.1	36.4	0.0	36.4	36.4
X^2 P-VALUE				0.257			0.315	
TOTAL		150	18.0	19.3	28.0	1.3	43.3	40.7

YS= Yerer Silassie, GG=Gende Gorba, PA.= Peasant associations, HHSEX=household head sex, HH= Household head, NM= non milking, M=milking, Y.BULL=young bull.

Donkey and poultry ownership pattern

The ownership status difference for donkey was significant ($P<0.05$) between the two PAs. Due to poor access of the area for transportation as compared to Gende Gorba, donkey was more important for households in Yerer Silassie. As a result more households of Yerer Silassie owned donkey than Gende Gorba households (Table 5).

Table 5. Difference in number of households owning poultry and donkey between the two PAs and gender of household heads in Yerer watershed.

VARIABLE	GROUP	TOTAL HH (N)	POULTRY			DONKEY
			NO BIRD	FEMALE	BOTH SEX	
			%	%	%	%
PA	YS	54	16.7	27.8	55.6	87.0
	GG	96	31.3	29.2	39.6	69.8
X^2 P-VALUE				0.091		0.018
HHSEX	MALE	128	21.9	30.5	47.7	78.1
	FEMALE	22	50.0	18.2	31.8	63.6
X^2 P-VALUE				0.021		0.176
TOTAL		150	26.0	28.7	45.3	76.0

YS= Yerer Silassie, GG=Gende Gorba, PA.= Peasant associations, HHSEX=household head sex, HH= Household head.

The ownership status for poultry was significantly (P<0.05) different between the two genders of household heads. Accordingly, 78.2 % (n=100) number of male headed household possessed poultry as compared to female headed households who possess only 50 % poultry in the area (Table 5).

Therefore, as indicated in the above results, highest proportion of farmers 84, 76.0, 74.0 and 67.3 % in the study area posses oxen, donkey, poultry and cows, respectively than sheep and goats. This may relate to the higher demand of oxen for power, donkey for transport, poultry for income and consumption and cow for reproduction of replacement oxen. The importance of donkey has been stressed by Gryseels and Goe (1984) in the highlands where they are used extensively to transport agricultural inputs and farm produce.

Herd and flock structure

Small ruminant flock structure

The age and sex composition of small ruminant flock is regulated by the main function of the flock. The flock structure of sheep and goat in the study area is given in Tables 6. Female sheep and goats contributed the highest proportion (70.1%) and (60.0%) of the flock, respectively in the study watershed. Getachew *et al*., (1993) also reported that breeding ewes above one year old make up the highest proportion within the flock which was 57% at Dogollo, and 54% at Inewari. Moreover, in the Debre Berhan area of the Ethiopian highlands, of the total 2133 sheep enumerated 16.3% were old broken mouthed ewes (Agyemang *et al*., 1985) indicating that a low rate of culling is practiced in the traditional flocks.

In the central highlands of Ethiopia where mixed farming is practiced the proportion of females is reported to range from 70-80% (Agyemang *et al*., 1985; Mukasa-Mugerwa *et al*., 1986). This higher proportion of female sheep and goats may have resulted from sale of male animals during the Easter holiday before the study was conducted. Moreover, it may relate with farmers production objectives and main reproduction function of the flock. The higher proportion of females in the flock is general fact, and hence under normal socio-economic and ecological factors in the tropical Africa, a flock contains 70-80% of females (Wilson, 1980). Therefore, the flock composition observed this study is similar with proportion reported from different parts of the country.

Among the different age groups of the sheep and goat flocks, age groups less than one year contribute the highest proportion of (43.6 and 37.3%) the flock, respectively. This age group also shares the highest proportion out of the total male and female sheep and goats in the flock. This may have resulted due to sale of the animals when they reach more than one year of age. Moreover,

this study was conducted during the dry season (*Bega*) when kidding/lambing was higher which resulted higher proportion of youngs below one year of age in the respective flocks.

Table 6. Flock structure of sheep and goats in Yerer watershed.

AGE GROUP (Year)	SHEEP				GOATS			
	FLOCK TOTAL		MALE	FEMALE	FLOCK TOTAL		MALE	FEMALE
	N	%	% OF TOTAL FLOCK	% OF TOTAL FLOCK	N	%	% OF TOTAL FLOCK	% OF TOTAL FLOCK
0-1	51	43.6	17.1	26.5	41	37.3	21.8	15.5
1-2	19	16.2	6.8	9.4	25	22.7	8.2	14.5
2-3	27	23.1	3.4	19.7	23	20.9	7.3	13.6
3-4	10	8.5	0.0	8.5	9	8.2	2.7	5.5
>4	10	8.5	2.6	6.0	12	10.9	0.0	10.9
TOTAL	117	100.0	29.9	70.1	110	100.0	40.0	60.0

In sheep flocks, females with age range of 2-4 years, contributed for 28.2% of the total sheep flock. Moreover, in goats flock, female goats within age range of 1-3 years contributed for about 28.1% of the total goats flock. These two age ranges for female sheep and goat are the productive age groups for the animals. Hence, most of the farmers in the study area posses female sheep and goats within the age range of 2-4 years and 1-3 years for the purpose of reproduction, respectively. Therefore, this may indicate the intention of farmers to increase the flock strength.

Cattle herd structure

The cattle herd structure is also governed by the overall function of the cattle in agricultural production system of the area. In the areas where crop production is dominant and demand for draught power is high, the herd tends to be comprised of higher proportion of male cattle (oxen) than others. In the study area, the proportion of male (68.0%) cattle was far higher than females (32.0%) in the total herd (Table 7).

Among the different age groups in the herd, about 48.3 and 71.1% of male cattle were found within the age range greater than 4 years in the total cattle and male cattle in the herd, respectively. Moreover, the herd is comprised of the highest proportion of 17.2 and 53.6% of female cattle within age of >4 years out of the total cattle and female cattle in the herd, respectively (Fig. 1). Similarly, in some areas of the Ethiopian highlands where crop production have relative importance, the number of oxen accounts for 38, 29 and 36% of the cattle herd at Inewari, Dogollo, and Ginchi, respectively (Getachew *et al.*, 1993). The higher proportion of oxen in this study as compared to the above figures indicates the dominance of crop production which forced farmers in the area to keep more oxen above 4 years in their herd. The highest proportion of both male and female cattle of age group >4 years may indicate the farmers are interested in oxen for traction and in cows for reproduction.

Table 7. Herd structure of cattle in Yerer watershed.

AGE GROUP (Year)	TOTAL HERD		MALE			FEMALE		
	N	%	TOTAL	% WITHIN MALE	% WITHIN TOTAL	TOTAL	% WITHIN FEMALE	% WITHIN TOTAL
0-1	33	5.9	21	5.5	3.8	12	6.7	2.1
1-2	36	6.4	17	4.5	3.0	19	10.6	3.4
2-3	66	11.8	35	9.2	6.3	31	17.3	5.5
3-4	58	10.4	37	9.7	6.6	21	11.7	3.8
4-5	51	9.1	30	7.9	5.4	21	11.7	3.8
5-6	57	10.2	40	10.5	7.2	17	9.5	3.0
6-7	74	13.2	55	14.5	9.8	19	10.6	3.4
7-8	92	16.5	71	18.7	12.7	21	11.7	3.8
>8	92	16.5	74	19.5	13.2	18	10.1	3.2
TOTAL	559	100.0	380	100.0	68.0	179	100.0	32.0

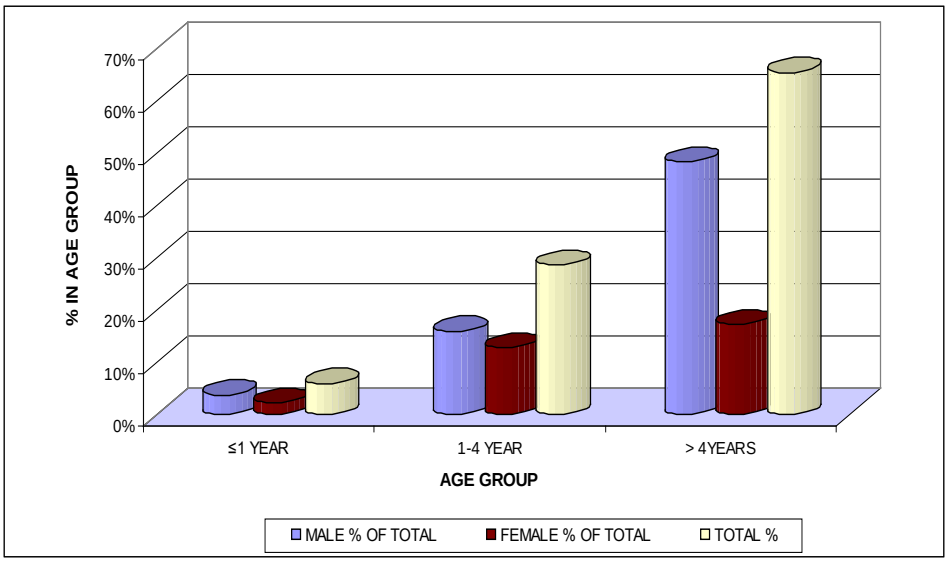

Fig. 1 Proportion of male and female cattle in different age group in Yerer watershed.

Conclusion

With respect to livestock holdings, more farmers in the area possessed oxen, donkey and poultry with ranging from 1-6, 1-5 and 1-30, respectively. In both sheep and goat flocks, females (70.1 and 60.0%) and animals below one year of age (43.6 and 37.3%), respectively accounted for higher proportion of the flock. Moreover, the total cattle herd consist higher proportion of oxen (53.6%) and cows (17.2%) above 4 years of age. Therefore, these flock and herd composition may indicate the main function of small ruminant and cattle for reproduction and power source, respectively.

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Reference

Agyemang, K., Negussie Akalework, A. Voorthuizen and F. M. Anderson, 1985. A rapid survey of reproduction in the traditional sector of Debre Berhan, Ethiopian highlands. pp. 175-185. In: R.T. Wilson and D. Bourzat (eds.). Small Ruminants in African Agriculture. International Livestock Center for Africa (ILCA), Addis Ababa, Ethiopia.

Bayer, W., 1986. Traditional small ruminant production in the sub-humid zone of Nigeria. pp. 141-166. In: R. Kanfmann, S. VonChater and R. Blench (eds.). Proceedings of livestock systems research in Nigeria's sub-humid zone. Addis Ababa, Ethiopia, 29 Oct-2 Nov. 1984, International Livestock Centre for Africa (ILCA).

Brehanu Belay, 1995. Traditional sheep management and production in the South Western part of Ethiopia. pp. 117-125. In: Proceedings of the fifth annual conference of Ethiopian Society of Animal Production (ESAP). Addis Ababa, Ethiopia.

Brokken, R.F. and Senaite Seyoum, 1992. Dairy marketing in sub-Saharan Africa. pp. 123-130. In: Proceeding of a symposium held at ILCA. Addis Ababa, Ethiopia, 26-30 Nov. 1990, International Livestock Centre for Africa (ILCA).

Getachew Asamenew, Haily Beyene, Workineh Negatu and Gezahegn Ayale, 1993. A survey of the farming system of vertisol areas of the Ethiopian highlands. pp. 29-49. In: M. Tekaligne, A. Abiye, K.L. Srivastava and D. Asegelil (eds.). Improved management of vertisols for sustainable crop-livestock production in the Ethiopian highlands: Synthesis report 1986-92. Technical Committee of the joint vartisol project. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia.

Gryseels, G. and F.M. Anderson, 1983. Research on farm and livestock productivity in the central Ethiopian highland: Initial Results, 1977-1980. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 52p.

Gryseels, G. and M.R. Goe, 1984. Energy flows on smallholder farms in the Ethiopian highlands. pp. 2-9. In: ILCA Bulletin No. 17. Addis Ababa, Ethiopia, January 1984, International Livestock Centre for Africa (ILCA).

Gryseels, G., Abyie Astatke, F.M. Anderson and Getachew Asamenew, 1984. The use of single oxen for crop cultivation in Ethiopia. pp. 20-25. In: ILCA Bulletin No. 18. Addis Ababa, Ethiopia, April 1984, International Livestock Centre for Africa (ILCA).

ILCA., 1979. (International Livestock Centre for Africa). Small Ruminant production in the humid tropics. ILCA System Study No. 3. International Livestock Center for Africa (ILCA), Addis Ababa, Ethiopia.

ILCA., 1990. (International Livestock Centre for Africa). Livestock system research *manual*, ILCA Working Paper No. 1, Volume 1. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 287p.

Mukasa-Mugerwa, E., Ephreim Bekele and Taddesse Tesema, 1986. Productivity of indigenous sheep and goats in the Ada district of Ethiopian highlands. pp. 81-87. In: K.O. Adeniji and J.A. Kategile (eds.). Proceedings of the workshop on the improvement of Small Ruminants in Eastern and Southern Africa. Nairobi, Kenya, 18-22 Aug. 1986.

Niftalem Dibissa, 1990. Sheep production on smallholder farms in the Ethiopian highlands - a farming system approach. A PhD. Dissertation presented to the Humboldt University, Berlin, Germany. 131p.

Sheno Research Centre, 1997. Initial result of base line survey of barley based farming system in high altitude areas of Menz. Draft report. Sheno, Ethiopia.

SPSS., 2003. Statistical Program for Social Study. Version 12.0.1, release of 2003 Chicago, Illinois, USA.

Wilson, R.T., 1980. Population and production parameters of sheep under traditional management in Semi-arid areas of Africa. *Trop. Anim. Hlth. Prod.* 12: 243-250.

Wilson, R.T., 1982. Husbandry, nutrition and productivity of goats and sheep in Tropical Africa. pp. 61-75. In: R.M. Gatenby and J.C.M. Trail (eds.). Small Ruminant Breed Productivity in Africa. International Livestock Centre for Africa (ILCA). Addis Ababa, Ethiopia.

Wilson, R.T., 1986. Livestock production in the central Mali: Long-term studies on cattle and small ruminants in the agropastoral system. ILCA Research Report No. 14. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 111p.

WOA, 2003. (Woreda Office of Agriculture Adaa Liben). General characteristics of Adaa Liben Woreda. Debre Zeit, Ethiopia. (Unpublished data)

Zelalem, A. and I. Fletcher, 1991. Small ruminant productivity in the central Ethiopian mixed farming systems. In: Proceeding of fourth National Livestock Improvement Conference. Addis Ababa, Ethiopia, 13-15 Nov. 1991, Institute of Agricultural Research (IAR).

Livestock production systems in Darolabu, Habro and Boke districts of Western Harerghe

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Abstract

A survey was conducted in Darolabu, Habro and Boke districts of Western Hararge to study livestock production system. One hundred thirty five farmers were interviewed using a semi-structured questionnaire. Ninety five percent of the respondents rear Ogaden cattle and 1.6% of the respondents rear Somali and Arsi cattle breed. Almost all of respondents rear Shenyo goat breed and 'Adolo' sheep breed. The major feeding systems in the study area are cut and carry system (97.6%). The major feed resources in the study area are natural pasture (24%), crop residue (4.8%), crop thinning (4%) and 66.4% of the respondents use combination of the above feed resources. Most of the respondents (84%) fatten their animals at backyard and 57.6% of the respondent use traditional herbs to treat their animals and 70% of them use traditional herbs and anthelmintics (Bolus) to fatten animals. According to the respondents the major livestock production constraints in the area are feed (68%), livestock diseases (48%), water (48%), low genetic potential (81.6%) and market problem (52%). Therefore, there is a need for intervention through on farm forage development, improvement of infrastructure like veterinary clinics, dam and pond construction and training on different marketable commodities like hide, skin and on how to integrate farmers indigenous knowledge with the improved fattening system to increase household income. Further detailed study is also required to identify the feed ingredients they use for fattening different species of animals, traditional herbs they use to treat sick animals and efficiency of the herbs.

Introduction

In Ethiopia natural pasture is the main source of feed for livestock for most part of the year (Lemma and Abubeker, 1995). However, because of the population pressure and the shrinking of grazing land, the feed from natural pasture especially in Harerghe area is very limited. Crop residue and agro industrial by products complement cattle feeding especially during the dry season in Harerghe where feed shortage is more critical. Around Harerghe semi-intensive livestock rearing is widely practiced with cattle back yard fattening being the most common. Similarly different husbandry practices are assumed to exist in the adjoining districts of Arsi zones. Crop residue, crop weeds in cultivated area, leaves strips and stover of maize and sorghum on field, food by products and different forages are used for fattening bulls, steers, oxen and infertile animals for sale or local consumption in most parts of Harerghe. However detailed traditional livestock rearing for milk, meat, ploughing was not known and well recorded in the Zone. Besides for a new research center like Machara, it is important to undertake detailed livestock production systems study that serve as a base for more comprehensive on station and on farm livestock studies. Therefore, the objectives of this study are to establish base line information on livestock feeding, breeding practices, health and housing practices in the area and identify major constraints and opportunities of livestock production in the Zone

Materials and Methods

The study was carried out in Western Harerghe zone of Oromia regional state where livestock fattening and marketing is a very usual practice. The region is characterized by high temperature and erratic rain fall. Based on the accessibility to conduct the survey three districts (Darolabu, Habro and Boke) in western Harerghe were selected. From each district 3 peasant associations (PAs) were selected and all necessary information related to livestock management practices, feed

resources, breeding practices, health problems and marketing system were collected. From each PA, 15 farmers were randomly selected among those who have enough number of livestock. In general a total of 135 farmers were interviewed. All necessary secondary data were collected from each district agricultural and rural development offices.

The collected data were systematically coded and analyzed using SPSS statistical soft ware package. From the analysis of descriptive statistics and the ANOVA significant differences between PAs were not observed. Therefore PAs were not considered as factors rather districts were considered as factors.

Results and Discussion

Description of interviewed farmers

In the study area household age of interviewed farmers were 20-40 years (60%), 41-60 years (29.6%), 61-90 years (9.6%) and below 20 years (0.8%). Household education level for adult education, 1-8 grade and none educated were 8.9%, 44.4% and 46.8%, respectively. Agriculture was observed to be the primary activity of the household in the study area. 95.2% of the household was male headed and 4.8% is female headed. Family size of the household ranged from 1-22 (7.34 ± 3.69) and the number of male and female household members ranged from 0-11 (3.37 ± 2.1) and 0-14 (3.41 ± 2.23), respectively.

Livestock holding

Livestock production is very important in the study area; especially cattle, goats, donkeys and sheep are the most common types of animals reared in the districts. Livestock number is relatively low in Habro district because of the high land agro ecology where there is an extreme land shortage including grazing land. Goat is the most important and preferable animal species reared in the area than sheep because of the socio-cultural habit of the community; so that the number of goat is significantly higher than sheep.

Table 1: Total livestock population of Darolabu, Habro and Boke districts

Livestock type	Number of livestock per districts		
	Darolabu	Habro	Boke
Cattle	197,160	43,029	125,563
goat	76,240	23,329	95,413
Sheep	6,001	4,552	3,455
Donkey	11,845	12,782	31,386
Camel	12,485	54	9,978
Horse	16	18	3
Mules	716	74	30
Poultry	48,320	43,265	46,186
Local bee hives	7,264	2,780	8,904
Improved bee hives	343	26	222

Sources: Districts Agricultural and Rural Development Offices (2007)

There is a difference in livestock holding between districts. Number of cattle, sheep, goat and camel owned by farm households in Darolabu is relatively higher as compared with the other districts. This might be due to larger grazing land holding per household in Darolabu which are semi-pastoralists in the low lands and pastoralists in the extreme low lands. Number of goat owned by households is significantly higher in Darolabu district (7.03±1.07) as compared to Boke (2.89±0.53) and Habro (3.11±0.43) districts. This might be due to the availability of more market opportunity for goats for hotels, butchers and house consumption in Darolabu district which encouraged the household to produce more goats. On the other hand most Harerghe farmers usually posses at

least one ox or cow at backyard regardless of other species and followed by goat, sheep and donkey according to their importance along all the agro ecologies.

Camel population is higher in Darolabu and Boke which are low land and lower in Habro which is a high land. This work is similar with report of Wagayehu and Habtemariam (1994) in which they indicated that camel population is higher in low land. Farmers prefer to rear goats in the study area especially in pastoral areas. Cattle breeds in the study area were Ogaden (95.2%), Somali (1.6%), Arsi (1.6%) and Borana (0.8%). The farmers mostly own 2 cows and 2 oxen. They also keep up to 3 goats at the backyard. This is because of high population pressure and consequently resulted in decreasing of grazing land and livestock number (72%). Breeds of goat and sheep reared in the study area are dominantly Shenyo and Adolo, respectively. On the average one household owns 1.8ha of land. They mentioned that there is decreasing trends of land per household. Hundred percent of them responded that they do not have any exotic or cross breed animals. So far they did not use AI technology to upgrade the local cattle breed. They indicated that there was no any organization supporting them with AI technologies.

Table 2: LSM ± SE livestock number and land size per household in studied districts (Darolabu, Habro and Boke)

Districts	Oxen	Cow	Bulls	heifers	calves	goat	sheep	camel	donkey	poultry	Bee hives	Land (ha)
Darolabu	2.11 ± 0.31	2.53 ± 0.46	0.86 ± 0.19	1.31 ± 0.23	1.22 ± 0.16	7.03 ± 1.07	0.67 ± 0.33	0.25 ± 0.2	1.22 ± 0.11	3.47 ± 0.68	1.03 ± 0.31	2.32 ± 0.19
Habro	1.6 ± 0.2	1.36 ± 0.15	0.67 ± 0.09	0.96 ± 0.11	1.27 ± 0.26	3.11 ± 0.43	0.64 ± 0.17	-	0.56 ± 0.10	3.82 ± 0.54	0.53 ± 0.10	1.67 ± 0.16
Boke	1.32 ± 0.12	1.69 ± 0.16	0.61 ± 0.14	0.77± 0.13	0.89 ± 0.16	2.89± 0.53	0.57 ± 0.21	-	1.07 ± 0.12	3.55 ± 1.14	0.45 ± 0.02	1.51 ± 0.09
Total	1.65 ± 0.12	1.6 9± 0.16	0.7 ± 0.08	0.99 ± 0.09	1.12 ± 0.12	4.16 ± 0.42	0.62 ± 0.13	0.07 ± 0.06	0.93 ± 0.07	3.62 ± 0.49	0.65 ± 0.12	1.80 ± 0.09

Livestock production and management

Primary objectives of rearing different species of livestock in the study area

Eight six percent of the respondent showed that they rear cows and Heifers for milk and cash generation through sale of milk and live animals, while oxen and bulls for cash generation and drought power (96.8% and beef source (0.8%). The farmers rear goats for milk (0.8%), milk and cash source (57.6%) and for milk, cash source and meat (41.6%). In general the rearing system of goats found in the study area is similar with the report of Peacock (1996). Goats are the most preferred animal type as meat animal for both household consumption and marketing followed by cattle and sheep. Goats are the most preferred species for meat. This is because of local communities believed that goat meat is tasty than sheep, and slaughtering goat is easier than cattle for house hold consumption. Sheep mainly used as a source of cash (66.4%) and as both meat and cash (30.4%) and less preferred for house consumption (3.2%). Almost all of the respondents keep poultry for egg production and sale of live bird. Mostly they do not use poultry as a source of meat. This might be because of cultural belief of the society. So it is important to intervene and create awareness in the area. Camel is kept for meat (1.6%), transport (40%), source of cash (0.8%), and for combination of all above mentioned purposes (57.6%). Equines especially donkey is used for transporting different commodities (52%) and as both cash sources and transportation (48%). They give donkeys for rent 5-15 birr/day. Most of the respondents (88%) produce only honey from bee hives and only 4% of the respondents produce both honey and wax. Eight percent of the respondents do not keep bee hives. Though there is an opportunity for bee production, there is under

utilization of the resources (personal observation). This might be because of lack of awareness and modern bee equipments.

Livestock rearing and housing system

Some of the farmers keep their animals in separate shelter (25.6%) and 12.8% of the respondents keep in partition from their house. Thirty nine percent of the respondents use group barn and 22.4% use combination of the above housing system. Pregnant, sick and fattening animals were kept in separate barn. Cattle and small ruminant fattening is a usual practice by Harerghe farmers. Eighty four percent of the respondents undertake cattle and small ruminant fattening in the study area. Most of the farmers fatten worked oxen (40%), bulls (6.4%), old/oxen, old /infertile cows (3.2%) and both worked oxen and bulls (32%). Even though there is a fattening practice in Harerghe, number of farmers involved varies from district to district. Ninty two percent of the respondents in Darolabu, 84.4% in Habro and 77.3% in Boke fatten their animals. Cattle fattening in Darolabu is relatively higher than the remaining district; this might be because of the large livestock number in the district.

Table 3: Minimum, maximum and LSM ± SE of livestock number fattened per household by district

District	Animal type	Minimum	Maximum No	Mean ± SE
Darolabu	cattle	0	13	2 ± 0.18
	Goats	0	6	1.44±0.26
	sheep	0	4	0.36±0.13
Habro	cattle	0	13	1.96±0.29
	Goats	0	5	1.96±0.29
	sheep	0	4	1.02±0.19
Boke	cattle	0	11	1.16±0.25
	Goats	0	5	0.57±0.19
	sheep	0	3	0.57±0.19

Most of the farmers (61.6%) fatten their animals from August–October and 30.4% fatten their animals from April-May. They prefer to fatten large size animal (62.4%), medium size (16.8%) and combination of the above (13.6%). The farmers fatten cattle for 7.08±2.81 months and small ruminant for 6.4 ±3.02 months.

Farmers sale their fattened animals at local market where these animals used for local community consumption and transported to big cites by the merchants. Price of matured unfinished cattle is on average 1890.2±210.21 birr and the price of matured finished cattle is 3350.28 ±330.19 in most months of a year. The farmers do not know the cost of production for fattening of the animals in the area; because according to their explanation so far they are not very well aware about improved fattening. So it was not possible to estimate profitability of their indigenous fattening practice. They use different feeds for finishing their animals; 85.6% of the respondents feed their animals mixture of crop by products, grasses/legumes and crop residue/straw. Only 3.2% of the respondents use concentrates to fatten their animals, 6.4% use crop alone. Most of the respondents (81.6%) use Albendazole to deworm animals used for fattening once every season. Seventy percent of the respondents use bolus for fattening. Fifty eight percent of the respondent use local herbs with bolus or with out bolus to fatten their animals. Thirty three percent of the respondent feed maize at milky stage, 16% use mixture of maize, sorghum and salt (bole mineral).

There is no purposive dairy production in the area rather the farmer keeps local cows to get calves and to produce small amount of milk for house hold consumption. There is lack of awareness to use AI techniques and lack of knowledge to rear cattle for milk production. However there is a potential in terms of market and climate condition to rear crossbreed dairy cows in the high land of study areas. In the study areas where cultivation is very common, they sell their ox by finishing after a given period ploughing and they replace by the cheaper ox.

Livestock feed and feeding system

About 24% of the respondent feed their animals on natural pasture grazing, 4.8% use crop residue, 4% use crop thinning, 0.8% use lopped fodder trees and 66.4% use combination of natural pasture, crop residue and crop thinning. Only 11.2% of the respondent use industrial by product as animal feed where as 88.8% of the respondent do not use this industrial by product. Eight one percent of the respondents indicated that crop residue support animals for 1-3 months and 17.6% of the respondents use it for 4-6 months. Similarly crop thinning (86.4%) is available only for 1-3months and 13.6% is available for 4-6 months. Fodder trees (96.8%) are available during dry season for 1-3 months.

In general most of the respondents indicated that natural pasture and crop residue support animals through out the year. Fifty six percent of the respondents use natural pasture for 1-3 month, 25% for 4-6 month, 15.2% for 7-9 month and 3.2% for a year. Nearly fifty percent of the respondent use browse trees during severe feed and water shortage as an alternative feed where as the remaining 50.4% of the respondent do not use this lopped fodder trees at all. About two percent of them offer this trees species by direct browsing, 24% offer by slight chopping, 4.8% offer by burning the thorns of the leaves and pods and 18.4% offer by using combination of the above treatment methods.

Grazing land

As indicated in table 4 grazing land is wider in the low land district because there is less cultivated land as compared to high land. According to the respondent grazing land decreases from year to year (86.4%) because of crop cultivation expansion and population pressure, where as 4% of the respondent indicated that it is increasing because of shortage of rainfall and decreasing of cultivation land which resulted in increasing of grazing land. About ten percent of respondents indicated that it is constant. According to 72% of the respondents livestock number decreased with declining of grazing land and hence there is an extreme feed shortage.

Table 4: Patterns of land use in Darolabu, Habro and Boke districts.

No.	Land use type	Area of land type in each District in (Ha)		
		Daro labu	Habro	Boke
1	Grazing land	135,138	536.4	58,841
2	Forest land	3,770	1,417	9,654
3	Bush land	31,967	30,789.96	125,254
4	Usable (potential) land like mountains	149,561	9,349	48,513
5	Crop lands (annuals and perennials)	55,899	22,894.52	70,378

Source: Districts Agricultural and Rural development offices (2007)

As indicated above grazing land is smallest in Habro district as compared with Darolabu and Boke districts. This is because Habro is a high land where there is high crop cultivation and serious land shortage. According to the experts from agricultural and rural development office report there is no low land PAs in the district except one peasant association (PA). Most of the land in the district is mainly used for “chat” and coffee production. Most of the farmers in this district rear their animals at back yard.

Most of the respondents (97.6%) keep their animals at backyard and sometimes they let the animals for grazing. Only 2.4% of the respondents do not tether their animals especially in the high land areas. Thirty two percent of the respondents tether their animals during wet season and 2.4% during the dry season, while 64.8% tether their animals all over the year. According to the respondents they purposely tie the animals for proper feeding (27.2%), to avoid field crop damage (2.4%) and for proper feeding, fattening and close follow up all together (70.4%). Fifty six percent of the respondents in the study area use cut and carry feeding system, which is the most common

feeding system in Harerghe in general and 44% use gazing on natural pasture especially in low land areas where there is ample grazing lands.

In low land areas livestock management mainly comprises pastoral, transhumance and settled production practices of moving livestock among different grazing lands. Sixty eight perent of the respondents move their animals from place to place to search for feed and water; 28.88% are partially settled and only 3.12% of the respondents donot move their herd. According to the respondents 64% indicated that there were problems during migration from one place to another searching for grazing land. Some of these problems in the order of their importance are predators, water shortage, diseases, conflict, food and transports. About ninty four percent of the respondents indicated young and matured animals move to search for feed and water and only 36% of the respondent mentioned that they do not have any problem during the movement. On average they move a distance of 18 ± 4.79 (5-120km) away from their home.

Most of the respondents (95.2%) indicated that in low land there is serious range land degradation around watering point. According to the respondents the major causes of the degradation around watering point are large livestock population (16.8%), soil erosion (17.65), nature of the soil (1.6%) and combination of livestock pressure and soil erosion (60%). According to the respondents there are a relative active sign of land degradation around watering point like active gullies (3.2%), poor biomass cover (4.8%), heavy soil erosion (3.2%), growth of undesirable plant (16.8%) and combination of the above indicators (72%). The stalk holders use their indigenous knowledge to solve these problems by using rotational grazing (10.4%), by spreading manure or humus on grazing lands (8.8%), protecting the area either by fencing (45.6%) and combination of the above methods (32%).

The interviewees (59.2%) indicated that there are also under utilization of resources due to the absence of watering point and less uniformity of the existing watering point. The farmers tried to use such wasted resources by moving animals to those area and coming back the next day to watering point. There are also problems on how to use communal resources like feed and water in the low land (pastoral) areas among different tribes.

Livestock health

Forty-eight percent of the respondents indicated that livestock diseases are the second serious problem in the area. Almost all of the respondents mentioned that there is shortage of veterinary clinics and service. Most of the respondents get health services for their animals through purchase of drugs (13.6%), some took sick animals to clinics (25.6%) to far places, others call for professionals (8%) and 36.8% use both traditional and modern treatment methods. Most of the respondents indicated that there are cases when they used these traditional treatments for those diseases that do not have modern medication like for instance rabies and anthrax. List of the most common livestock diseases and their treatments (traditional and modern) are given below.

Table 5: Seasonal prevalence of economically important livestock diseases

Rank	Disease type	Dry season	Semi-dry season	Wet season	Through out the year	Semi-dry & wet season
1	Anthrax (Abbaa sanga)	12%	4%	26.4%	40.8%	1.6%
2	Black leg (Abbaa gorbaa)	8%	8%	56%	6.4%	1.6%
3	Foot & mouth Disease (FMD)	18.4%	11.2%	48.8%	17.6%	3.2%
4	Ectoparasite	9.6%	8.8%	47.2%	4.8%	15.2%
5	Lumpy skin disease(LSD)	16.8%	12%	39.2%	19.2%	2.4%
6	Gastro intestinal disorder	16%	3.2%	47.2%	19.2%	5.6%
7	Urination problem	10.4%	7.2%	30.4%	24%	4%
8	Pastoralists	27.2%	12%	20.8%	5.6%	0.8%
9	Locomotory disorder	11.2%	6.4%	27.2%	16.8%	7.2%
10	Respiratory disease	16.8%	7.2%	25.6%	22.4%	32%
11	Eye infection	17.6%	4.8%	16%	24.8%	1.6%
12	Rabies	9.6%	27.2%	21.6%	16.8%	9.6%

Livestock and Livestock product marketing

We investigated household level current livestock and livestock marketing behavior in three selected districts of western Harerghe by considering 135 house holds. Livestock marketing problem is the fifth major important production constraint according to the respondents. Absence of market centers (0.8%), Price problem (26.4%), distance to market area (10.4%) and problems like lack of market information, broker problem, distance traveled and price problems all together (52%) are the major problems mentioned concerning livestock marketing in the areas.

Sixty five percent of the respondents buy animals from local market, 10.4% buy from the community in the village, 2.4% buy from merchants and 21.6% buy animals from both community and local market. Accordingly 74.4% of the interviewees responded that price of animals fluctuate significantly between the nearest and farthest market. Ninty two percent of the interviewees sale their animals (either fattened or un fattened) to the merchants, 2.8% sale to hotels and 2.2% sale to local butchers at local market.

Table 6: LSM ± SE of number of market, distance of nearest and farthest market in each districts.

Districts	Number of market	Distance of farthest market	Distance of Nearest market
Darolabu	2 ± 0.21	15.24±1.83	7.37±0.96
Habro	2.04±0.08	15.39±2.51	10.46±2.28
Boke	2.5±0.18	26.69±2.32	6.48±0.85

Concerning animal product utilization in the area, there are losses of marketable commodities .This might be because of lack of market information (where and how to sale), absence of buyer (demand) at local market, lack of knowledge on how to produce and manage properly until it reaches end users hand. Some of these commodities are hide, skin, wax and honey. 88% and only 4% of the respondents produce honey and wax for home use, respectively. In the case of hide and skin only 2.4% of the respondents supply for sale, 62.4% of the respondents use for home utilization and 35.2% of the interviewers discard hide and skin as a waste by product. They mentioned that there is no buyer or merchants for these items in the market. So licensing merchants to collect hide and skin, cooperating small micro-enterprises to be involved in collecting this commodities, developing awareness of the farmers through extension is very important in the area for intervention.

Purchase and sale prices of animals for fattening are relatively higher than animals for other purpose in same market, including small ruminants. This is because of the differences in animals body condition (frame size) selected for fattening. Farmers prefer to fatten large size animals with good body condition and physical appearance for fattening than small size animals (62.4%). There is also price variation among districts for fattened (Finished) animals, probably because of variation in number of market centers in the area, market information exchange, number of merchants (buyers and sellers) and involvement of brokers in searching for market and prices.

Purchase price of cattle before fattening is $1895.83 ± 67.47.75, $1841.11 ± 62.43 and $1940.91 ± 77.76 in Darolabu, Habro and Boke district, respectively. On the other hand the sale price of finished cattle at local market in Darolabu, Habro and Boke districts are $309.17 ± 14.82, $368.52 ± 19.07 and $323.41 ± 15.42, respectively. Though the price seems to be higher, the profitability of the fattening practice is not known because most of the farmers do not know the cost of production.

Major livestock production constraints in the study area

There are some identified factors or problems which affect animal production in western Harerghe. Respondents ranked that feed (grazing land) shortage as first priority problem (68%), Livestock

diseases as a second problem (48%), water shortage as third priority problem (48%), low genetic potential as a forth problem (81.6%) and Market problems as a fifth major production constraint (89.6%) in the study areas.

Conclusions and Recommendations

The study results showed that there is good indigenous knowledge of livestock production and management. There are good tradition of cattle and small ruminant fattening, marketing and good ways of feeding, management at the backyard, especially with cut and carry system. Also there is good tradition of treating sick animals using local materials found in the areas where there are no veterinary clinics. Even though there is different important indigenous knowledge in the area, there are wastage of resources and improper utilization of existing potentials and opportunities due to lack of knowledge and awareness to intensively utilize livestock sector. There are under utilization of animal products like hide, skin, bee colony and dairy animals. Livestock feed shortage, livestock diseases, water shortage, low genetic potential of the local animals, poor extension service in utilizing different inputs, lack of training and creating awareness to farmers to inter to market oriented production system and poor marketing system are the most important production problems in the area. Strategic forage development and expanding of the use of these potential forages like elephant grasses and different legumes through extension, training and experience share are important areas for intervention. Infrastructure development like establishing of veterinary clinics with professionals, roads construction, market development, licensing merchants in the areas where there are losses of commodities, and seasonal provision of different inputs like modern hives, forage seeds etc need intervention. Further studies on how to integrate the indigenous knowledge of the farmers with the modern one like detail study of profitability of indigenous cattle fattening technique and economic losses due to under utilization of animal products are required.

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References

FAO. 1988. FAO Production year book. Vol. 42, FAO, Rome.

Lemma Gizachew and Abubeker Hassen. 1995. Effect of pasture improvement on dry season weight gain of Horro bulls. In proceedings of third national conference of the Ethiopian Society of Animal production, Held on 27-29 April 1995, Addis Abeba, Ethiopia. Pp. 282-286.

Peacock C., 1996. Improving goat production in the tropics. A Manual for development workers. Published jointly by Farm-Africa and Oxfam (UK and Ireland), Oxfam, UK, 389 pp.

Wagayehu and Habtemariam. 1994. Assessment of socio-economic impact of the dairy goat development project in eastern Hararghie, Ethiopia. A report for Alemaya University of Agriculture, Dire Dawa, Ethiopia.

Potential livestock production constraints in Yerer watershed of Adaa Liben district.

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Abstract

The study was carried out in 'Yerer watershed' of Adaa Liben district which comprises two peasant associations namely Yerer Silassie and Gende Gorba, with an objectives to identify major livestock production constraints, their causes and farmers perception for possible solutions to overcome the identified constraints. A total of 150 sample farmers (10 %) of household heads in the watershed were included in the study.

As the study result indicated, Shortage of feed, grazing land, lack of clean and sufficient water and poor productivity of local animals were major constraints for livestock production by about 75.8 % (n=97), 44.2 % (n=38), 49.1 % (n=28) and 48.9 % (n=22) of farmers in decreasing order of importance. These constraints were found to be equally important (P>0.05) in both study PAs of the watershed.

The suggested causes for feed shortage, land shortage and poor productivity of local animals were not statistically different (P>0.05) in the two PAs. Accordingly, about 88.3 % (n=113), 94.2 % (n=81) and 57.8 % (n=26) of the farmers suggested that encroachment of grazing land by crop land, increasing population pressure and unavailability of other job opportunity, inherent low productivity of local animals, respectively to be a major cause for these constraints. However, suggested causes for water problem were different (P<0.05) for the two study PAs. Hence, about 78.6 % (n=22) and 31.0 % (n=9) of farmers at Yerer Silassie and Gende Gorba, respectively identified unavailability of sufficient and clean water as the major cause for the problem.

Farmers have also suggest possible solutions for the identified constraints, which were not different (P>0.05) in both PAs. Accordingly, about 60.9 % (n=78), 58.1 % (n=50), 94.7 % (n=54) and 93.3 % (n=42) of the farmers, respectively suggest that allocation of grazing land, control expansion of crop land, introduction of improve forage and control hill side cultivation as a solution for feed shortage, family planning and creation of other job opportunities for land shortage, development of clean and sufficient water source for water related problem, and introduction of improved breed and crossing of the local breed with improved one for improvement of productivity of local animals. Therefore, all concerned institutes need to strengthen their efforts in addressing both livestock production and natural resource problems in the watershed. Moreover, family planning and policy intervention are also needed to limit population growth and expansion of crop land towards grazing areas, respectively.

Key words: Livestock production system, constraints, feed shortage, watershed.

Introduction

Ethiopia has great potential for increased livestock production, both for local use and export market. However, development of the sector has been constrained by inadequate nutrition, disease, a lack of support services such as extension services, insufficient base line information to plan improved services, and absence of policy support to improve animal breeding, marketing and processing. Moreover, the high concentration of animals in the highlands, together with the fact that cattle are often kept for status, reduces the economic potential of Ethiopian livestock (www.1upinfo, 2003).

Different authors have described constraints in different level that affect livestock production in the country. Befekadu and Brehanu (2000) and Lakew *et al*., (2000) indicated that inadequate feed and nutrition, widespread diseases and poor health, poor breeding stock, and inadequate livestock policies with respect to credit, extension, marketing and infrastructure as major constraints affecting livestock performance in Ethiopia. The prevailing production constraints in the livestock sub sector of the country would vary depending on the agro ecology of the areas where the activity is carried out.

Moreover, it has been long recognized that the limitations to increase livestock development (increasing production and productivity) in Ethiopia are multidimensional (Alemayehu, 2003). According to him, livestock production constraints can be grouped into socio-economics and technical limitations. The socio-economics constraints encompass policy issues, land tenure, institutional, marketing and budgetary. The major problems that were grouped as technical constraints include animal health, feed shortage, and poor production performance of local breeds. However, the type of constraints and the extent at which it affect the production systems would vary depending on the production system the farming community perceive. Therefore, this study was carried out with the objectives of identifying major livestock production constraints, its causes and farmer's perception for possible solutions of the problems to be used in future research and development interventions.

Materials and Methods

Description of the study area

This study was carried out in Adaa Liben district of the east Showa administrative zone of Oromiya Regional State (ORS). The specific study area "Yerer watershed" comprises two peasant associations (PAs) of the 45 PAs in the district namely Yerer Silassie and Gende Gorba. Yerer Silassie and Gende Gorba PAs share common boundaries and are totally part of the watershed, and cover a land mass of about 3372 and 3820 ha., respectively (WOA, 2003). These two PAs are geographically located at $8^{O}50$ to $8^{O}53$ latitude and $38^{O}55$ to $38^{O}59$ longitude.

The overall farming system in Adaa Liben district in general and in the study area in particular is characterized by well integrated mixed crop-livestock production system. Crop production is dominant over the livestock production in the district in general and the watershed in particular. Livestock production is a second important system next to crop for the overall farming system in the study area. The major contribution of livestock production for the farming community is provision of draft power, transport and as a means of security. According to WOA (2003) report, the specific study PAs (Yerer Silassie and Gende Gorba) has a total livestock population of 5,269.4 and 6,777.2 TLU, respectively. The livestock classes held by farmers in the study area include; cattle, equines, small ruminants and poultry (WOA, 2003).

Sampling methods

The two peasant associations in the Yerer watershed, Yerer Silassie and Gende Gorba were included in the study. Three villages from each PA: Buti, Korke and Makana for Yerer Silassie, and Goditi, Dedema and Worko for Genda Gorba were included in this study. About 10 percent of the household or total of 150 sample household farmers were randomly selected based on the proportion of total households in the two PAs using Probability Proportional to Size (PPS) approach (Cochran, 1997). Therefore, out of the total households (525) in Yerer Silassie and (950) in Gende Gorba, proportion of 54 and 96 household were included in the study, respectively. At village level, in Yerer Silassie 12, 15, and 27 households were selected randomly for Buti, Korke and Makana, and at Gende Gorba 28, 39, and 29 households were selected randomly for Goditi, Dedema and Worko, respectively.

Data collection and analysis

Two methods/approaches, discussion with key informants for baseline information and formal (diagnostic) survey using well structured questionnaire were used for data collection. During the primary phase of the study, group discussion was held with key informants to investigate and have an overview about major livestock production constraints, their causes and possible solutions to overcome the identified constraints in livestock production system. The information generated during key informant discussion phase was used for the development of the questionnaire for the formal survey. The questionnaire was pre-tested on sample households in the actual study area. Single visit multiple subject survey method was employed in diagnostic survey (ILCA, 1990). Data were analyzed using person chi-square test and logistic regression procedure of SPSS (SPSS, 2003).

Results and Discussions

Overall constraints to the sub-system

During the group discussion phase of the study, different constraints of livestock production were identified and further detail information about their priority, causes and suggested solutions were evaluated during the diagnostic (formal) survey phase. The identified constraints are presented in Table 1.

Table 1. Priority differences among the different livestock production constraints in Yerer watershed.

Constraints	Total HH		Priority of The Problem					
			1st		2nd		3rd	
	N	%	N	%	N	%	N	%
Disease prevalence	37	25.2	6	4.1	24	16.4	7	6.3
Feed shortage	128	87.1	97	66.0	23	15.8	8	7.2
Lack of capital	6	4.1	2	1.4	1	0.7	3	2.7
Lack of knowledge	37	25.2	2	1.4	19	13.0	16	14.4
Lack of water	57	38.8	5	3.4	24	16.4	28	25.2
Land shortage	86	58.5	25	17.0	38	26.0	23	20.7
Low productivity of local breeds	45	30.6	10	6.8	13	8.9	22	19.8
Poor market access	8	5.4	0	0.0	4	2.7	4	3.6
X2 P-Value			0.000					
Total	404	100	147	100	146	100	111	100

HH= Household heads

On prioritizing the importance of the constraints significant (P<0.001) difference was observed. From a total of 147 farmers, about 87.1, 58.5, 38.8, 30.6, 25.2, 5.4 and 4.1% identified feed shortage, land shortage, lack of water and low productivity of local animal breeds, disease prevalence and lack of knowledge, poor market access and lack of capital as major constraints of livestock production. These constraints were part of the major constraints affecting livestock performance in Ethiopia (Befekadu and Brehanu, 2000; Lakew *et al*., 2000).

Major constraints to livestock production

Feed

About 75.8% of the farmers in the two PAs ranked feed shortage as the first priority constraint (Table 2).

Table 2. Farmers response difference for the priority of major livestock production constraint between the two PAs in Yerer watershed.

Constraints	PA	Total HH (N)	Priority						X2 P-Value
			1st		2nd		3rd		
			N	%	N	%	N	%	
Feed Shortage	Yerer Silassie	44	31	70.5	12	27.3	1	2.3	0.075
	Gende Gorba	84	66	78.6	11	13.1	7	8.3	
	Total	128	97	75.8	23	18.0	8	6.3	
Land Shortage	Yerer Silassie	31	10	32.3	10	32.3	11	35.5	0.211
	Gende Gorba	55	15	27.3	28	50.9	12	21.8	
	Total	86	25	29.1	38	44.2	23	26.7	
Lack of water	Yerer Silassie	28	2	7.1	11	39.3	15	53.6	0.782
	Gende Gorba	29	3	10.3	13	44.8	13	44.8	
	Total	57	5	8.8	24	42.1	28	49.1	
Low productivity of local animals	Yerer Silassie	17	5	29.4	5	29.4	7	41.2	0.616
	Gende Gorba	28	5	17.9	8	28.6	15	53.6	
	Total	45	10	22.2	13	28.9	22	48.9	

PA.= Peasant associations, HH= Household heads

Farmers suggested different reasons/causes for this constraint in the area (Table 3). 88.3% (n=113) of the farmers identified lack of grazing land, expansion of crop land, population pressure and decrease of natural pasture in combination as the major causes of feed shortage. The mentioned causes are similar and related to the unavailability of grazing area. The justification given by, about 88.3% (n=113) of the farmers was encroachment of grazing land by crop land to be a major cause for feed shortage, mainly due to high demand for additional crop land and lack of alternative off-farm activities for the increasing human population in the area. Also illegal cultivation of protected and grazing areas is the other reason of the problem.

Different possible solutions suggested by the interviewed farmers and are presented in Table 4. The difference between the two PAs for suggested solutions was not statistically significant. Allocation of grazing land, control expansion of crop land, introduction of improve forage and control hill side cultivation together, and creation of other job opportunities for the new generation have been suggested as major solutions by about 60.9 and 9.4% of the farmers, respectively (Table 4).

Table 3. Farmers response difference for suggested causes of feed shortage problem between the two PAs in Yerer watershed.

List of causes for feed shortage Problem	Total HH		Yerer Silassie		Gende Gorba	
	N	%	N	%	N	%
Area is not good for forage	5	3.9	2	4.5	3	3.6
Climate change	2	1.6	2	4.5	0	0.0
Feed shortage & unavailability in dry season	3	2.3	1	2.3	2	2.4
Lack of forage material, Poor feed conservation & Poor forage growing practice	5	3.9	4	9.1	1	1.2
Lack Of Gazing Land, Expansion Of Crop Land, Population Pressure & Decrease Of Natural	113	88.3	35	79.5	78	92.9
X2 P-value				0.059		
Total	128	100	44	100	84	100

HH= Household heads

Farmer's interest to grow improved forages is a good indicator to improve feed availability in the area through introduction of improved forages using different development strategies. These

strategies may include forage development on the backyard, farm boundaries, conservation areas and through integration with food crops.

Table 4. Farmers response difference for suggested solutions of feed shortage problem between the two PAs in Yerer watershed.

List of solutions for feed shortage Problem	Total HH		Yerer Silassie		Gende Gorba	
	N	%	N	%	N	%
Allocation of grazing land, control expansion of crop land, introduction of improve forage & Control Hill side cultivation	78	60.9	29	65.9	49	58.3
Closure of mountain area for good pasture Utilization	3	2.3	2	4.5	1	1.2
Creation of other job opportunity	12	9.4	1	2.3	11	13.1
Decrease animal number	2	1.6	0	0.0	2	2.4
Develop of forage on farm boundary & Hillside	1	0.8	1	2.3	0	0.0
Fallow crop land for feed source	1	0.8	1	2.3	0	0.0
Family planning	6	4.7	3	6.8	3	3.6
Feeding available crop residue	1	0.8	0	0.0	1	1.2
It is difficult to solve	1	0.8	1	2.3	0	0.0
No Comment	6	4.7	1	2.3	5	6.0
On time & proper feed conservation	3	2.3	1	2.3	2	2.4
Provision of feed with good price,	9	7.0	2	4.5	7	8.3
Resettlement	2	1.6	1	2.3	1	1.2
Use of irrigation	2	1.6	1	2.3	1	1.2
Use of modern cultivation	1	0.8	0	0.0	1	1.2
X2 P-value				0.339		
Total	128	100	44	100	84	100

HH= Household heads

The study result indicates that, grazing land holding in the area is not compatible with crop land and livestock holding. The available grazing land is also overgrazed and deteriorated. Farmers reported that grazing land was allocated for each farmer during the land allocation program of the pervious military government. However, due to uncontrolled expansion of crop land, the areas that were allocated for grazing and closure were converted into arable land. Therefore, based on the land use map developed in the previous land allocation program, reallocation of grazing land may serve as a solution to the problem and needs governmental intervention.

Land

Land shortage has been identified as the second important constraint to livestock production in the study area. This constraint was equally important in the two PAs included in the study and ranked first by 29.1% (n=25) and second by 44.2% (n=38) of the farmers in the watershed. Therefore, this constraint is the second important constraint in the study area (Table 2).

The two major causes identified for this constraint were population pressure, unavailability of other job opportunity and expansion of crop land (Table 5). There was also no significant difference observed on the causes of this problem between the two PAs. About 94.2% (n=81) of the farmers suggested that this constraint resulted due to the increasing population pressure and unavailability of other job opportunity which in turn increased the demand for crop land. Poor management and inefficient utilization of land were not identified as a cause to the problem. However, due to lack of natural resource management practice much of the land has become unproductive as a result of natural resource degradation. Despite the topographic feasibility for irrigation, the crop production mainly depends on seasonal and unreliable rainfall, which indicates inefficient utilization of the land.

Table 5. Farmer's response difference for suggested causes of land shortage problem between the two PAs in Yerer watershed

List of causes for land shortage Problem	Total HH		Yerer Silassie		Gende Gorba	
	N	%	N	%	N	%
Expansion of crop land	5	5.8	0	0.0	5	9.1
Population pressure & Unavailability of other job	81	94.2	31	100.0	50	90.9
X2 P-value				0.084		
Total	86	100	31	100.0	55	100.0

HH= Household heads

From a total of 86 farmers, about 58.1 and 18.6% of the farmers suggested family planning and creation of other job opportunities together and creation of other job opportunity as solutions to the problem (Table 6).

In general, land shortage has direct association with feed shortage, because almost all farmers in the area put land shortage as the major constraint in relation to unavailability of grazing land which resulted due to the increasing demand for crop land in the area.

Table 6. Farmers response difference for suggested solutions of land shortage problem between the two PAs in Yerer watershed.

List of Solution for Land Shortage Problem	Total HH		Yerer Silassie		Gende Gorba	
	N	%	N	%	N	%
Control expansion of crop land, allocation of grazing land	4	4.7	1	3.2	3	5.5
Creation of other job opportunity	16	18.6	4	12.9	12	21.8
Family Planning & other job opportunity	50	58.1	20	64.5	30	54.5
Land Re-allocation and other job opportunity for landless	3	3.5	0	0.0	3	5.5
No Comment	8	9.3	2	6.5	6	10.9
Resettlement	5	5.8	4	12.9	1	1.8
X2 P-Value				0.173		
Total	86	100	31	100	55	100

HH= Household heads

Water

Lack of water may be expressed as shortage of sufficient quantity, shortage of clean water and long distance of water points. As water is a scarce resource in many parts of rural Ethiopia, both people and their livestock commonly travel long distances daily to obtain the water they need. Much time and energy is expended during daily trekking to distant water supplies. As a result, animals lose condition and their productivity is reduced (Abiye *et al.*, 1986). About 42.1 (n=24) and 49.1% (n=28) of the farmers of the area ranked this problem as second and third priority, respectively (Table 2), and hence identified as the third important constraint for livestock production in the area.

More farmers at Yerer Silassie about 78.6% (n=22) identified unavailability of sufficient water as the major cause for the problem as compared to 37.9% (n=11) of the farmers at Gende Gorba. Moreover, about 31.0% (n=9) of the farmers at Gende Gorba identified unavailability of clean water as the major cause for the problem as compared to 7.1% (n=2) of the farmers at Yerer Silassie (Table 7). Therefore, unavailability of sufficient and clean water independently was important causes to the problem at Yerer Silassie and Gende Gorba, respectively. Though the causes of the problem were significantly ($P<0.05$) different for the two PAs.

Table 7. Farmer's response difference for suggested causes of water shortage problem between the two PAs in Yerer watershed

List of causes for water shortage Problem	Total HH		Yerer Silassie		Gende Gorba	
	N	%	N	%	N	%
It relate with settlement pattern	1	1.8	0	0.0	1	3.4
Lack of clean water	11	19.3	2	7.1	9	31.0
Lack of enough water in the area	33	57.9	22	78.6	11	37.9
Long Distance, Lack of enough water in the area	6	10.5	3	10.7	3	10.3
The area is dry	2	3.5	1	3.6	1	3.4
Use of water for irrigation	4	7.0	0	0.0	4	13.8
X2 P-Value				0.022		
Total	57	100	28	100	29	100

HH= Household heads

All farmers who have water related problems gave their possible solutions (Table 8), which were not significantly (P>0.05) differ between the two PAs. Among these solutions, development of clean and sufficient water source was suggested by about 96.4% (n=27) and 93.1% (n=27) of the farmers at Yerer Silassie and Gende Gorba, respectively. As reported by farmers, water development in providing sufficient and clean water for their livestock may be done through maintaining and constructing water harvesting ponds by organizing the mass labour work of the local community. Due to lack of investment capital and technologies, clean water development for human consumption is mainly the responsibility of governmental and non-governmental institutions working in the area.

Table 8. Farmers response difference for suggested solutions to overcome water shortage problem between the two PAs in Yerer watershed.

List of Solutions For Water Shortage Problem	Total HH		Yerer Silassie		Gende Gorba	
	N	%	N	%	N	%
Clean & enough water develop in the area	54	94.7	27	96.4	27	93.1
Release of water properly from the dam	2	3.5	0	0.0	2	6.9
Water diversion	1	1.8	1	3.6	0	0.0
X2 P-Value				0.225		
Total	57	100	28	100	29	100

HH= Household heads

Low productivity of local breeds

The problem of low productivity of local breeds was equally important (P<0.05) for all farmers in the area (Table 2). About 48.9% (n=22) of the farmers ranked this problem as the third priority which totally ranked as fourth important constraint for livestock production system in the area. As stated by Alemayehu (2003), the genotype of Ethiopian livestock has evolved largely through natural selection influenced by environmental factors. This has made the stock better able to withstand feed and water shortages, disease challenges and harsh climates; but the capacity for high levels of production has remained limited. As a result poor production performance has identified as constraint for the livestock sector in the country. All farmers who identified this problem as a constraint also gave their suggestion for its causes. Differences were not observed between the two PAs for the potential causes of the problem. About 57.8 and 37.8 % of the farmers identified inherent low productivity of local animals and lack of improved breed and knowledge as the major causes for the problem, respectively (Table 9).

Table 9. Farmers response difference for suggested causes of low productivity of local animal breeds between PAs in Yerer watershed

List Of Causes For Low Productivity Of Local Breeds	Total HH		Yerer Silassie		Gende Gorba	
	N	%	N	%	N	%
Feed Shortage & Unavailability	1	2.2	0	0.0	1	3.6
Lack Of Improved Breed & Lack Of Knowledge	17	37.8	9	52.9	8	28.6
No Use Of Crossbreeding	1	2.2	0	0.0	1	3.6
Poor Productivity of Local Breed	26	57.8	8	47.1	18	64.3
X2 P-Value					0.331	
Total	45	100	17	100	28	100

HH= Household heads

About 93.3% of the farmers irrespective of their PAs have suggested introduction of improved breed and crossing of the local breed with improved one together as a solution for the improvement of productivity of local animals (Table 10). Considering farmers suggested solutions, selection of productive local animals, crossbreeding, introduction of improved breeds and specialization of livestock production system seem to be applicable in the area.

Table 10. Farmer's response difference for suggested solutions of low productivity of local animal breeds between the two PAs in Yerer watershed

List of Solutions For Low Productivity of Local Breeds	Total HH		Yerer Silassie		Gende Gorba	
	N	%	N	%	N	%
Allocation of Grazing Land From Crop Land	1	2.2	0	0.0	1	3.6
Introduction of Improved Breed & Crossing Of Local With Improved Breed	42	93.3	16	94.1	26	92.9
Maintaining Good Animal With Small No	1	2.2	0	0.0	1	3.6
Proper Use of Available Resource	1	2.2	1	5.9	0	0.0
X2 P-Value					0.413	
Total	45	100	17	100	28	100

HH= Household heads

Therefore, as far as the major constraints to livestock production in the area are concerned, feed shortage, land shortage especially unavailability of grazing land, lack of clean and sufficient water, and inherent low productivity of the local animal breeds were identified as the major constraints in decreasing order of priority.

Conclusions and Recommendations

Feed and land shortage, lack of clean and sufficient water and low inherent productivity of local animals were identified as the major constraints to livestock production in the area and were equally important for both PAs. The interventions made by different institutions to alleviate these constraints were negligible. Therefore, all concerned institutes need to strengthen their efforts in addressing both livestock production and natural resource problems in the watershed. Moreover, family planning and policy intervention are also needed to limit population growth and expansion of crop land towards grazing areas, respectively.

Reference

1upinfo website, 2003. http://www.1upinfo.com/country-guide-study/ethiopia/Ethiopia 124. html.

Alemayehu Mengistu, 2003. Country pasture/Forage resources profiles: Ethiopia. Food and Agriculture Organization of the United Nations (FAO); http://www.fao.org/ag/agp/agpc/doc/counprof/ ethiopia/ethiopia.htm

Befekadu Degefe and Brehanu Nega, 2000. Annual report on the Ethiopian economy. Volume 1, 1999/2000. The Ethiopian Economic Association, Addis Ababa, Ethiopia. 429p.

Cochran W. G., 1997. Sampling Technique. 3rd edition. John Wiley & Sons, Inc., New York, USA.428p.

ILCA., 1990. Livestock system research *manual*, ILCA Working Paper No. 1, Volume 1. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 287p.

Lakew Desta, Menale Kassie, S. Benins and J. Pender, 2000. Land degradation and strategies for sustainable development in Ethiopian highlands: Amhara region. ILRI Socio-economics and policy research Working paper 32. International Livestock Research Institute (ILRI), Nairobi, Kenya. 122p.

SPSS., 2003. Statistical Program for Social Study. Version 12.0.1, release of 2003 Chicago, Illinois, USA.

WOA, 2003. (Woreda Office of Agriculture Adaa Liben). General characteristics of Adaa Liben Woreda. Debre Zeit, Ethiopia. (Unpublished data)

The potential and prospect of aquaculture development in Ethiopia

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Abstract

For a country like Ethiopia where food shortage is chronic in quantities as well as qualities, fishery resources are the most likely recommended. In the wake of mounting difficulties in producing enough food from land areas in general and wild aquatic resources in particular, more attention should be given to alternative sources of food production like aquaculture. Tilapia, clariid catfishes, and common carp are the most likely fish farm candidates. But areas suitable to intensive warm-water species production are lowlands and semi-desert areas where water resources are usually limited, unless perennial streams are used. Considering the nutritional, environmental, social, and economic conditions, as well as suitable fish species and resource potential, it can be concluded that Ethiopia could substantially benefit from aquaculture. It is believed that sites near water resource could best be exploited by integrated subsistence or semi-intensive operations in rural areas. The current policies of government seem to be sufficient for starting aquaculture practices in the country at subsistence and commercial scale. But if they happen to be supported at regional and sectoral levels through strategies and program the situation will become much more conducive.

Key words: Aquaculture, fish, Ethiopia

Introduction

It is well known that world fisheries production has a spectacular contribution to the global food production. Though catches between 1950 and 1990 increased to some 100 million tons (Heckmann, 2005), they are now in slow decline, and as a result, prices have risen. As a panacea for increasing food production and as a way to cope with wild stock scarcity and price increase, aquaculture is being exercised to ensure food security while improving natural resource management and the conservation of biodiversity. In addition to the above-mentioned reasons, Bardach *et al.* (1972) stated that favorable feed conversion rates and high productivity per hectare as compared with traditional agricultural methods and products could be reasons for rapid growth of aquaculture activities.

It has become an established fact that protein from foods of animal origin is dangerously lacking in the everyday diet of much of the population of Africa (Maar *et al.*, 1966). Others like carbohydrate and lipids are relatively found for a great deal of ill health and many deaths each year in almost all the countries of Africa. With regard to the situation of capture fisheries, Ethiopia has an estimated annual total exploitable potential of 60,000 tons from lakes and streams (LFDP, 1996). The per capita fish production is less than 240g (FAO, 2003), but if population as a factor is taken the total annual fish demand will be more than 65,344 tons, approximately 1 kg/person (FAO, 2003). The national demand for fish is continuously increasing. It is currently (ONAR, 2004) estimated at 85,000 tons, and would increase to about 100,000 tons and 120,000 tons by the years 2010 and 2015, respectively, if population grows at present rate. In view of this the supply from the water bodies can no more meet the demand. In addition if other positive factors that trigger the demand such as low fish price, increased distribution networks and improved product quality are considered, the demand will be much higher. Contrary to the increasing demand the supply from the currently exploited natural stocks has already shown signs of stock decline due to overfishing (Reyntjens and Tesfaye, 1998). Furthermore, the growing hydroelectric projects together with the

irrigation projects will potentially aggravate the threat on the riverine stocks (Abebe and Stiassny, 1998). This therefore calls for an increasing attention to be given for aquaculture development in Ethiopia from the point of view that it can contribute to the conservation of biodiversity. According to FAO (2003) report in 2001, 54,187 tons (107,918 US$) fishery product was exported while; 35,575 tons (78,056 US$) was imported verifying that for the first time export exceeded import of fishery products. Hence the fishery sector in Ethiopia is contributing to the national economy, despite its small quantity.

Many researchers have suggested small-scale commercial aquaculture, for Ethiopia faced with deficit in animal proteins, in particular to supply during fasting periods (Balarin, 1986). Aquaculture in Ethiopia is still non-existent inspite of the fact that the country's physical and socio-economic conditions favor its development. The high central Plateau above 2,500 m (11% of total area) could be appropriate for all year round farming of cold-water species. The surrounding and central highlands are believed to be present temperature characteristics favorable to the breeding of a large number of species, from cold water to warm water. However, such developments require significant technical support in terms of provision of fingerlings, demonstration and extension services, which are lacking. Taking this in to account the Sebeta fish-breeding and research center is attempting aquaculture activity for culture-based stock enhancement operation in to natural water bodies and man made reservoirs since 1973.

Although the potential for aquaculture in Ethiopia has so far been assessed at a country level by Balarin (1986) and at a continental level for Africa by Kapetsky (1994), very recent information as to what extent Ethiopia is appropriate for aquaculture is lacking. The present paper is an attempt to satisfy part of the need for information on aquaculture potential in Ethiopia. As aquaculture is a diverse activity, it needs an understanding of the diverse issues influencing its development. Therefore, this paper builds on the experience gained in Africa (Kapetsky, 1994), Latin America (Kapetsky and Nath, 1997) and in particular Ethiopia (Balarin, 1984) in the analysis of factors important for aquaculture development and operation.

Candidate fish species for aquaculture

A number of factors need to be considered before deciding on species for use in aquaculture. The standard criteria for evaluating the aquaculture potential of species relate to a number of characteristics such as growth rate, yield and market value (Hecht and de Moor, 2005). In this paper species such as carp, catfish and tilapia exemplify ones that need to receive the largest possible effort and attention for Ethiopian case.

Tilapia

"Tilapia" is the generic name of a group of cichlids endemic to Africa. The group consists of three aquaculturally important genera- *Oreochromis, Sarotherodon* and *Tilapia*. Tilapia feeds on a wide variety of natural foods, including plankton, some aquatic macrophytes, planktonic and benthic aquatic invertebrates, larval fish, detritus, and decomposing organic matter (Popma and Masser, 1999). With heavy supplemental feeding, natural food organisms typically account for 30 to 50% of tilapia growth. In general tilapias are so efficient in using natural food that crop of more than 3,000 kg/ha can be sustained in well-fertilized ponds without supplemental feed. Fish can reach market size (80-120 g) in 3-6 months, depending on the level of fertilization with inorganic N-P-K fertilizers and/or organic manures and on-farm feeds, made from materials such as rice bran, wheat middling and brewery wastes, mixed with little fish meal to supplement natural diet (Beveridge and Haylor, 1998). Basically, pond culture is the most popular method of growing tilapia because of the ability of the fish to utilize natural foods (Rakocy and McGinty, 1989).

Tilapias are more tolerant than most commonly farmed freshwater fish to high salinity, high water temperature, low dissolved oxygen, and high ammonia concentration. Nile tilapia being the least saline tolerant among commercially important tilapia, it can grow well at salinities up to 15 ppt, performing better below 5 ppt (Popma and Masser, 1999). Tilapias are more resistant to viral, bacterial and parasitic diseases than other commonly cultured fish, especially at optimum temperatures for growth

Due to its presence in almost all the drainage basins of Ethiopia (Shibru Tedla, 1973) and its good cultural characteristics (Rakocy and McGinty, 1989; Popma and Masser, 1999), *Oreochromis niloticus* is highly appreciated as a candidate species for Ethiopia. It is also worth to note that neither species hybrid exceeded its parental species (*O. niloticus*) in growth rate significantly (Beveridge and Haylor, 1998).

Catfish

The family Clariidae members are one of the most widely distributed catfish members, which are distinguished by the accessory air-breathing organ. This organ enables them to exist for hours at a time out of water, or indefinitely in oxygen-poor waters and even moist mud. The extreme hardiness of the Clariids renders them well suited to culture in arid regions such as tropical east Africa (Bardach et al., 1972). The African catfish *Clarias gariepinus*, endemic to Africa, has the widest latitudinal range of all freshwater fishes, and is renowned for its fast growth rate, omnivorous habit, tolerant of environmental extremes and disease (Beveridge and Haylor, 1998). The clariids proved to be cheaper to produce than other catfishes since they require relatively fewer high quality fishmeal-based feeds and few quantity of water for production (Rahman and Verga, 1992; Beveridge and Haylor, 1998). Among local catfish species found in Ethiopia, species known as having a good breeding potential are *Clarias* species (Breuil, 1995).

Clariid catfishes can become sexually mature after 1-2 years and a female produces 20,000 to 1 million eggs depending on body size (60- 70,000/kg body weight) (Beveridge and Haylor, 1998). Bardach *et al.* (1972) pointed out that, the eggs of *C. mossambicus* could be fertilized artificially

Carp

Carp under this topic refers to the common carp, *Cyprinus carpio*. Carp is known to be cultured widely for human protein consumption having the longest history of culture. Its hardiness at all life stages, and the relative ease adaptation of carp to breed in captivity made the culture of carp successful (Bardach *et al*., 1972; Bell and Canterbery, 1976). They have such qualities as: the ability to grow in acid and alkaline water; the ability to tolerate a wide range of temperatures (survive cold winter periods); the ability to adapt easily in highly turbid waters; and the ability to tolerate low O_2 level (0.3-0.5 mg/L) (IWRAS, 2005). Salinity up to 5 ppt is tolerated. Salty waters are no good for carp (ORISSA, 2006); hence salinity is recommended to be less than 3 ppt.Though the ecological spectrum of carp is broad, best growth is obtained when water temperature ranges between 23 ^{0}C and 30 ^{0}C. The optimum pH range is 6.5-9.0. Carps are omnivorous, with a high tendency towards the consumption of animal food, such as water insects, larvae of insects, worms, mollusks, and zooplankton. Carp spawn seasonally in temperate climates and year round in the tropics and to spawn they require at least 18 ^{0}C for a prolonged period (Bardach *et al*., 1972; IWRAS, 2005). Breeding is carried out in hapas (palm bark made nets), cement tanks or small ponds. Submerged aquatic plants are used as substrata for egg laying.

Potential fish feed

The presence of agriculture is an important indicator of aquaculture potential in two ways: first, agriculture implies at least a minimum amount of infrastructure for development, such as a road transportation system, a local labor force and villages or towns for essential supplies and, second

there should be a source of by-products for fish feed or fertilizer (Kapetsky and Nath, 1997). For small-scale fish farming, agricultural by-products can contribute to higher yields than would be possible from the natural production of the pond. For commercial fish farming, use of by-products from agriculturally produced industrial food processing can reduce feed costs by allowing replacement of part of the formulated feeds otherwise needed.

Per capita consumption of milk is estimated at 19 liters per year, while meat consumption is about 13.9 kilos a year of which beef and veal contribute 64 percent; and sheep, goats, chicken and camels provide the remainder (Alemayehu, 2003). Although there are over 90 slaughterhouses, slaughtering of livestock takes place mostly in villages. Abattoir slaughtering is significant only in the bigger towns. A certain level of bone meal, blood meal, and edible fat production takes place in Addis Ababa; virtually all blood and rumen contents go to waste. Over 62 million hectares of grazing area in 2000 estimated to supply over 69.5 million tons of dry matter per year (ONAR, 2003). Crops of cereals and pulses give 6.9 million tons of residues (Alemayehu, 2003). These resources also represent potential composting material for aquaculture pond fertilization. Although not considered as direct feeds those indicated in table 1 plus the above mentioned potential composting materials represent an enormous potential for pond use.

Table.1 Agro-industrial by-products produced in Ethiopia

By-Products	Sugar cane	Molasses	Filter Press Cake	Bagasse	Milling by-products	Oil Seed Mills	Sisal Waste	Brewery grains	Grain Screenings	Sweet Potato Tops	Banana Waste
Production (tons)	78,000	51,000	35,000	300,000	48,240	40,000	2,100	5,970	30,000	60,000	5,000

Source: Alemayehu Mengistou (2003)

From Table 1 it can be seen that Ethiopia has vast stock feed resources totaling 655, 500 tons/yr, hence this leaves scope for the use of supplementary feeds and fertilizers in pond culture. There are large amounts of by-products available in the rural areas from small-scale agro-industries (Balarin, 1986).

Environmental factors required for aquaculture

The site selected for an aquaculture enterprise would have a significant impact on the success of the operation. A site must meet the biological criteria for the species proposed, as well as the facilities required. The three most important factors to investigate are water quantity, water quality and the subsoil type found at the proposed site (Boren et al., 2003).

Availability and quality of water

The main sources of water for ponds are precipitation, runoff, pumped or gravity water from perennial water bodies such as streams, rivers, lakes and reservoirs, and pumped ground water. Ethiopia is endowed with a substantial amount of water resources.

Most rivers in Ethiopia are seasonal and about 70% of the total runoff is obtained during the period June-August (AQUASTAT, 2005). The amount of runoff by river basin is described in Table 1. Rivers, which have a perennial flow, mostly draining from the wet highland zones, could possibly be used as water resources for ponds by stream diversion provided that flood controls are taken in to account. The lowland areas known to have long duration of dry season can potentially provide waters to ponds from their major water bodies. In addition, the areas are regarded as flood prone areas and construction of micro reservoirs not only solve problem of flood damage, but also provide seasonal water. According to MoWR (2000), there will be livestock water supply to all the regions, particularly to lowland areas.

In these areas the micro reservoirs that are going to be developed for domestic/livestock watering could be used for fish production. Here lies the most potential subsistence fish farming option by adopting an integrated approach. Ethiopia has several lakes (an area of about 7000km^2) (AQUASTAT, 2005), a number of saline and crater lakes as well as several wetland areas. All the major lakes, Except Lake Tana which is the source of Abbay River in the Blue Nile Basin, are found in the Rift Valley and among these lakes only Ziway has freshwater while the others are all saline (Wood and Talling, 1988). Such large water bodies however are not as easily managed but there is nevertheless the scope for raising fish in pens and cages. Furthermore, such water bodies could even be used by gravity or pump to supply ponds and tanks in sustainable manner.

Table 2: Major drainage basins and their area, annual runoff, ground water and irrigable land potential in Ethiopia

No	River basin	Area in Km2	Available water (annual runoff) (x109m3)	Irrigable land (ha) (medium Large scale)	Irrigated area (2001)	Ground water potential (x109m3)
1	Tekeze (Atbara)	86,500	8.2	189,500	24,270	0.2
2	Abay (Blue Nile)	204,000	52.62	1,001,550	47,020	1.8
3	Baro-Akobo	75,912	11.81	600,000	13,350	0.31
4	Omo-Gibe	79,000	17.96	86,520	40,300	22,454
5	Rift Valley	52,739	5.63	139,300	25,770	0.1
6	Mereb	5,900	-	67,560	0	0.05
7	Afar/Danakil	62,882	0.86	3,000	0.0	-
8	Awash	112,696	4.6	205,400	112,500	0.14
9	Aysha	2,223	0.22	-	0	-
10	Ogaden	77,121	0.86	-	0	-
11	Wabi-Shebele	202,697	3.16	204,000	22,790	0.04
12	Genale-Dawa	171,042	5.88	423,300	3,530	0.03
	Total	1,132,712	111.8	2,320,130	289,530	2.77

Source: AQUASTAT (2005)

Ethiopia has many small, medium and large reservoir dams constructed for hydropower generation, irrigation and drinking water supply. In total, there are nine medium and large dams with a total capacity of almost 3.5 Km^3 (WWDSE, 2002). Two large dams are used for hydropower generation only, one dam is used both for hydropower generation and irrigation supply, two dams are used for irrigation supply and the remaining four for water supply to the city of Addis Ababa and the town of Gondar. Small dams (micro-dams) constructed for irrigation supply are concentrated in the Amhara and Tigray regional states. For instance, in the Amhara region in Northern Showa zone there are reservoirs established for irrigation purposes by governmental and non-governmental organizations in the four administrative woredas (Basona (>2700m asl), Kewet (1380m asl), and Efratona gidim (1600m asl)) (unpublished field report by Sebeta fish-breeding and research center)). The extent to which these reservoir dams have been stocked with fish is unknown. For stocking dams such species as *Clarias* and tilapia are highly appreciated (Maar et al., 1966). From among the exotic fish species carps are also good for stocking dams. As it is well known Ethiopia has very many different kinds of fish living naturally in the rivers, streams and lakes including *Clarias* and tilapia species. So there is no point in introducing a new kind of fish to waters where fish that are just as good already occur naturally.

The ground water potential of the country is not known with any certainty, but so far only a small fraction of the ground water has been developed mainly for local water supply purposes (AQUASTAT, 2005). The ground water potential by drainage basins is indicated in Table 1. According to Tesfaye (1988) there are considerable ground water potentials, which would best be used in conjunction with surface waters in aquifers of high, moderate or low productivity. For

instance, the Rift Valley and adjacent areas have some of the best aquifers, while the highland volcanics of older age have moderate to low productivity aquifers.

Characteristics of soil for aquaculture

Soil is important factor to consider when constructing an aquaculture facility. A facility constructed to rear aquatic organisms in earthen ponds or raceways requires a soil composed of largely clay (minimum clay content of 20%) because clay soils hold water and prevent seepage better than other soil types (Bardach *et al.,* 1972; Sloane, 2001; New, 2002). A mix of clay-loam soils are the best soils for pond building as they hold water well and the nutrients help to make the water green with food (ORISSA, 2006).

The public irrigation schemes which comprise medium- and large-scale irrigation schemes with areas of 200-3,000 ha and above 3,000 ha, respectively in the country have an estimated area of about 97,700 ha (AQUASTAT, 2005). Since such schemes can have canals and reservoirs of considerable size, they can be potential sites for installing cages and pens. Basically, all formal large-scale irrigation systems comprise four functional sub-systems each with potential niches for integrating aquaculture (Fernando and Halwart, 2000). These subsystems with their respective potential niches for aquaculture include: water source (in storage dam and open wells), water delivery (in primary canals and distributed storage), water use (in farm ponds), and water disposal (in primary drains and evaporation ponds).

Because of their smaller size (generally 1000km^2 surface area) and because they are easier to manage, cages are more adaptable than pens (Beveridge, 1984). In addition, they can be used not only for grow out of fish to market size, but also for breeding and fry production of fishes such as tilapias and for nursing of planktivorous juvenile stages of carps.

Socioeconomic economics of aquaculture

Market potential was inferred from population density, since it is difficult to obtain comprehensive marketability data compatible with this type of study. Therefore population density data analyzed by IFPRI (2005) based on GIS information was directly adopted. The basic assumption being the greater the population density the better the market opportunity for farmed aquatic products (Kapetsky, 1994; Kapetsky and Nath, 1997).

On the other hand, the assumption that there is a relation ship among population density, land use and land cost (Kapetsky and Nath, 1997), preclude at some point alternative uses of land use for aquaculture (especially small-scale aquaculture). Thus, relatively high population densities will be a constraint to the placement of aquaculture due to increased probability of land use and land cost.

Although historically, Ethiopians are considered as meat eaters with annual 10kg per capita consumption, due to cultural patterns and presence of fertile central highlands for considerable expansion of cattle breeding, fish demand remained higher during the two month fasting periods of Ethiopian Orthodox Church followers (Breuil, 1995). However this has to be reconsidered, since there may be extreme regional variation. For instance, Breuil (1995) reported the capital City per capita fresh fish consumption as 0.9 kg/yr, in the production area (Awassa, Arbaminch, Sodo) 8.5 kg/yr and in the Gambella close to Baro River 10 kg/yr as extreme regional variations. It looks in the production areas that there is a crystal clear stimulation of fish demand by regular supply of good quality product at an acceptable price. However, the poor market supply of fish is forcing Ethiopians to prefer beef to fish (Abebe and Stiassny, 1998). In a similar manner, the report by Breuil (1995) stated the result of market survey conducted in 1986, which reflected the same tendency of stimulation by regular supply. From among interviewed consumers who said that they would eat more fish if supplies were more regular were 58%, 45% if fish shops were located

closer to their homes and 38% if fish prices were lower. Ethiopian consumers prefer whole fresh fish as opposed to the bulk provision of filleted fish by fish marketing enterprises (Breuil, 1995). Fish products are processed traditionally into dried fish known as "Kuanta" at some places like Lake Ziway and Arbaminch areas and also smoking is another means of processing. The Ethiopian Meat Concentrates started at industrial level to process and can fish products in 1990 at a capacity of 100,000 cans/day. But this canning has ceased due to poor product quality and weak demand (FAO, 2003).

Very recently, by Ziway fishery research center made fish marketing survey in some sub-cities of rift valley lakes and showed the same tendency of high demand, but unattractive supply and prices of fish. Also the report of undergraduate student (personal communication) showed that changes in the prices of animal products such as meat (70% increases between 1990-1993 as compared to the 30% increase in fish price) will have a significant impact on Ethiopian's food preference habits. Furthermore, the increased availability of fishery products in most private restaurants and hotels of the capital (personal communication) will contribute to such changes in preference habit.

Policy issues and institutions

The government has issued several policies, and strategies, that have firmly established the transfer from centrally planned economy towards a more liberal market-oriented and decentralized economic system in which the private investments could play a dynamic role in the economy. The government policies and strategies are targeted towards the establishment of commercial farms and agro-industries in order to establish viable economy in the country.

Aquaculture as an alternative means of achieving food security is considered as an integral part of rural and agricultural policies and strategies. The current economic policy of market liberalization is opening a room for private sectors to get engaged in the fish market operations. Due to this the state fish marketing operation has fallen to about 8% (FAO, 2003).

As to the proclamation number 315/2003 on fisheries development and utilization, the government has set aquaculture development as one of its objectives. Furthermore, it states that the ministry of Agriculture at federal level and agricultural bureaus at regional level have been given the mandate in issuing directives regarding standards for the establishment of aquaculture. Most policies and strategies do not address aquaculture at all, except for rural and agricultural policies and strategies, thus may become difficult to familiarize the practice and ease land and water holdings.

As to the environmental policy of Ethiopia, any proposed introduction of exotic species into water ecosystems is subject to detailed ecological studies and environmental impact assessment. It also advocates the importance of recycling of wastewater without entailing high cost till it become safe for health and the environment.

Recently, government structural adjustments and trade liberalization policies are being considered, and these could include guidelines for changes in pricing and marketing of several farm products, including fisheries. The intention to give incentives to farmers to target their production to market demands and to practice natural resource conservation could sustain the agriculture sector.

The fisheries and aquaculture sub-sector is believed to have faced with considerable constraints relating to the weak institutional capacity of actors in the sub-sector, the remoteness of productive areas, lack of basic infrastructure and equipment, and the degradation of natural resources. There is no fisheries and aquaculture sub-sector plan including detailed strategies and action programmes. There are no fisheries legislations in many regions.

The highlands of Ethiopia are more densely populated than the lowlands. In the lowlands, there are large unsettled tracts of land that can be developed with either rain-fed agriculture or irrigation as deemed feasible. Hence, the Government's policy emphasis is to expand medium and large commercial farms in the lowlands to ensure that such initiatives are not displacing existing settled farmers.

Conclusions and Recommendations

Maximum potential yields and choice of farm organism is primarily related to water temperature inter related to local climatic conditions and altitude. The high land plateau region temperature is almost unsuitable for the good growth of warm-water species discussed so far. However, the hot lowlands of Ethiopia are likely to have temperature conditions permitting all year round intensive production of warm water species. These areas include the north eastern, south eastern and north western where large tracts of land are found unutilized for agricultural purposes. Unfortunately, most of these areas are with limited water. This then makes intensive production to be limited using only perennial water bodies. The greater portion of central part of Ethiopia although subject to cool conditions (2-3 months), is marginal for warm water species. Carps might find a more wide spread sites in Ethiopia in terms of the potential ecological zones. It would appear that Ethiopia has inland water resources, high demand (even for export), good economics with developing fish market and agricultural inputs of considerable amount as conducive to the development of aquaculture.

The future is bright in Ethiopia for aquaculture; as the goal in the country is to continue to reduce poverty and eliminate hunger, expand commercialized and diversified agriculture. If social and environmental sustainability issues can be successfully addressed, increasing market demand and higher prices should open opportunities for a range of producers and investors. Above all institutional and policy factors should be reconsidered to put in place fish farming infrastructure and extension services prior to any project development.

References

Abebe Getahun and Stiassny, M. L. J. (1998). The freshwater biodiversity crisis: the case of the Ethiopian fish fauna. *SINET: Ethiop. J. Sci.* **21(2)**: 207-230.

Alemayehu Mengestou (2003). Country pasture/ Forage resource profiles: Ethiopia. http://www.fao.org/ag/agp/AGPC/doc/counprof/ethiopia/Ethiopia.htm

AQUASTAT (2005). FAO's Information System on Water and Agriculture: Ethiopia. http://www.fao.org/ag/agl/aglw/aquastat/countries/ethiopia/index.stm

Balarin, J.D. (1984). Fish Farming and Irrigation: Integrated techniques for protein production. *Harare, proc. African Regional symposium on smallholder Irrigation*, University of Zimbabwe: 151-166.

Balarin, J. D. (1986). National reviews for aquaculture development in Africa: 9. Ethiopia. *FAO Fish. Circ.,* (700): 109pp.

Bardach, J. E.; Ryther, J. H. and McLarney, W. O. (1972). *Aquaculture: The farming and Husbandry of Freshwater and Marine Organisms.* New York: Willey-Interscience, publishing. 868pp.

Bell, F. W. and Canterbery, E. R. (1976). *Aquaculture for the developing countries: A feasibility Study*. Cambridge, Ballinger publishing company. 266pp.

Beveridge, M. C. M. and Haylor, G. S. (1998). Warmer-water farmed species. **In:** *Biology of farmed fish*, pp. 383-406, (Black, K. D. and PiCkering, A. D., eds). Shefield Accademic Press, USA and Canada.

Beveridge, M.C.M., 1984 Cage and pen fish farming. Carrying capacity models and environmental impact. *FAO Fish.Tech.Pap*., (255) : 131 p.

Boren, J., Terrell, T., Cowley, E. D. and Hurd, B. J. (2003). Growing Trout in New Mexico ponds. Cooperative Extension Service: College of Agriculture and Home Economics. www.cahe.nmsu.edu

Breuil, C. 1995.Review of the fisheries and aquaculture sector: Ethiopia. *FAO Fish. Circ.,* (890): 29pp.

FAO (2003). Fishery country profile of Ethiopia. FID/CP/ETH. Rev. 3. http://www.fao.org/fi/fcp/en/ETH/profile.htm

Fernando, C.H. & Halwart, M. (2000) Possibilities for integration of fish farming into irrigation systems. *isheries Management and Ecology*. **7:** 45-54.

Hecht, T. and de Moor, I. (2005). Small Scale Aquaculture In Sub-Saharan Africa. ttp://www.cdserver2.ru.ac.za/cd/011120_1/Aqua/SSA/main.htm

Heckmann, R. (2005). Vietnam: A potential Giant in Asia for Aquaculture. http://www.aquaculturemag.com

IWRAS (Inland Water resources and Aquaculture services) (2005). Cultured Aquatic species information programme; *Cyprinus carpio*. http://www.fao.org/figis/servlet/static

Kapetsky, J.M. (1994). A strategic assessment of warm water fish farming potential in Africa. *CIFA Technical Paper*. No. 27. Rome, FAO. 67p.

Kapetsky, J.M. and Nath, S.S. (1997). A Strategic Assessment of The Potential For Freshwater Fish Farming In Latin America. *FAO COPESCAL Technical Paper*. (10). 128p.

LFDP (1996). Lake management plans. Working paper No. 23, MOA. 31p.

Maar, A., Martimer, M. A. E. and Van Der Lingen, I. (1966). Fish culture in central East Africa. FAO Fish. Rep. No. 20. 140pp.

MOFED (Ministry of Finance and Economic Development) (2000). Federal Democratic Republic of Ethiopia (FDRE): Sustainable Development and Poverty Reduction Program.

New, M. B**.** (2002). Farming freshwater prawns A manual for the culture of the giant river prawn (*Macrobrachium rosenbergii). FAO Fish. Tech. Pap*., (428). 212p.

ONAR (2003). The livestock Department Master plan Study. African Development Fund.

ORISSA (2006). Watershed development mission: Pond Construction and Selecting Good Places for Ponds, Better-Practice Guidelines (No. 2) http://www.streaminitiative.org/Library/pdf/bpg/worlp/WBPG2.pdf

Popma, T. and Masser, M. (1999). Tilapia life history and biology. *Southern Regional Aquaculture Center*. No. 283.

Rackocy, C. E. and McGinty, A. S. (1989). Pond culture of Tilapia. *Southern Regional Aquaculture Center*. No. 280.

Rahman, M. N. and Varga, I. (1992). Culture of African Magur (*Clarias gariepinus*) In Bangladesh Department of Fisheries, Government of Bangladesh. http://www.fao.org/docrep/field/003/AC380/AC380E00.htm

Reyntjens, D. and Tesfaye Wudneh (1998). Fisheries management- a review of the current status and research needs in Ethiopia. *SINET: Ethiop. J. Sci.* 21(2): 231-266.

Shibru Tedla (1973). *Freshwater Fishes of Ethiopia.* Department of biology. Haile Selassie I University, Addis Ababa, Ethiopia. 101pp.

Sloane, M. B. (2001). New Mexico Aquaculture. New Mexico University Circular.No.543. http://www.cahe.nmsu.edu/pubs/_circulars/circ543,html

Tesfaye Chernet (1988). Hydrological map of Ethiopia 1:2,000,000. Published by Ethiopian Institute of Geological surveys (EIGS).

Wood, R. B. and Talling, J.F. (1988). Chemical and algal relationships in a salinity series of Ethiopian inland waters. *Hydrobiologia* **158**: 29-67.

WWDSE (Water Work Design and Supervision Enterprise) (2002). Water sector development program (project Eth/98/001/, volume II. Main report. Ministry of Water Resources.

Reproduction and Breeding

Livestock reproduction performance under smallholder management system in Yerer watershed of Adaa Liben district

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Abstract

The study was carried out in 'Yerer watershed' of Adaa Liben district which comprises two peasant associations namely Yerer Silassie and Gende Gorba, with an objective to evaluate reproductive performance of local breeds of animals under smallholder management condition. A total of 79 cows, 38 goats and 44 sheep under the management of 150 selected sample farmers (10 % of household heads) in the watershed were included in the study.

The result observed in this study indicate that age at first calving (50.36 ± 1.00 months), calving interval (25.56 ± 1.65 months) and annual reproductive rate (59.74 ± 2.70%) for local cows in the area are similar with the results reported for the same breed and in the same district. However, The average age at first lambing/kidding of 17.01 ± 1.38 and 13.18 ± 1.45 months and lambing/kidding interval of 12.14 ± 0.94 and 11.52 ± 0.96 months in sheep and goats, respectively were longer than figures reported within the country. The average annual reproductive rate of 192.4 ± 15.5 percent in sheep and 195.5 ± 15.3 percent in goats were higher than other reports within the country and in same district.

Therefore, the potential reproductive performance of the animals in the study area could play significant role in improving the productivity of the animals through appropriate selection and management options.

Key words: Annual reproductive rate, age at first calving/lambing/kidding, calving/lambing/ kidding interval, reproductive performance.

Introduction

The reproductive performance of breeding female is probably the single most important factor influencing herd/flock productivity. This is so because, all forms of output (milk, meat, traction, wool and hides) depend on it, and it is the determinant of output, which varies mostly between flocks/ herds within a population (ILCA, 1990). Therefore**,** reproductive performance influences efficiency of milk and meat production and rate of genetic progress in both selection and crossbreeding programs (Mukasa-Mugerwa and Azage, 1991), and the size of the calf crop for herd replacement (Kiwuwa *et al*., 1983).

Reproductive performance, therefore, is often the determinant of output which is most accessible for improvement, simply by using management practices already used by the farming community. The usefulness of data on reproductive performance lies in their ability to help researchers to identify causes for poor reproductive performance, and hence design opportunities for improvement (ILCA, 1990).

Many different factors influence reproductive performance of the animal. These include nutrition, genetic basis, diseases and health status, and the huge variety of management practices either alone or in conjunction with the others. Establishing relationships between these factors and reproductive performance is a must when identifying constraints in particular systems (ILCA, 1990).

The expression 'reproductive performance' does not usually refer to a single trait, but to a combination of many traits. In general, the main traits that would be considered in assessing reproduc-

tive performance are age at first calving/lambing/kidding, the interval between successive calving/lambing/kidding (calving/lambing/kidding interval) and, from these two the potential lifetime production (reproductive life).

Cattle in traditional system of Sub-Sahara Africa (SSA) have delayed mean AFC of 47.9 months, (ranging from 33.4 to 62.5 months) (Martin, 2004). According to Mukasa-Mugerwa (1989) the average age at first calving in *Bos indicus* cattle is about 44 months, compared with about 34 months in *Bos taurus* and *Bos indicus* x *Bos taurus* crosses in the tropics.

According to Otte and Chilonda (2002), the mean age at first lambing is 17.5 months in traditional systems of SSA. In the same report, the mean age at first kidding in mixed systems was reported as 16.4 months. The age at first lambing/kidding is primarily governed by the effects of age, weight and nutrition on the early onset of puberty and indicated that ewe lambs experienced their first oestrus when they are 40-70% of the mean adult body weight (Owen, 1976). According to Solomon *et al.* (1995), Horro ewe lambs could attain puberty at seven months of age weighing 21 kg and produce viable lambs without any adverse effect on their subsequent growth and reproductive performance. A study (Mukasa-Mugerwa *et al.,* 1994) that looked into the reproductive performance of Menz sheep in Ethiopian highlands reported that ewe lambs attain puberty (first oestrus) at 10 months of age and 16.9 kg mean weight or 56 % of their mature body weight.

According to Galal *et al.* (1981) in the study conducted at two sets of locations, the mean calving intervals were estimated as 16.9 and 16.13 months for local cows under dry and wet conditions, respectively. Osman and Russell (1974) and Galal *et al.* (1981) also reported calving intervals of 14.9 and 14.63 months, respectively for Zebu cattle. Moreover, calving interval in Ethiopian Zebu was reported to range from 12 months to 36 months (Swensson *et al.*, 1981; Goshu *et al.*, 1985; Mukasa-Mugerwa, 1989).

Mukasa-Mugerwa *et al.* (1983) reported an average calving interval of 25 months for indigenous cattle in the Debre Zeit area, this figure is higher than calving interval reported by Galal *et al.* (1981) and Osman and Russell (1974) for the same breed. It is also longer than the result of Zelalem and Lendin (2000) for calving intervals of 15.83, 17.07 and 15.53 months for local breeds at Holetta, Selale and Debre Zeit, respectively. Moreover, based on 31 records Gashaw (1992) reported the mean calving interval of 15.5 months for crossbred dairy cows under farmers' management in Selale.

Annual reproductive rate (ARR) is the other criterion used to evaluate the reproductive performance in small ruminants and cattle. It is the average number of births per breeding female per year. Annual reproductive rate is a function of litter size and calving or parturition interval, which is commonly expressed as percentage. Particularly, in cattle, it is also referred as calving rate (CR) (ILCA, 1990).

In general, many cows in tropical regions produce calves every other year or two calves in three years (Entwistle, 1983), and calving rate is frequently not higher than 45 % (Mukasa-Mugerwa and Mattoni, 1987).

Annual reproduction rate is affected by the year and season of lambing, parity and post partum weight of the dam (Gautsch, 1987). Annual reproduction rate is also related to litter size, lamb mortality and lambing interval (Gatenby, 1986). Shorter intervals coupled with moderate litter sizes lead to relatively high annual reproduction rate compared with longer intervals even if sheep are highly prolific (Gatenby, 1986).

In small ruminants, mean lambing and kidding rates of 109.8 % and 121.1% were reported for traditional production systems in SSA, respectively (Otte and Chilonda, 2002). Moreover, mean

lambing rate (114.9%) and kidding rate (126%) were reported by the same authors for mixed production systems of SSA.

The mean ARR of 1.4 per ewe was regarded as favorable in contrast to estimates elsewhere in Africa that are generally below 1.2 (Gatenby, 1986; Wilson, 1989). However, Gatenby (1986) and Wilson (1989) reported that mean ARR for Menz sheep in Ethiopian highlands was 1.4. According to Mukasa-Mugerwa (1981), the average ARR of 105 and 126 percent were reported in sheep and goats, respectively under the traditional management system in Adaa Liben district. Hence, these relationships show that reproduction rate is influenced by litter size, young mortality and interval between parturitions. With these backgrounds, this research was undertaken to assess the reproductive performance of local animal breeds in Yerer watershed of Adaa Liben district.

Materials and Methods

Description of the study area

The study was carried out in Adaa Liben district of the east Showa administrative zone of Oromiya Regional State (ORS). The specific study area "Yerer watershed" comprises two peasant associations (PAs) namely Yerer Silassie and Gende Gorba (located at $8^{o}50$ to $8^{o}53$ latitude and $38^{o}55$ to $38^{o}59$ longitude), which share common boundaries and are totally part of the watershed, and cover a land mass of about 3372 and 3820 ha., respectively (WOA, 2003).

The overall farming system in Adaa Liben district in general and in the study area in particular is characterized by well integrated mixed crop-livestock production system. The crop production is a dominant over the livestock production in the district in general and in the watershed in particular. Livestock production is a second important system next to crop for the overall farming system in the study area. The major contribution of livestock production for the farming community is provision of draft power, transport and as a means of security. According to WOA (2003) report, the specific study PAs (Yerer Silassie and Gende Gorba) has a total livestock population of 5,269.4 and 6,777.2 Tropical Livestock Unit (TLU) (1 TLU= 250kg of live weight), respectively. The livestock classes held by farmers in the study area include; cattle (oxen, cows, heifers, bulls and calves), equines (donkey, mule and horse), small ruminants (sheep and goat) and poultry (WOA, 2003).

Sampling methods

Three villages from each PA's: Buti, Korke and Makana for Yerer Silassie, and Goditi, Dedema and Worko for Genda Gorba were included in the study. About 10 percent of the household or total of 150 sample household farmers were randomly selected based on the proportion of total households in the two PAs using Probability Proportional to Size (PPS) approach (Cochran, 1997). A total of 79 cows, 38 goats and 44 sheep under the management of 150 selected sample farmers/ household heads in the watershed were included in the study.

Data collection and analysis

Details on age of animals (determined by dentations and/or by owner's interview), its function in the herd/flock and reproductive history (age at first calving/lambing/kidding, calving/lambing/ kidding interval, litter size, sex of offspring, season of birth, etc.) of female animals were collected through intensive interview with owners using well prepared questionnaire.

The data were analyzed using GLM (General Linear Model) procedure of Statistical Analysis System software (SAS, 1999).

Results and Discussions

Age at first calving/lambing/kidding

As reported by farmers, the average age at first calving (AFC) for local Zebu cows was 50.36 ± 1.0 months (Table 1), which is within the range of 33.4 to 62.5 months and 35 to 53 months reported by Martin (2004); McDowell (1972); Mekonnen (1987) and Mukasa-Mugerwa *et al.* (1989) for Zebu cows under traditional management system in SSA and Ethiopia, respectively. Moreover, this result is similar with the average AFC of 53 months reported by Mukasa-Mugerwa (1981) for local Zebu cows in the same district. The AFC of local cows observed in this study is higher than 34 months reported by McDowell and Leining (1978) for Zebu cattle. It is also higher than mean AFC of 47.0 ± 0.1 months reported for Boran heifers (44.60) at Mkwaja Ranch, Tanzania (Trail *et al.*, 1985). This might be associated with management difference between the reported and present study areas.

Table 1. Average age at first calving/lambing/kidding (month) in cow, goats and sheep as reported by farmers in Yerer watershed.

Group	Age at first calving/lambing/kidding								
	Cow			Goat			Sheep		
	N	$\overline{X}$	±SE	N	$\overline{X}$	±SE	N	$\overline{X}$	±SE
Overall	79	50.36	1.00	38	13.18	1.45	44	17.01	1.38
Yerer Silassie	34	49.41	1.55	24	14.33	1.18	12	21.00	2.98
Gende Gorba	45	50.93	1.35	14	11.64	1.55	32	15.13	1.82

The average age at first lambing and kidding (Mean ± SE) for sheep and goats in the study area as reported by farmers were 17.01 ± 1.38 and 13.18 ± 1.45 months, respectively (Table 1). These results are higher than the average age at first lambing and kidding of 13.8 months (for sheep) and 11.9 months (for goats) reported by Mukasa-Mugerwa (1981) for the same breeds and in the same district. The age at first lambing for sheep in this study is also higher than 13.7 months for Thin-tailed sheep reported by Mukasa-Mugerwa *et al.* (1986) and 16.5 months for Menz breed reported by Gautsch (1987) at Debre Berhan. Moreover, it is higher than the mean age at first lambing and kidding of 17.5 months and 16.4 months, respectively in traditional and mixed system of SSA (Otte and Chilonda, 2002). This might be due to management difference within same district and breed difference reported for other areas. However, it is within the range of 13-18 months and 15.9-18.2 months reported by Agyemang *et al.* (1985) and Niftalem (1990), respectively for Menz breed at Debre Berhan. The longer age at first lambing and kidding in both sheep and goats in this study might be due to the independent and interaction effect of nutritional problem during the current study period. The feed supply from natural pasture on which these animals mainly depend on has declined from 20 percent (Mukasa-Mugerwa, 1981) to 5.2 percent after 22 years.

Calving/lambing/kidding interval

The least squares mean for the main effects affecting calving/lambing/kidding interval in cattle, sheep and goats are presented in Table 2. As reported by farmers, the overall average calving interval (CI) for local Zebu cows was 25.56 ± 1.65 months, which is similar with CI of 25.8 months reported by Mukasa-Mugerwa (1981) for local Zebu cow in the same district. Moreover, the CI observed in this study is within the range of 12.2 to 26.6 months reported by Mukasa-Mugerwa *et al.* (1983) for Zebu cattle under traditional management system of Ethiopian highlands, and also similar to the average CI of 25 months reported by Mukasa-Mugerwa *et al.* (1983) for local cattle in Debre Zeit. The present CI is also within the range of calving interval for Ethiopian Zebu reported by Swensson *et al.* (1981), Goshu *et al.* (1985) and Mukasa-Mugerwa (1989) which ranged from 12 months to 36 months.

The CI of local cows in this study is longer than the mean calving intervals of 16.9 and 16.13 months for local cows under dry and wet conditions, respectively (Galal *et al.*, 1981). Moreover, it is longer than calving intervals of 14.9 and 14.63 months reported for Zebu cattle (Osman and Russell, 1974). In general, if the ideal calving interval ranges of 12 to 13 months (360 to 390 days) for cattle (Kiwuwa *et al.,* 1983) and the excess of 16.7 months in *Bos indicus* cows (Enduvie, 1985) is considered, the observed CI in local Zebu cows in this study is higher. This difference might be resulted due to the management and breed difference of the reported and present study areas.

Table 2. Least squares means for factors affecting calving/lambing/kidding interval (month) in cow, sheep and goats as reported by farmers in Yerer watershed.

Variable	Group	Cow			Sheep			Goat		
		N	$\overline{X}$	±SE	N	$\overline{X}$	±SE	N	$\overline{X}$	±SE
Overall		87	25.56	1.65	62	12.14	0.97	47	11.52	0.96
PA	YS	27	25.74	3.99	16	10.81	1.51	18	10.03	1.42
	GG	60	24.38	2.53	46	12.37	1.50	29	12.49	1.31
Parity Number	2	26	29.29	3.72	13	11.49a	1.77	7	13.82	2.13
	3	20	23.71	4.66	17	9.41a	1.75	12	11.13	1.69
	≥4	41	22.18	2.75	32	13.87b	1.16	28	8.84	1.47
Offspring Sex	FEMALE	45	25.28	3.03	29	10.99	1.28	18	11.23	1.41
	MALE	42	24.85	3.26	33	12.18	1.36	29	11.29	1.27
Birth season	DS	61	27.18	2.12	38	9.96	1.11	28	11.75	1.13
	SRS	10	24.21	5.39	9	12.30	2.11	6	8.49	2.17
	MRS	16	23.80	4.32	15	12.51	1.52	13	13.55	1.52
Birth type	SINGLE	-	-	-	52	11.79	1.11	13	9.49	1.55
	TWIN	-	-	-	10	11.39	1.93	34	13.03	1.29

Means in the column within variables followed by different superscript letters were significantly (P<0.05) different.
YS= Yerer Silassie, GG=Gende Gorba, DR=Dry Season, SRS=Short rain season, MRS=Main rain season

The lambing/kidding interval in small ruminants is a good indication of efficiency of reproduction. According to farmers' response, the overall mean lambing/kidding interval in sheep and goats were 12.14 ± 0.97 and 11.52 ± 0.96 months, respectively (Table 2). These lambing/kidding intervals are within range from 7.7 to 14.6 months of lambing intervals in Africa (Wilson, 1989). These lambing and kidding intervals are higher than the average lambing/kidding interval of 8.43 ± 0.17 months (Mukasa-Mugerwa and Lahlou-Kassi, 1995) and 8.73 months (262 days) (Tekelye *et al.*, 1993) reported for Ethiopian highland sheep. Moreover, the average lambing and kidding intervals in sheep and goats observed in this study are longer than lambing and kidding intervals of 7.97 ± 1.6 months and 8.17 months (245 days) reported by Mukasa-Mugerwa (1981) in sheep and goat, respectively in the same district. The observed lambing interval in sheep is also longer than 8.73 months (262 days) reported for Menz breed under station (Gautsch, 1987), and it is almost similar to lambing interval of 13.17 months (395 days) reported by Niftalem (1990) and 11.5 months (345 days) reported by Agyemang *et al.* (1985) for Menz breed under sedentary production system. Therefore, the longer lambing/kidding interval of small ruminants observed in this study might be resulted from the difference in population size and the less precision of farmers to estimate the intervals between subsequent parturition by recalling.

Based on farmers response, the lambing interval in sheep was longer (P<0.05) for ewes above third parity (Table 2). This is in agreement with Sani and Tiwari (1974) who stated that frequent lambing puts more stress on the ewe unless she is fed appropriate diet to enable her to recover as a result the lambing interval would become longer. Therefore, as the age or parities of the ewe increases up to third lambing, the lambing interval would get shorter and becomes longer at fourth and higher lambing. On contrary, all other main effects did not influence the kidding interval of goats.

Annual reproductive rate (ARR)

Annual Reproductive Rate (ARR) was calculated as a function of litter size and calving/lambing/ kidding interval. As reported by farmers and indicated in Table 3, the ARR in local cows was found to be higher (P<0.05) for cows having four and more parities. Hence, this result indicates that the ARR in cows increases as the age or parity of the cow increases. The average ARR of 59.74 ± 2.70 % of local cows observed in this study is within the ARR range of 56 to 62 % reported by Galal *et al*. (1981) for Zebu cows and similar to the ARR of 58.7 and 58.2 % for Zebu cows under traditional and mixed production systems of SSA, respectively (Otte and Chilonda, 2002). However, the average ARR of this study is higher than the ARR of 46.4 percent reported by Mukasa-Mugerwa (1981) for local cows in the same district. In general, if the maximum calving rate of 45 percent (Mukasa-Mugerwa and Mattoni, 1987) is considered, the observed ARR in Zebu cattle in this study is considered to be higher. This might be due to better feeding strategy (supplementation) of cows as reported by farmers during the current study period than the strategy used during Mukasa-Mugerwa (1981) study.

Table 3. Least squares means for factors affecting annual reproductive rate (%) in cattle, sheep and goats, as reported by farmers in Yerer watershed.

Variable	Group	Cow			Sheep			Goat		
		N	$\overline{X}$	±SE	N	$\overline{X}$	±SE	N	$\overline{X}$	±SE
Overall		87	59.74	2.70	62	192.43	15.51	47	195.45	15.26
PA	YS	27	56.24	6.37	16	205.92b	22.52	18	209.25	26.41
	GG	60	59.55	4.03	46	181.29a	22.24	29	198.83	24.26
Parity Number	2	26	53.14a	5.94	13	197.25	26.33	7	156.19a	39.50
	3	20	54.09ab	7.45	17	215.66	25.97	12	241.34b	31.38
	≥4	41	66.46b	4.39	32	167.90	17.22	28	214.60b	27.37
Offspring Sex	Female	45	60.26	4.83	29	196.78	19.09	18	214.83	26.16
	Male	42	55.53	5.20	33	190.43	20.21	29	193.25	23.55
Birth Season	DS	61	56.14	3.38	38	213.61b	16.45	28	190.01	20.99
	SRS	10	53.47	8.61	9	178.07a	31.47	6	249.84	40.38
	MRS	16	64.07	6.89	15	189.13b	22.59	13	172.27	28.26
Birth type	Single	-	-	-	52	132.28a	16.51	13	171.54a	28.86
	Twin	-	-	-	10	254.93b	28.66	34	236.55b	23.93

Means in the column within variables followed by different superscript letters were significantly (P<0.05) different.
YS= Yerer Silassie, GG=Gende Gorba, PA.= Peasant associations, DR=Dry Season, SRS=Short rain season, MRS=Main rain season

The overall means for ARR in sheep and goats in the study watershed were estimated to be 192.43 ± 15.51 and 195.45 ± 15.26 %, respectively (Table 3). The average ARR of small ruminants observed in this study is higher than the mean ARR of 1.2 (120%) elsewhere in Africa and 1.4 (140%) reported for Menz sheep in the Ethiopian highlands (Gatenby, 1986; Wilson, 1989). It is also higher than the ARR of 1.13 (113%) and 1.36 (136%) reported for sheep and goats in the mixed production system in SSA (Otte and Chilonda, 2002). Moreover, the average ARR of 105 and 126 percent in sheep and goats were reported by Mukasa-Mugerwa (1981) for the same area is also lower than the result observed in this study. Under station management, ARR of 1.66 (166%) was reported by Gautsch (1987) for Menz breed. Niftalem (1990) and Agyemang *et al*. (1985) have also reported ARR of 1.10 (110%) and 1.03 (103%), respectively for Menz breed under Sedentary management system. All these figures are lower than ARR found in this study for sheep. This higher ARR might be due to higher reproductive performance particularly with higher litter size of the animals as the nutritional problem remains at the same low level.

As per farmers response, the ARR in sheep was higher (P<0.05) at Yerer Silassie compared to Gende Gorba. This might be due to better access of the animals to graze on natural pasture which is mainly resulted due to better grazing land holding of farmers in Yerer Silassie than in Gende Gorba (Samuel, 2005). Also the ARR in sheep was higher (P<0.05) during the dry season (*Bega*).

In contrary, Gautsch (1987) and Niftalem (1990) reported that ARR for Menz sheep was highest when ewes lambed during the short rainy season and lowest when lambing occurred during the dry season. However, higher ARR during long dry '*Bega*' season in this study might be related with higher conception rate of the ewes during the main rainy season during which relatively better feed was available and giving birth during the dry season; hence the ARR for this season was higher than other seasons of the year. This result is similar to the report of Mukasa-Mugerwa (1981) who identified lambing and kidding peak season from December to March and from October to February, respectively within the dry season of the year in the same district.

The ARR was also higher ($P<0.05$) for twin than single lambing, which mainly resulted from the increasing effect of litter size on the ARR of all animals. Similarly, as reported by farmers, the ARR in goats was affected by birth type ($P<0.05$). The highest ARR of 236.55 ± 23.93 percent was obtained from twin born. Moreover, higher ARR of 241.34 ± 31.38 percent was recorded for goats at third parities ($P<0.05$). This is in agreement with the report of Gautsch (1987) who indicated that ARR was highest for ewes that lambed for the fourth time or more. Therefore, when the age or parity of doe's increases its tendency to give multiple births would also increase which in turn increases the ARR after the third kidding until the animal gets older.

Conclusions and Recommendations

The result observed in this study indicate that age at first calving (50.36 months), calving interval (25.56 months) and annual reproductive rate (59.74%) for local cows in the area are similar with the results reported for the same breed and in the same area. However, the average age at first lambing/kidding and lambing/kidding interval in sheep (17.01 and 12.14 months) and goats (13.18 and 11.52 months) observed in this study, respectively are longer than the average figures reported for the same breed in different parts of the country as well as in same study area. The average ARR of cow (59.74±2.70%), sheep (192.43±15.51%) and goat (195.45±15.26%) observed in this study were higher and similar as compared with the average ARR reported elsewhere in Africa and Ethiopia as well as in same district.

Therefore, proper management system is critical in improving the age at first lambing/kidding and lambing/kidding interval in sheep and goat. However, potential reproductive performance of animals in the study area could play significant role in improving the productivity through appropriate selection and management options.

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References

Agyemang, K., Negussie Akalework, Voorthuizen, A. and Anderson, F. M., 1985. A rapid survey of reproduction in the traditional sector of Debre Berhan, Ethiopian highlands. In: R.T. Wilson and D. Bourzat (eds.). Small Ruminants in African Agriculture. International Livestock Center for Africa (ILCA), Addis Ababa, Ethiopia. pp. 175-185.

Cochran W. G., 1997. Sampling Technique. 3rd edition. John Wiley & Sons, Inc., New York, USA.428p.

Entwistle, K.W., 1983. Reproduction in *Bos indicus* cattle in northern Australia. Proceeding of the Australian society of animal production (ASAP), Australia. 13: 60-61.

Food and Agriculture Organization of the United Nations (FAO). 2002. Food and Agriculture Organization of the United Nations (FAO), Agricultural Database System. Web site: http://fao.org/agristat.html

Galal, E.S.E., Beyene Kebede and Azage Tegegne, 1981. A study on the reproduction of local Zebu and F_1 crossbred (European x Zebu) cows. II. Age at first calving and calf production. *Eth. J. of Agri. Sci.* 3:87-95.

Gashaw Geda, 1992. Assessment of feed resource base and performance of crossbred dairy cows distributed to smallholder in the Selale Dairy Development Project area. An MSc. Thesis presented to the School of Graduate Study of Alemaya University. 171p.

Gatenby, R.M., 1986. Sheep production in the Tropics and Sub-Tropics. Tropical Agricultural Series, Long man group limited. New York, USA. 351p.

Gautsch, K.D., 1987. Comparative productivity of indigenous sheep in the highland areas of Ethiopia and Rwanda. SRCG Working Document No. 14. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 75p.

Goshu Mekonnen, Kassahun Demeke and Tesfaye Asefa, 1985. Assessment of the state dairy farms. *Eth. J. Agri. Sci.* 7: 51-67.

International Livestock Centre for Africa (ILCA)., 1990. Livestock system research *manual*, ILCA Working Paper No. 1, Volume 1. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 287p.

International Livestock Research Institute (ILRI), 2000. Handbook of livestock statistics for developing countries. ILRI Socio-economics and policy research Working paper 26. International Livestock Research Institute (ILRI), Nairobi, Kenya. 207p.

Kiwuwa, G.H., Trail, J.C.M., Yousef, M.K., Worku, G., Anderson, F.M. and Durkin, J.W. 1983. Crossbred dairy cattle productivity in Arsi region, Ethiopia. Arsi Rural Development Unit, Assela (Ethiopia). ILCA Research Report No. 11. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 29p.

Martin Upon, 2004. The role of livestock in economic development and poverty reduction. Pro-poor livestock policy initiative (PPLPI) Working paper No.10. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. 57p.

McDowell, R.E., 1972. Improvement of livestock production in warm climate. Freeman, San Francisco. 711p.

McDowell, R.E. and K.B. Leining, 1978. Handling of European cattle in the tropics for reproductive efficiency. Paper presented in eleventh congress International Da Raca Chianima Sao Paulo, Brazil. 30p.

Mekonnen Haile-Mariam, 1987. Growth and reproduction performance of Boran and crossbred cattle at Abernosa ranch. An MSc Thesis presented to the School of Graduate Study of Alemaya University. 138p.

Mukasa-Mugerwa, E., 1981. A study of traditional livestock production in Ada district of Ethiopia. Mimeograph. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 154p.

Mukasa-Mugerwa, E., 1989. A review of a productive performance of female *Bos indicus* (Zebu) cattle. ILCA Monograph 6. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 134p.

Mukasa-Mugerwa, E. and Azage Tegegne, 1991. Reproduction performance in Ethiopian Zebu (*Bos indicus*) cattle: constraint and impact on production. pp. 16-28. An invited paper presented at fourth national livestock improvement conference. Addis Ababa, Ethiopia, 13-15 Nov. 1991, Institute of Agricultural Research (IAR).

Mukasa-Mugerwa, E. and A. Lahlou-Kassi, 1995. Reproductive performance and productivity of Menz sheep in Ethiopian highlands. *Small Ruminant Research*. 17: 167-177.

Mukasa-Mugerwa, E. and M. Mattoni, 1987. Reproductive performance of the Ethiopian highland Zebu. In: eleventh international congress of animal reproduction, AI. Dublin, Ireland.

Mukasa-Mugerwa, E., A.N. Said, A. Lahlou-Kassi, J. Sherington and E.R. Mutiga, 1994. Birth weight as risk factors for perinatal ewe supplementation and gestation weight gain in Ethiopian Menz sheep. *Preventive Veterinary Medicine.* 19: 45-56.

Mukasa-Mugerwa, E., Ephrem Bekele and Tadesse Tesema, 1983. Reproductive performance of indigenous cattle in the Ada district of central Ethiopian highlands. Mimeograph. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 99p.

Mukasa-Mugerwa, E., Ephreim Bekele and Taddesse Tesema, 1986. Productivity of indigenous sheep and goats in the Ada district of Ethiopian highlands. pp. 81-87. In: K.O. Adeniji and J.A. Kategile (eds.). Proceedings of the workshop on the improvement of Small Ruminants in Eastern and Southern Africa. Nairobi, Kenya, 18-22 Aug. 1986.

Niftalem Dibissa, 1990. Sheep production on smallholder farms in the Ethiopian highlands - a farming system approach. A PhD. Dissertation presented to the Humboldt University, Berlin, Germany. 131p.

Osman, A.H. and W.S. Russell, 1974. Comparative performance of different grades of European-Zebu crossbred cattle at Ghurshi dairy farm, Sudan. *Tropical Agriculture (Trinindad).* 51: 549-558.

Otte, M.J. and P. Chilonda, 2002. Cattle and small ruminant production systems in sub-Saharan Africa: A systematic review. Livestock information, sector analysis and policy branch, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. 98p.

Owen, J.B., 1976. Sheep production. Baillier and tindall, London. 436p.

Samuel Menbere, 2005. Characterization of Livestock Production System: *A Case Study of* Yerer Watershed, Adaa Liben District of East Showa, Ethiopia. An MSc. Thesis presented to the School of Graduate Study, Alemaya University. Alemaya, Ethiopia. 184p.

Sani, K.L. and S.B. Tiwari, 1974. Effects of early re-breeding on certain aspects of sheep production. *Indian J. Anim. Sci.* 44: 767-770.

The Statistical Analysis System (SAS), 1999. SAS, Version 8. SAS Institute Inc., Cary, North Carolina, USA. 1485p.

Solomon, G., A. Solomon and Yohannes Gojjam, 1995. Factors affecting pre weaning survival of Horro lambs at Bako research center. pp. 140-145. In: Proceeding of the third annual conference of Ethiopian Society of Animal Production (ESAP). Addis Ababa, Ethiopia, 27-29 Apr. 1995.

Swensson, C., J. Schaar, E. Brannang and L.B. Meskel, 1981. Breeding activities of the Ehio-Swedish integrated rural development project. II. Reproductive performance of Zebu and crossbred cattle. *World Animal Review*. Food and Agriculture Organization of the United Nations (FAO), Italy, Rome. 38: 31-56.

Tekelye, B., E. Bruns, O.B. Kasali and E.R. Mutiga, 1993. The effects of endoparasites on the reproductive performance of on-farm sheep in Ethiopian highlands. *Indian J. of Anim. Sci.* 63:8-12.

Trail, J.C.M., K. Sones, J.M.C. Jibbo, J.W. Durkin, D.E. Light and M. Murray, 1985. Productivity of Boran cattle maintained by chemoprophylaxis under trypanosomiasis risk. ILCA Research Report No. 9. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 76p.

Wilson, R.T., 1989. Reproductive performance of African indigenous small ruminants under various management systems: A review. *Animal Reproduction Science.* 20:265-286.

WOA, 2003. (Woreda Office of Agriculture Adaa Liben). General characteristics of Adaa Liben Woreda. Debre Zeit, Ethiopia. (Unpublished data)

Reproductive performance of dairy cows in the Yerer Watershed,Oromiya Region, Ethiopia

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Abstract

The study was conducted in the Yerer watershed located in Ada Liben Woreda of East Shoa Zone of Oromiya Region from August 2003 to September 2004. The objectives of the study were to characterize the overall reproductive performance of local and crossbred dairy cows of the Yerer watershed, and to understand age at first calving, calving intervals, and availability of AI for local and crossbred dairy cows, and their influences on production.

The major livestock kept by the farmers were cattle, equine, poultry, sheep and goats with an average holding of 5.45 ± 2.7 Tropical Livestock Unit (TLU) per household. The proportion of oxen over female cattle was high. Except Babogaya and Goditti village near Debre Zeit town, AI service was not available in the other villages of the watershed. Genotype of cows in the reproductive herd was 80 percent local, 20 percent Holstein /Friesian crosses.

Age at first calving of the local dairy cows was 58.09 ± 13.04 months (n = 95) and mean age at first calving for crossbred dairy cows was 44.67± 17.1 months (n = 24). The overall average calving rate in the watershed was 68.7 percent. The local dairy cows were characterized by longer calving interval (21.66 ± 8.2 months) (n = 84) than for crossbred cows (16.3 ± 4.1 months) (n = 22). The limiting factors to increase milk production, according to farmers were unavailability of cross breeding facilities, feed shortage, disease problems and lastly absence of credit facilities. Farmer's perception to have crossbred dairy cows and to increase exotic germplasm in the reproductive herd was highly positive, for the purpose of generating income.

Introduction

Ethiopia is one of the least developed countries in the world with per capita income of 130 US Dollars (World Bank, 1996). Poverty and food insecurity are the two major problems in the country. As in many developing countries, agriculture is the mainstay of the Ethiopians and about 85 percent of the total population is engaged in the sector. The contributions of the sector to the country's Gross Domestic Product (GDP) and exports are about 60 % and 90 %, respectively (World Bank, 1995). Animal production plays a significant role in the countries economy. The livestock sub sector contributes approximately 12- 15 percent to the GDP (McDaC, 1999).

Reproduction performance

Reproductive performance is one of the major factors, other than milk production, that affects productivity of a dairy herd. Reproductive performance is a biologically crucial phenomenon, which determines the efficiency of animal production. The production of milk and replacement stock is not possible unless the cow reproduces. It has been indicated that possible genetic improvement in virtually all traits of economic importance is closely tied to reproductive rate (Kiwuwa *et al.,* 1983). Nutrition plays a pivotal role in influencing the maintenance of efficient reproductive performance. Nutritional status of animals, among other factors, is the main constraint for the productivity of dairy herd (Payne, 1970) and improving the feeding regime can improve the reproductive performance (Mukassa-Mugerewa, 1989).

First calving makes the beginning of a cows productive life (Meaker *et al*., 1980). the estimated age at first calving of local cows at Andassa Ranch of Fogera heifers in North western parts of Ethiopia was found to be 53.8 months (Asheber, 1992).

Average calving interval in tropical breeds varied between 334 and 730 days. Calving interval is reported to have low heritability and can be improved thorough better nutrition and early breeding (Falvey and Chantalakhana, 1999). Getachew (2002) has reported that in Ginchi watershed cows have longer calving intervals (22.2 months)

Table 1.Age at first calving of local cows

Types	Age at first calving in months	Country	Source
At Andasa Ranch of local cows	53.8	Ethiopia	McDowell (1972)
Fogera heifers in North western parts of Ethiopia.	50.0	Ethiopia	McDowell (1972)
Boran cows	35-52	Ethiopia	Wahid (1976)
Boran cows	45.2-51.1	Ethiopia	(Mekonnen,1987; IAR,1991)
Fogera	53.8	Ethiopia	Asheber (1992)
Horro cattle	55.3	Ethiopia	Mulugeta et al., (1991)
Small sized East African zebu	37-48	Ethiopia	(FAO, 1993; Itty et al., 1995)
In Ginchi watershed local cows	50.6	Ethiopia	Getachew (2002)

Table 2.Calving interval of local cows

Types	Calving interval in days	Country	Source
Local cows	497.6	Ethiopia	Azage (1981)
Arsi cattle	439	Ethiopia	Kiwuwa et al., (1983)
Local cows	465	Ethiopia	Mekonnen (1987)
Horro	435	Ethiopia	IAR (1991)
Fogera	346	Ethiopia	Asheber (1992)
Fogera	559 ± 137	Ethiopia	Addisu (1999)
Tropical breeds	334-730	Ethiopia	Falvey and Chantalakhana (1999)
Zebu cattle	366-798	Ethiopia	Falvey and Chantalakhana (1999)
In Ginchi watershed local cows	666	Ethiopia	Getachew (2002)

Table 3.Age at first calving of crossbred cows

Crossbred	Age at first calving in months	Country	Source
Highland crosses of Ethiopia*	33.5	Ethiopia	Azage (1981)
50 % Friesian - zebu	29.1	Ethiopia	Alberro (1983)
75 % Friesian 25 % zebu	33.6	Ethiopia	Kiwuwa et al., (1983)
50 % Friesian 25 % Arsi and 25 % Boran	57.6	Ethiopia	Teferi (1994)
75 % Friesian 25 % Arsi	48.3	Ethiopia	Teferi (1994)

* Unknown blood level

Table 4.Calving interval of crossbred cows

Types	Calving interval in days	Country	Source
Highland crosses*	422	Ethiopia	Azage (1981)
50 % Friesian - zebu inArsi	428	Ethiopia	Kiwuwa et al. 1983
50 % Friesian - Boran	371	Ethiopia	Alberro (1983)
50 % Friesian - Boran	552	Ethiopia	Mekonnen (1987)
Crossbred dairy cows in Selale*	464	Ethiopia	Gashaw (1992)
50 % Friesian - Arsi	524	Ethiopia	Teferi (1994).

* Unknown blood level

The objectives of the study were to characterize the overall reproductive performance of local and crossbred dairy cows in the watershed

- Age at first calving of both local and crossbred dairy cows
- Calving intervals of local and crossbred dairy cows
- Availability of AI for local and crossbred dairy cows

Materials and methods

The study was conducted in Yerer watershed of Ada Liben Woreda of the Eastern Shoa Administrative Zone of Oromiya Regional State.

Location and climate of the area

Ada Liben Woreda is located 45 km south east of Addis Ababa, at an altitude of 1600 to 2400 m above sea level. Situated at 8° 44' N and 38° 58' E. Mean minimum and maximum temperatures are 10.6 and 25.0 °C, respectively. The rainfall pattern of the area is bimodal with the small rains (short rainy season) occurring between February and April and main rains (long rainy season) between mid June and mid September. The mean annual rainfall is 800 mm (WBOA, 2003). The long term mean annual rainfall shows that the short rains contribute 30 percent of the annual precipitation (Astatke *et al.,* 1995).

The Woreda has a total land of 161,056.3 ha of which about 119,449.5 ha and 6461.83 ha of land is being used for crop cultivation and as pasture land, respectively (WBOA, 2003). Also about 10,632.5 and 1630 ha of land is supposed to be covered by forest, bushes and shrubs, and lakes (water lands), respectively (WBOA, 2003).

The particular study area "Yerer Watershed" found in Ada Liben Woreda some about 14 km north of Debre Zeit and consists of two Peasant Associations (PAs), namely Yerer Silase and Gende Gorba which covers about 3,372 and 3,820 ha of land, respectively (WBOA, 2003). Total watershed area covers about 4.5 percent of the Woreda.

The human population of Yerer Silase and Gende Gorba peasant associations is estimated to be 4,104 and 7,427 with population density of 121.7 and 194.4 person per sq. km, respectively (WBOA, 2003).

The number of households in Yerer Silase and Gende Gorba are 525 and 950, respectively. In Yerer Silase PA, out of the total number of households 19.32 percent (101) are female headed and the rest 80.76 percent (424) are male headed. In the Gende Gorba PA, female headed households account for 13.7 percent (130) and male headed are 86.3 percent (820) (WBOA, 2003).

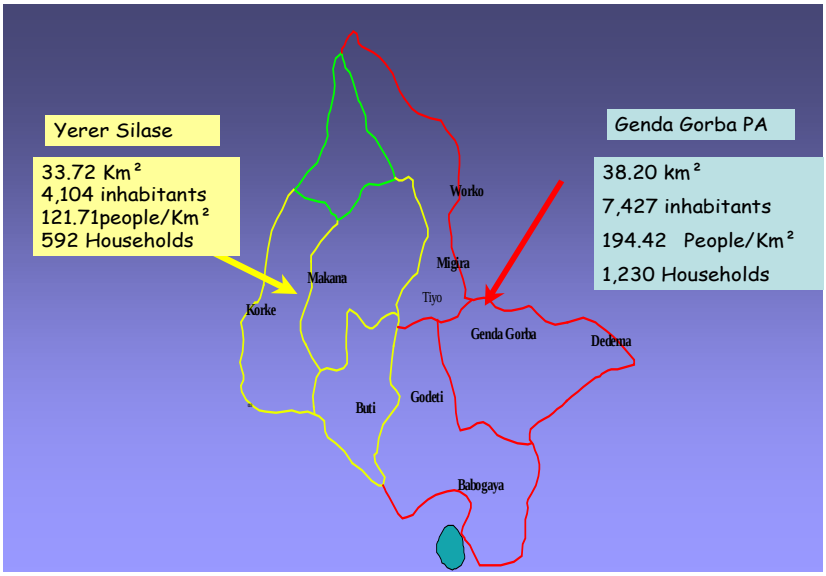

Figure 1.Map of the study area

Although rain fall is bimodal, it is the big rains that are mainly used for crop production. Rains during the months of July to September are very intense. Cropping operations are not carried out during the small rains, but it helps to grow grasses for livestock and is also used for preparation for cultivation during the main rains. The Yerer watershed has one of the peak of the woreda (3100 m.a.s.l.) as one gets over mountain (WBOA, 2003). Because of the sloppy topography, and clearing of forests for expanding of cultivated land and accelerated the soil erosion gradually destroying the soil resource in the study area (Hurni, 1990).

The average minimum and maximum air temperature data at 1.5 m from ground for twenty seven years (1977-2003) ranged from 7.9 (1985) to 28.2°C (1987). However mean annual temperature for this period was 18.5°C (Kahsay, 2004). Highest temperature was observed for the months of March, April, May, and June, while the months October, November and December had the lowest temperatures.

Data for the study

Both qualitative and quantitative data were used for the study using exploratory and diagnostic survey. The data that were obtained through secondary information were included. The study covered six villages of the two PA's. Using Participatory Rural Appraisal (PRA) and rapid survey, attempts were made to take inventories of the present dairying in all villages, and to understand the overall situations, type of resources, present situations for the development.

Sampling procedure

Both the PAs of the watershed area formed the first level of stratum for this study. In each PA three villages, Buti, Korke and Mekana for Yerer Silasa, and Goditti (Babogaya and Goditti), Dedema and Worko for Gende Gorba were considered in the study as second level of stratum.

Resource constraints were decided from PRA and rapid survey. Based on the inventory taken at the time of rapid survey it was estimated that there were 368 households having dairying. Of these, 120 households or 32.6 percent of the total dairying households were considered in the formal survey.

The methodology used was a formal survey of a representative sample of dairy production units within the dairy shed. Farmer-recall (over one year) techniques were used for collecting production data.

Data collection

Based on the information generated through PRA, a questionnaire was used and record sheets were developed for the formal interview /diagnostic survey (Jabbar and Mullins 1997; Rey *et al.,* 1999). Before starting the actual formal survey, the developed questionnaires were pre-tested for the suitability of the study. Enumerators (two) were trained and used to collect the data for formal survey. Field observation was taken in the sampling area.

Statistical methods

The statistical analysis used in this study varied depending on the type of variables and information obtained. However, quantitative data were analyzed using descriptive statistics (percentage, mean comparison, mode, median, standard deviation, coefficient of variation etc.). Computer software SPSS 12.1 were used for data management and analysis.

Results and discussion

Reproduction performance of local cows

An important prerequisite for the sustainability of a dairy production system is that cows must have efficient reproductive performance. This is essential for the production of the main commodity of interest of milk, as well as to provide replacement animals.

First calving marks the beginning of a cows productive life and influences both the productive and reproductive life of the female, directly through its effect on life time calf crop and milk production and indirectly through its influence on the cost invested for up-bringing (Mukassa-Mugerewa 1989). Age at first calving differ due to variation in management regimes and genetic merit of the stock. Based on the response from the Yerer watershed farmers, the overall estimated mean age at first calving was 55.39 ± 14.9 months.

Age at first calving of local cows

In terms of genotype, mean estimated age at first calving for the local cows in the watershed was 58.09 ± 13.04 (Table5) months which is closer to three fold of the expected-one (20-25 months) , which might be due to late maturity to puberty and poor management conditions as well as poor genetic makeup (n = 95).

The present finding is close to the report of Asheber (1992) who estimated age at first calving of 53.8 months for Fogera. The estimated age at first calvings were 45.2 months and 51.1 months for Boran cattle (Mekonnen,1987; IAR,1991), 50 months for warm climate local cows (McDowell, 1972), 35-52 months for Boran (Wahid, 1976), 55.3 months for Horro cattle (Mulugeta *et al.,* 1991), 37 to 48 months for small sized East African Breed (FAO, 1993; Itty *et al.,* 1995), In Ginchi watershed, age at first calving of 50.6 months was reported for local cows (Getachew, 2002).

Calving interval of local cows

Calving interval refers to the period between two consecutive calvings and is a function of days open and gestation length. Calving interval is reported to have low heritability and can be improved thorough better nutrition and early breeding (Falveyand and Chantalakhana, 1999).

The overall estimated mean calving interval for the cows of Yerer watershed was found to be 20.57 ± 7.8 months, (Table 6) which is longer calving interval than the optimum to be acceptable (12 to 13 months) which might be due to poor nutrition, lack of detection and follow-up for estrus.

Mean calving interval of local cows in the watershed (Table 6) was estimated to be 21.66 ± 8.2 months (650 days) which is longer calving interval than the optimum to be acceptable (12 to 13 months) which might be due to poor nutrition, lack of detection and follow-up for estrus.

Similarly Falvey and Chantalakhana, (1999) indicated that average calving interval in tropical breeds varied between 334 and 730 days. Getachew (2002) reported longer calving interval of 22.2 months (666 days) in the Ginchi watershed. Such a wide variation in calving interval offers wide scope for improvement through management.

Reproduction performance of crossbred cows

Age at first calving of crossbred cows

Table 5 shows mean age at first calving of 44.67± 17.1 months (n = 24) for crossbred dairy cows. Most frequent response from farmers was that it takes four to five years to obtain the first calf from local cows. On the other hand, crossbred cows had shorter age at first puberty than local cows, which is influenced by genotype and due to management factors.

Table 5.Age at first calving (in months) of crossbred and local cows in Yerer watershed

Genotype	N	Mean	SD	Minimum	Maximum
Crossbred	24	44.67	17.089	24	96
Local	95	58.09	13.045	36	120
Total	119	55.39	14.89	24	120

Calving interval of crossbred cows

For crossbred dairy cows, the estimated mean calving interval was 16.3 ± 4.1 months (n = 22). In the watershed crossbred dairy cows have shorter calving interval than local cows due to better management conditions and better detection and follow-up in postpartum anoestrus interval, which is influenced by genotype and other management factors (the health condition of the cow, approaches and aids to oestrus detection and the quality and quantity of feed supplied to dairy cows either pre-partum or post-partum or both severely affect PPAI).

Similar studies undertaken by Gashaw (1992) indicted that the mean calving interval for crossbred dairy cows in Selale based on 31 records was 15.4 months or 464 days in Selale. A calving interval of 14.3 months or 428 days was reported by Kiwuwa *et al*. (1983) for F_1 crosses (½ Friesian x ½ zebu) in Arsi.

Table 6.Calving interval of crossbred and local dairy cows in the Yerer watershed

Genotype	N	Mean	SD
Crossbred	22	16.3909	4.097
Local	84	21.6613	8.198
Total	106	20.5675	7.816

The overall average percentage of calving rate in the watershed was 68.7 percent. Similarly, Falvey and Chantalakhana (1999) indicated that the calving rate of Zebu cattle ranged from 20 to 90 percent, and the acceptable calving rate should be greater than 70 percent.

Table 7.Farmers interest to have crossbred dairy cows (reason for choice of genotype) in Yerer watershed

Reason for choice of genotype	Number of households	Percent
Higher milk yield	50	47.2
Stronger animal	33	31.1
Unavailability	19	17.9
Nicer animal	4	3.8
Total	106	100

Cows in milk

In most of the households (93.3 percent) only one or two cows and hardly three households had more than four milking cows these was mainly due to shortage of feed and shortage of land for dairy cattle (Table 8). Brokken and Senait (1992) also indicated that around Debre Zeit area the number of milking cows ranged from 1 to 5, with an average of two heads per household.

Table 8.Number of cows milked in household based on farmers response in Yerer watershed

Number of cows milked	Number of households (percent)
0	1(0.8)
1	85(70.8)
2	27(22.5)
3	4(3.3)
4	1(0.8)
5	1(0.8)
8	1(0.8)
Total	120(100)

Almost half of the owners of dairy cows in the watershed own only milking cows and there were no dry cows (Table 9). It may be due to the fact that they own hardly one or two cows and data were gathered during the calving season.

Table 9.Percentage of milking cows in household based on farmers response in the watershed (n =119)

Percentage dairy cows	Number of households	Percent
0.00	1	0.8
25.0	4	3.4
33.33	8	6.7
40.0	1	0.8
42.85	1	0.8
50.0	41	34.5
60.0	1	0.8
66.67	2	1.7
80.0	1	0.8
100.0	59	49.7
Total	119	100.0

Among the farmers of Yerer watershed, 90.8 percent of the farmers owned local breed and the rest owned crossbred Friesian cattle. Considering only reproductive age group, 80 percent had local breed, and 20 percent of farmers kept crosses of Friesian breed.

Among the farmers, 9.2 percent (n =11) had crossbred cattle with less than 50 percent Friesian blood, 0.8 percent of farmers (n = 1) had 50 percent cross-bred and 10 percent (n =12) kept cows with more than 50 percent of exotic inheritance.

Out of the total crossbred dairy cows, 62.5 percent (n =15) were located in Babogaya and Godtti village and 16.7 percent (n = 4) were found in Dendema villages, which are 5 to 10 km, respectively from the roadside and near to the Deber Zeit and Godino towns. Table 10 shows the source of the first crossbred dairy cows in the herd. Mostly they were introduced in the watershed through purchasing pregnant cow from development projects like International Livestock Research Institute (ILRI) (from 1987 to 2003) and local markets. However, about 80 percent of farmers stated that they were unable to get crossbred cows easily in the Yerer watershed.

Table 10.Source of first crossbred cows according to farmers response in Yerer watershed

Source	Number of households	Percent
Unavailability of crossbred cows	95	79.8
Purchased pregnant cow from development projects	12	10.1
Purchased cow from neighbours farmer/market/	10	8.4
Mating local cows with a crossbred bull	2	1.7
Total	119	100.0

The limiting factors to increase the level of exotic germplasm as ranked by the farmers are presented in Table 11. Over 55 percent of farmers consider that logistic problem of crossbreeding such as unavailability of semen, inefficient AI service or non-existence of superior bulls were limiting to upgrade this technique. It was found to be especially so for the farmer around Babogaya and Goditti village who own crosses with high percentage of exotic inheritance. Feed shortage, lack of credit facilities and disease problems were also limiting factors for substantial number of farmers.

Falvey and Chantalakhana (1999) reported that certain socio-economic factors, such as income from off-farm jobs, availability of capital, milk prices, price of land, farmer education and training, and availability of family labour influence a dairy farmer's decision on whether to expand and improve dairy operations.

Table 11.Factors limiting use of crossbred animals in the (reproductive) herd in the Yerer watershed

	Number of households	Percent
Logistic problems with crossbreeding (AI) service	67	55.8
Not enough feed	17	14.2
No credit	16	13.3
Delicate animal	11	9.2
Too expensive	6	5.0
Disease problem	2	1.7
Shortage of man power	1	0.8
Total	120	100

To increase milk production, priority constraints were identified. The first and most important problem in the area was lack of extension service or development agents did not advise about dairy production, followed by lack of enough feed to increase production. The third constraint reported by farmers of Yerer watershed was lack of AI service in the area. The fourth drawback in the watershed was the unavailability of credit facilities for dairy production. The fifth constraint was that eventhough Yerer watershed is located near to the national Veterinary Institute (the place where vaccine is manufactured), no preventive steps have been taken to overcome contagious disease. Market facilities including access to main road and shortage of water were identified as six and seventh constraints respectively. Though the farmers wish to keep more number of dairy animals, unavailability of infrastructure has forced them to keep hardly one or two cows. Increasing human population and gender issues were generally non-technical constraints which need to be given attention in the area.

Conclusions and recomendations

Except in Babogaya and Goditti village AI facility was not available in the other villages of the watershed. In the reproductive herd, main germplasm were local cattle.

Based on the responses of the farmers, the estimated averages for age at first calving were 58.09 ± 13.04 and 44.67 ± 17.1 months, for calving interval were 21.66 ± 8.2 and 16.3 ± 4.1 months, lactation length were 7.2 ± 1.44 and 8.6 ± 1.9 months for local and cross bred dairy cows respectively. The daily milk yield of 1.09 and 5.9 liters, lactation yield of 238.35 and 1558.12 liters were obtained for local and crossbred cows, respectively. Thus, one crossbred cow was equivalent to five local cows in terms of daily milk yield. The average total milk and milk products consumed per household consumption unit per year was 28.48 kg and of this 23.44 liters was fresh milk, 0.895 kg was butter, 3.73 kg was local cheese. The ratio of estimated fresh milk marketed to milk produced was 0.083:1

Main reasons for choice of crossbred genotype and increase exotic germplasm in the reproductive herd were to increase the milk production. Farmer's perception to have crossbred dairy cows (increase exotic germplasm) was highly positive. The limiting factors to increase the level of exotic germplasm were logistical problems with crossbreeding service, feed shortage, fear of disease incidence, and absence of credit for dairying according to the farmers response.

As per the study the influencing factors can be classified into four categories: a) technical components, b) institutional, c) government policies, and d) farmers' socio-economic factors are the main to be tackled to for the adoption of improved dairy program in the area. Lack of any of these supportive factors could become a constraint to the level of achievement of any dairy development program.

Generally, in order to promote the reproductive performance of dairy cows and to promote improved dairy production system in the area integrated type of development program will be very important and by doing, so dairying is likely to become one of the main occupations of the farmers of Yerer watershed.

Reference

Alberro, M. 1983. Comparative performance of F_1 Friesian x zebu heifers in Ethiopia. Anim. Prod. 37: 247-252

Asheber Sewalem. 1992. Evaluation of the reproductive and preweaning growth performance of Fogera cattle and their F_1 Friesian crosses at Andassa Cattle Breeding Station, Ethiopia. M.Sc. Thesis, Alemaya University of Agriculture, Dire Dawa, Ethiopia.

Astatke, A., Mohamed Saleem, A. M. and EI Wakeel, A. 1995. Soil water dynamics under cereal and forage legume mixtures on drained vertisols in the Ethiopian highlands. Agric. Water Management, 27:17-24.

Azage Tegegne. 1981. Reproductive performance of pure zebu cattle and their crosses with temperate breeds in Ethiopia. M. Sc. Thesis, Alemaya College of Agriculture. Dire Dawa, Ethiopia.

Brokken. R. F. and Senait Seyoum (ed). 1992. Dairy marketing in sub- Saharan Africa. Proceedings of a symposium held at ILCA. Addis Ababa. Ethiopia. 26-30 November 1990. ILCA (International Livestock Centre for Africa) Addis Ababa, Ethiopia.

Falvey, L. and Chantalakhana, C. (ed). 1999. Smallholder Dairying in the Tropics. ILRI (International Livestock Research Institute) Nairobi. Kenya 462 pp.

FAO. 1993. (Food and Agriculture Organization of the United Nations). The state of Agriculture 1993, FAO, Rome. Italy.

Gashaw Geda. 1992. Assessment of feed resource base and performance of crossbred dairy cows distributed to smallholder in the Selale Dairy Development Project area. M. Sc. Thesis, Alemaya University of Agriculture, Dire Dawa, Ethiopia.

Getachew Eshete. 2002. Assessment of feed resource, their management and impact on livestock productivity in the Ginchi watershed. M. Sc. Thesis, Alemaya University, Dire Dawa, Ethiopia.

Hurni, H. 1990. Degradation and conservation of the soil resources in the Ethiopia highlands. In: African Mountains and Highlands: Problems and Prospective. B. Messerli and H.Hurni (ed). Marceline, Missouri (USA). Pp 51-64

IAR. 1991. (Institute of Agricultural Research).In: Proc. of 4th National Livestock Improvement Conference. 13-15 Nov., 1991, Addis Ababa, Ethiopia.

Itty, P., Swallow, B. M., Rowlands, G. J., Mulatu, W. and d'Iteren, G. D. M. 1995. The economics of village cattle production in tsetse-infested area of southwest Ethiopia. Preventive Veterinary Medicine, 22, (3): 183 – 196.

Jabbar Emmanuel Tambi and Mullins Gary. 1997. Market-oriented smallholder dairying research working document No. 3. A methodology for characterizing dairy marketing systems. ILRI (International Livestock Research Institute). Nairobi, Kenya.

Kahsay Berhe, 2004. Land use and land cover changes in the central highlands of Ethiopia: The case of Yerer mountain and its surroundings. . M. Sc. Thesis, Addis Ababa University, Addis Ababa, Ethiopia.

Kiwuwa, G. H., Trial, J. C. M., Kurtu, M. Y., Getachew, W., Anderson, F. M. and Durkin. J. 1983. Crossbred dairy cattle productivity in Arsi Region, Ethiopia. ARDU and ILCA. Research Report No. 11. ILCA Addis Ababa, Ethiopia.

McDaC. 1999. Survey of the Ethiopian economy: Review of past reform development (1992/93-97/98). Addis Ababa, Ethiopia, pp157.

McDowell, R. E. 1972. Improvement of livestock production in warm climate. W. H. Freeman, San Francisco, California. USA. PP711.

Meaker, H. J. Coetsee, T. P .N. and Lighan, A. W.1980. The effect of age at first calving on the reproductive performance of beef cows. South African. J. Anim. Sci. 10:105-113

Mekonnen Haile-Mariam. 1987. Evaluation of growth and reproductive performance of Boran cattle and their crosses with Friesian at Abernossa, Shoa, Ethiopia. M. Sc. Thesis, Alemaya University of Agriculture, Dire Dawa, Ethiopia.

Mukassa-Mugerewa, E. 1989 A review of reproductive performance of female Bos indicus (Zebu) cattle. Monograph 6. ILCA (International Livestock Centre for Africa). Addis Ababa, Ethiopia.

Mulugeta Kebede, Tesfaye Kumsa and Gebre-Egziabher Gebre-Yohannes. 1991. Some productive and reproductive performance of Horro cattle at Bako Research center. In: Proc. Of National Livestock improvement Conference (NLIC) 13-15 Nov. 1991 Addis Ababa, Ethiopia. pp 78-82.

Payne, W. J. A. 1970. Cattle production in the tropics: breeds and Breeding, Vol.1, Essex, Longman, pp, 262-313.

Rey, B., Agyemang, K., Thorpe, W., Mullins, G., Diedhiou, M., Nokoe., S. and Shapiro, B. 1999. Market-oriented smallholder dairy research working document no. 4. A research methodology for characterising dairy production systems, ILRI (International Livestock Research Institute) Nairobi. Kenya.

Wahid, A. 1976. Livestock Resources of Pakistan Sahiwal Cattle. Monograph 6. University of Karachi. Pakistan.

WBOA. 2003. (Woreda Bureau of Agriculture Ada Liben). Annual report. Debrezeit, Ethiopia.

World Bank. 1995. World Development Report 1995. Oxford University Press. New York. USA.

World Bank. 1996. African Development Indicators 1996. The World Bank Washington, D.C. USA.

Managemental risk factors affecting performance of dairy cattle in urban and per-urban dairy farms: cases of Ada, Akaki and Lome weredas'

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Abstracts

The study was designed to assess risk factors contributing to or affecting reproductive performance of dairy cows reared by pre-urban and urban small scale dairy farmers in Dukem, Debre Zeit and Mojo towns. A total of 40 private farms were included in the study and 202 individual dairy cows were examined for gross abnormality of reproductive organ. From the observation made on the housing system commonly used for dairy cows in the three towns 29% were identified to be at a bad situation. Nineteen percent of the housing system was classified to be uncomfortable flooring (very rough stone bedded floor) to keep the animal comfortably lying down. Forty six percent of the farms were reported to be attended by the owners while 33% of farms reported to be attended by employee with minimal supervision from the owner in Bishoftu where the repeat breeding is very high. Both artificial insemination and natural mating were exercised by 28% of the farms whereas the dominant farm number was using AI (67%). Forty two percent of the farms do not request for PD.

Only one person from Dukem and none from Bishoftu and Modjo reroted to feed grass hay as a sole basal diet.

Five major health problems were identified to be the determinant factors that affect reproductive performance of dairy cows in these towns. These were repeat breeding, abortion, RFM, hypocalcaemia, and others like uterine /vaginal prolapsed, metritis, and anoestrus. From the analysis made significant variation were observed ($p<0.01$) on the occurrence of reproductive problems among the study areas. Repeat breeding was the most serious problem at DZ and its surroundings followed by abortion and RFM. Retained foetal membrane was the first ranking problem at Modjo where as abortion is the first ranking problem at Dukem. Although it is statistically non-significant the problem of repeat breeding is seen to be varying with the type of attendant, breeding methods and feed type.

Key words: urban and peri urban dairy, reproductive performance, repeat breeding, small scale dairy,

Introduction

In Ethiopia, as in most of Sub-Saharan Africa, production and consumption patterns of milk have been changing with the dynamic increase in the human population. Annual increase in milk consumption demand is estimated at 2.5%, while the average annual growth in milk production is estimated to be only 1.4% (Rey et al. 1993). The effort to narrow the gap between demand and supply was based on importation of milk and milk by-products, and importation of live animal. Accordingly, exotic cattle breeds were introduced for the last four decades with importation of semen and high producing dairy cattle breeds from different parts of the world and kept under state and private farms in urban and per-urban areas (Gebre-Michael and Heinonen, 1989). Today, an estimated number of 300,000 crossbred cows exist throughout the country (CSA, 2004; SDDP, 1998).

An important prerequisite for the profitability of a dairy production is that cows must have efficient reproductive performance (Perera, 1999). From a practical point of view, however, maintaining an optimum level of reproductive efficiency is largely a matter of matching the genotypes to the available resources, environmental factors and application of appropriate management strat-

egies to allow animals to express their full reproductive potential (Scott, 2001). Accordingly, the impact achieved in dairy industry in light of the large population number, high domestic demand for dairy products and favourable climatic conditions in most part of the country is unsatisfactory. The results from different studies indicated that lactation yield of Holstein-Friesian cows under Ethiopia condition produce less than 3500 kg milk per year, whereas the average for the same strain of cows in developed countries is over 6000 kg (Mureja, 1994; Mekonnen, 1994). Furthermore, upgrading by back crossing to the temperate breed under the prevailing management and health care conditions gave variable and often rather disappointing results (Kiwuwa et al. 1983; Beyene, 1992; Mureja, 1994; Mekonnin, 1994).

The low reproductive efficiency has increased markedly with the introduction of new breeding technologies and management system like artificial insemination and intensive production (Scott, 2001). These circumstances include failure to detect heat, inseminating the wrong cow, or inseminating the oestrus cow at the wrong time, failure to feed adequately according to yield and physiological demand, and poor husbandry practice (Scott, 2001). Thus, new challenges in management and also in the control of diseases are becoming important factors influencing the private dairy production systems (Gebre-Michael and Heinonen, 1989).

Material and methods

Study area

Three wereda's in Eastern Shewa zone of Oromia regional state namely Akaki, Ada and Lome wereda's were included in the study. These wereda's are known for their market oriented small scale urban and peri urban dairy production where the cross bred animals dominate the herd.

Study animals

A total of 40 small scale urban and peri urban private dairy farms were included in the study. Sixteen farms were from Dukem town of Akaki woreda, 15 from Bishoftu of Ada and 11 were from Mojo of Lome wereda's. Two hundred two dairy cows in these 40 farms in three towns were clinically examined for gross reproductive organ abnormalities.

Sampling methods

Questionnaire survey: A pre-designed questionnaire was used to interview farm owners/ attendants of all farms in the respective areas focusing on the husbandry and farm situation, breeding and health management, responsible animal care taker, feed type and feeding system used.

Observational data: Grading of the housing system (based on presence or absence of wall, built floor structure and materials used, materials used for top covering and spaces per animal) and animal management (breeding system, health care, record keeping system) were done by veterinarian during data collection. The housing was said to be comfortable when the space allows the animal to lie down and stand comfortably, floor is made of non-slippery concrete with smooth surface, wall built and top covered with iron sheet, and well aerated. On the contrary, the housing was said to be at bad situation when the space is crowded, the floor is muddy or rough stone flooring and not comfortable to lie down both in term of space and structure, suffocated and the animal is exposed to climatic stressing.

Clinical examination and sampling

Clinical examination was done for pregnancy diagnosis, identification of anatomical problems in repeat breeders and confirmation of proper uterine involution in postpartum cows.

Statistical analysis

Data were analysed by using statistical analysis system (SAS), 2000. Descriptive statics and Chi square test were used to analyze the data.

Result

All animals considered were crossbred animal of different age and physiological status kept under intensive and semi intensive production system (Table 1). Overall, nearly 50% of the farms visited have one or two dairy cows, and some farms have no replacement heifers totally.

Table 1. Herd size and replacement heifers owned in studied farms

Location	Type of animal	Total No. farms	Mean number of animal	SD	Min	Max
Bishoftu	Cross breed	15	**6.53**	**2.53**	**2**	**10**
	Replacement heifers	15	**2.53**	**1.19**	**0**	**5.0**
Dukem	Cross breed	16	**4.50**	**4.45**	**2.0**	**20.0**
	Replacement heifers	16	**1.94**	**2.29**	0.0	**10.0**
Modjo	Cross breed	11	3.45	1.44	2.00	6.00
	Replacement heifers	11	**0.90**	**1.04**	**0.00**	**3.00**

Housing system

From a total of 40 farms included in the study 29% of the farms housing system categorically placed under bad situation (leaking roofs, very narrow space per animal, not well drained, irregular flooring made of block of stones) where as 71% of the farms had fairly good housing system (Table 2). From overall visited farms bout 29% percent were earthen floor (43.75% at Dukem, 45.5% at Modjo and none at Bishoftu) while 19% of the remaining was very rough flooring made of a block of stones. Thirty three percent of the farms do not have exercising paddock and cows are totally confined/tethered through out the year. Statistically significant differences were observed between location on the housing type ($p<0.02$), floor type and structure ($p< 0.01$), and presence of free stall ($p< 0.002$).

Table 2. Housing type, floor structure and presence or absence of free stall in the farms overall and by locations

Overall housing type	Number of farms	Percentage	Cumulative frequencies	Cumulative percentage
Top iron sheet, built wall, concrete floor	30	71.43	30	71.43
Only top iron sheet cover	9	21.43	39	92.86
Top with plastic sheet cover	3	7.14	42	100.00
Floor type				
Smooth concrete floor	22	52.38	22	52.38
Rough stone flooring	8	19.05	42	100.00
Soil floor	12	28.57	34	80.95
Free stall				
Present	28	66.67	28	66.67
Absent	14	33.33	42	100.00
Housing type by farm location *				
Bishoftu				
Top iron sheet, built wall, concrete floor	12	80.00	80.00	
Only top iron sheet cover	3	20.00	100.00	
Top with plastic sheet cover				
Dukem				
Top iron sheet, built wall, concrete floor	14	87.50	87.50	
Only top iron sheet cover	1	6.25	93.75	

Overall housing type	Number of farms	Percentage	Cumulative frequencies	Cumulative percentage
Top with plastic sheet cover	1	6.25	100.00	
Modjo				
Top iron sheet, built wall, concrete floor	4	36.36	36.36	
Only top iron sheet cover	5	45.45	81.82	
Top with plastic sheet cover	2	18.18	100.00	
Floor type by farm location **				
Bishoftu				
Smooth concrete floor	13	86.67	86.67	
Soil floor	0	0	86.67	
Rough stone flooring	2	13.33	100.00	
Dukem				
Smooth concrete floor	5	31.25	31.25	
Soil floor	7	43.75	75.00	
Rough stone flooring	4	25.00	100.00	
Modjo				
Smooth concrete floor	4	36.36	36.36	
Soil floor	5	45.45	81.82	
Rough stone flooring	2	18.18	100.00	
Presence of Free stall in the farm ***				
Bishoftu				
Present	11	73.33	73.33	
Absent	4	26.67	100.00	
Dukem				
Present	6	37.50	37.50	
Absent	10	62.50	100.00	
Modjo				
Present	11	100.00	100.00	
Absent				

Feeding and animal care

Twenty two farms were reported to be attended by the family members (family head, children and elders) while 7 farms were totally attended by employee (Table 3).

Statistically significant difference ($p<0.01$) were observed between the type of basal diet they used to feed dairy cows in those three town. Of all 42 farms only one farm in three towns was reported to use grass hay as a sole basal diet (Fig 1). Eighty seven percent of the farms in Bishoftu town offer wheat and/or tef straw and grass hay based on availability without consideration for the type and quality of the feed where as 63% of farmers in Dukem use sole straw feeding as a basal diet (Table 4). The major supplementary feed used was the combination of wheat middling and oil seed cakes in all the study areas. Statistically no significant difference was observed in supplementary feed type preferences among the three areas. However, nearly 50% of the farms use different supplemental feeds based on availability rather than their nutritive values (Table 5).

Table 3: type of farm attendants taking care of dairy cows in the studied areas

Attendant	Location			Total
	Bishoftu	Dukem	Modjo	
Family members	7 (46.67%)	8 (50.0%)	7 (63.64%)	22
Employee	5 (33.33%)	1 (6.25%)	1 (9.09%)	7
Both	3 (20.0%)	7 (43.75%)	3 (27.27%)	13
Total	15	16	11	42

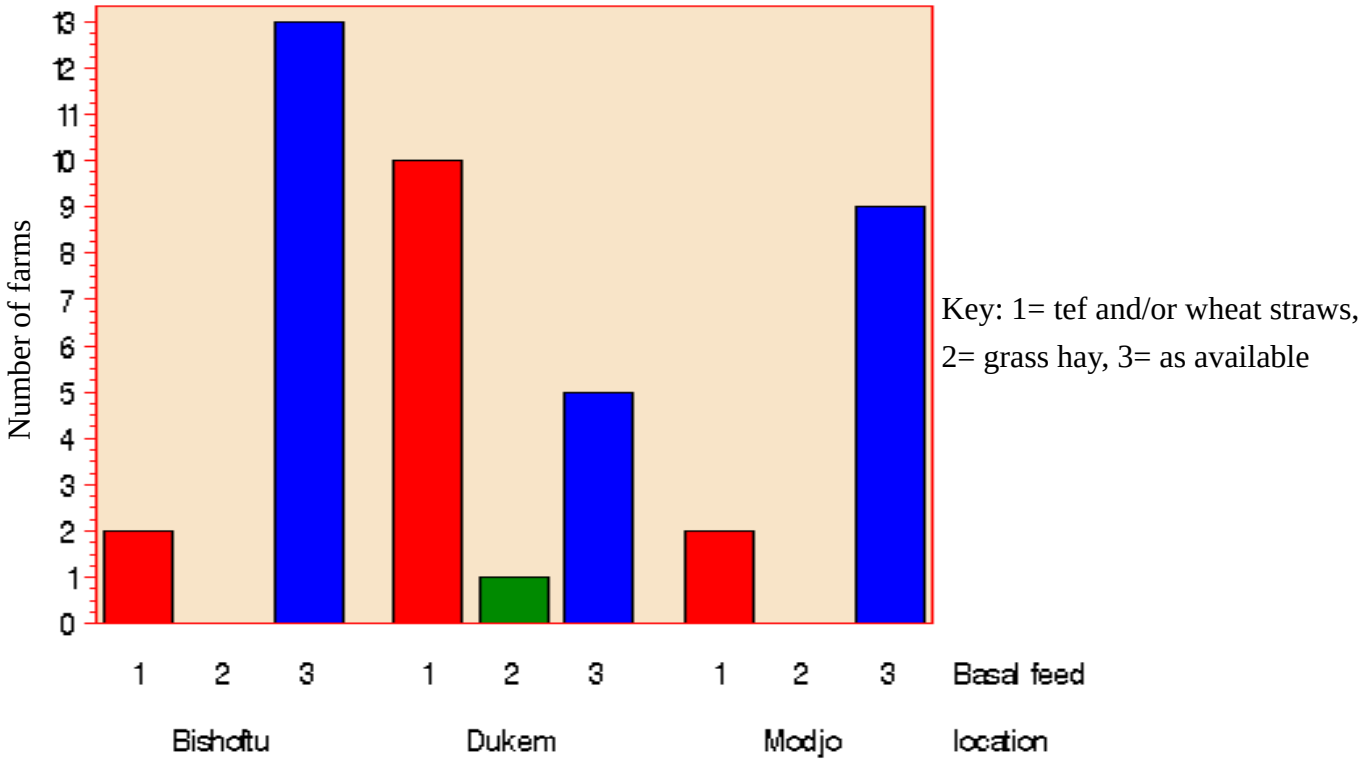


Fig. 3 Basal feed commonly used in the Bishoftu, Dukem and Modjo tows

Table 4. Basal feed and supplementary feeds commonly used for dairy cows by location

Basal feed type	Location			Total
	Bishoftu	Dukem	Modjo	
Straws	2 (13.33%)	10 (62.50%)	2 (18.18%)	14
Grass hay	0 (0.00)	1 (6.25%)	0 (0.00)	1
All available	13 (86.7%)	5 (31.25%)	9 (81.82%)	27
Total	15	16	11	42
Supplemental feed type				
Oil seed cakes (Noug seedcake, lean seed oil seed cake, cotton seed cake) and Wheat bran (wheat short, wheat middling's)	8 (53.33%)	9 (56.25%)	5 (45.45%)	22
All available (molasses, poultry litter, oil seed cakes and wheat bran)	7 (46.67%)	7 (43.75%)	6 (45.45)	1
Total	15	16	11	42

Health and breeding management

Totally 18% of the farm owners reported that they did not ever vaccinate their cows against any diseases. The remaining 82% reported that they annually vaccinate their animals against anthrax and blackleg (Table 5). None of the interviewed farms were strategically deworm their animals unless there is sign of disease.

About 67% of the farms interviewed reported that they use artificial insemination as a sole breeding method where as 5% of the farms solely use natural mating due to associated problems of AI and time demanding in using AI (Table 5 and 6). From those who solely or alternatively using AI breeding method about 12% use non specific or non dependable signs of behavioural oestrous to invite the inseminator for AI service (Table 6).. Forty two percent of the farms do not go for pregnancy diagnosis after their animals got served.

Table 5: Husbandry, health and breeding management commonly exercised in Bishoftu, Dukem and Modjo tows

Health care exercised	Frequency	Percent	Cumulative Percent
Vaccination	33	82.50	82.50
Present			
Absent	7	17.50	100.00
De-worming			
Present	6	15.00	15.00
Absent	34	85.00	100.00
Breeding system exercised			
Artificial insemination	28	66.67	66.67
Natural mating	2	4.76	71.43
Both	12	28.57	100.00
Heat signs commonly used to detect cows in oestrus			
Discharge, mounting, bleating, drop in production	14	33.33	33.33
Discharge, bleating, decrease production	23	54.76	88.10
Bleating and milk reduction	5	11.90	100.00
Experience of using pregnancy diagnosis			
Yes	24	57.14	57.14
No	18	42.86	100.00

Table 6: Breeding system and major heat signs used to detect oestrus by location

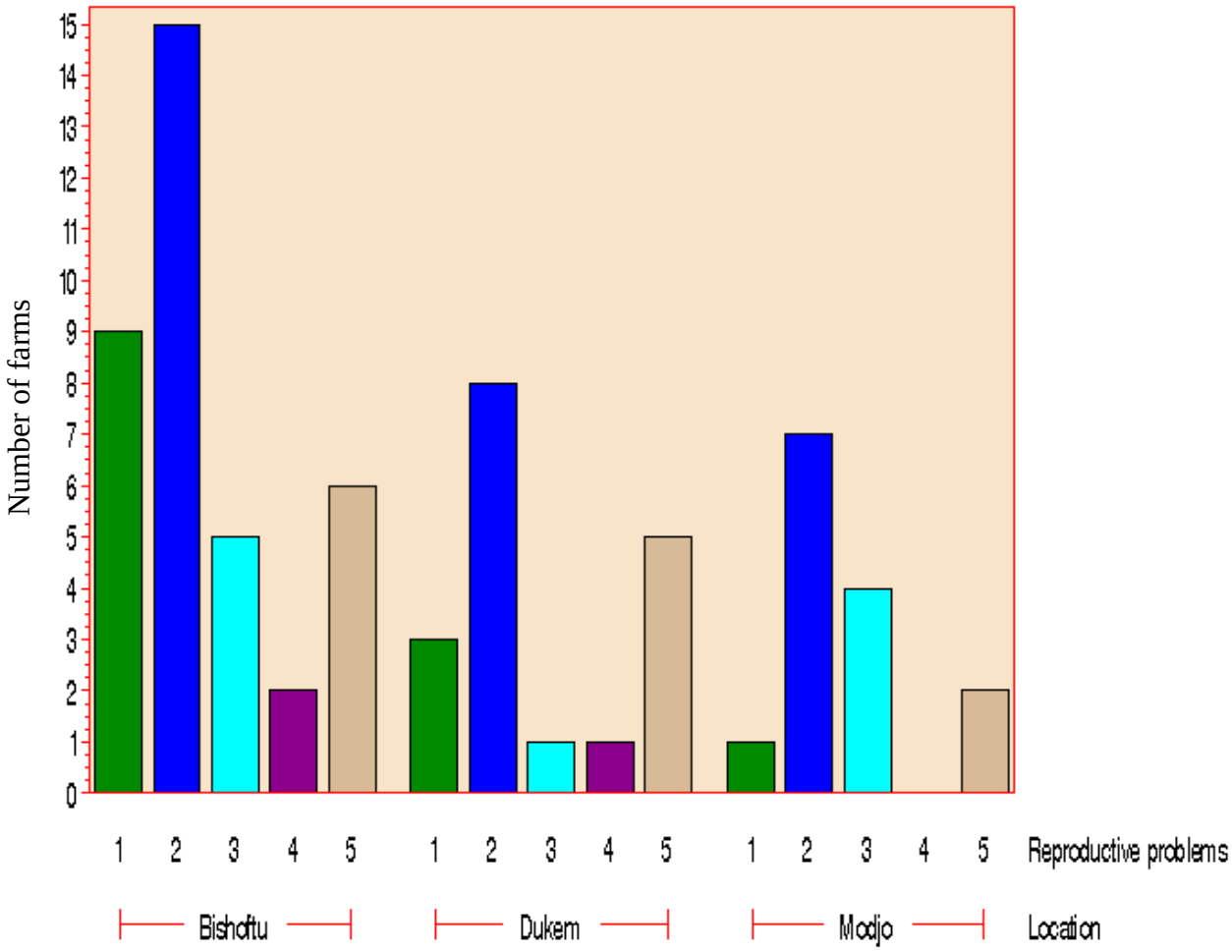
Signs of oestrus	Location			Total
	Bishoftu	Dukem	Modjo	
AI	9 (60.0%)	12 (75.0%)	7 (63. 64%)	28
Natural mating	1 (6.67%)	1 (6.25%)	0 (0.0)	2
both	5 (33.33%)	3 (18.75%)	4 (36.36)	12
Total	15	16	11	42
Major heat sign used				
Discharge, mounting, bleating, drop in production	6 (40.0%)	4 (25.0%)	4 (36.36%)	14
Discharge, bleating, decrease production	6 (40.0%)	10 (62.5%)	7 (63.64%)	23
Bleating and milk reduction	3 (20.0%)	2 (12.5%)	0 (00.0%)	5
Total	15	16	11	42

4. Reproductive problems encountered

Five major reproductive problems were identified during the study period. These are repeat breeding, RFM, abortion, hypocalcaemia and others like metritis, dystocia, prolapse, and anoestrous (Table 7) with higher prevalence of repeat breeding problem in the study areas. These problems were reported from Debre Zeit in the order of importance as repeat breeding, abortion, others, and RFM, where as repeat breeding followed by others in Modjo are the encountered reproductive problems (Fig 2). From the result of the survey the number of repeating in farms with the problem ranges from 4 to 11 times with the most frequent figure ranging from 5-7 time / animal. No significant difference was observed between locations on the occurrence of these problems.

Table 7: Reproductive problems encountered by location

Problem type	Location			Total
	Bishoftu	Dukem	Modjo	
Abortion	9 (24.32%)	3 (16.67%)	1 (7.14%)	13
Repeat breeding	15 (40.54%)	8 (44.44%)	7 (50.00%)	30
Retained foetal membrane	5 (13.51%)	1 (5.56%)	4 (28.57%)	10
Hypocalcemia	2 (5.41%)	1 (5.56%)	0 (0.00)	3
Others	6 (16.22%)	5 (27.78%) ,	2 (14.29%)	13
Total	37	18	14	69



Key: 1= Abortion, 2= Repeat breeding, 3= Retained foetal membrane, 4= Hypocalcemia, 5= others (metritis, prolapse, unoestrus, cysts); others = metritis, prolapse, unoestrus, cystic problems

Fig 2. Type of reproductive problems encountered by location

Discussion

The low productivity of dairy herds in different parts of the world is essentially related to: 1) low reproductive performance due to inadequate management (nutritional, sanitary and housing) and 2) low genetic merit of cows (Diskin *et al.*, 2003; Kinder *et al.*, 1995; Ferreira, 1991; Ferreira, 1997). This accounts for the fact that many possible causes of reproductive problems including but not limited to hormonal disturbance or pathology that affects normal reproductive function of heifers and/or cows can be associated with substandard feeding, husbandry and health manage-

ment practices to which mostly the owners do not pay attention. The higher frequency of repeat breeding in the absence of any palpable pathology of reproductive organ both in heifer and cows examined during this study is an indicator of inadequacy in management system, and goes in line with the previous reports cited.

Previous studies made on husbandry and management reported an association between occurrence of heel erosions and digital dermatitis when housing environments were not hygienic (Bergsten and Pettersson, 1992; Philipot et al., 1994; Hultgren and Bergsten, 2001). Increased foot problems may occur when cows' feet are excessively exposed to manure and urine, which increases the risk for the development of these two conditions. The result of the current study indicate that 19% and 28.6% of the overall farms were at risk of getting foot problem due to highly rough surface of the floor (made of block of stone flooring) and soil flooring (muddy and irregular floor), respectively. Accordingly, the defective flooring structure in both cases can affect the reproductive performance of the animals.

Although the data that confirms the post partum weight loss in these animals was not available and not supported by hormonal assay as well, the poor nutritional quality of tef straw and wheat straw (the dominant basal feed identified in this study) could be one of the risk factor that cause lower conception rates/higher repeat breeding. This goes in line with the study made by Ferreira *et al*., (2005) who has shown that number of services per conception in a group of animal under feed restriction was higher compared to control group (2.12 vs. 1.44, $P<0.05$). Similarly many studies have shown that weight loss prior to breeding or AI may reduce fertility (Perkins, 1985; Spicer *et al*, 1990; Pedron, 1993; Whitaker *et al*, 1993; Ferguson, 1996), probably because follicles growing under a state of NEB may have lower quality due to the effects of metabolic imbalance (Spicer *et al*., 1990; Britt, 1992 and 1994; Ferguson, 1996). The present finding is in full agreement with this report due to the fact that most farms included in this study supplement their animals not based on the nutritional demand rather on the availability of the concentrate as well as basal feed on the market.

Over the past several decades, milk yield of cows has increased markedly world wide. However, one negative impact of this improvement is reduced fertility: cows open for longer months, increased services per conception and higher incidence of reproductive problems (Dhaliwal et al. 1996; Grohn and Rajala-Schultz 2000). This has brought about the importance of sound management system to utilize the genetic potential of the animals and to make decisions on whether or not a given individual cows to be re-bred. The internationally accepted effective management procedure for herds with reasonably good reproductive efficiency recommend not to re-breed any cows in second or more later lactation with production below 80% of the herd average (Gordon King, 2000), and to breed cows producing between 100 and 120% of herd average for up to 160 days PP. If not pregnant by that time, continue milking but cull when daily yield is no longer profitable. Cows producing more than 120% of the herd average can be inseminated up to 250 days PP (Gordon King, 2000). This provides a variable format in which the poorest producers are replaced automatically without any expense of re-mating (voluntary culls). From the results of the current study it is observed that farmers rebreed cows even those that have dried before getting conceived (repeating an average of 6-7 times, ranging from 4 to 11 times per lactation), and not deliberately culling due to poor performance. In most studied herds, however, 50% or more of cows have history of repeat breeding of 6x or above which means day open greater than 120 days and calving interval (CI) of over 13 months. The prevailing services per conception on farm included in this study amounts to more than 5 which indicate poor reproductive efficiency. This accounts for poor husbandry system associated with poor knowledge of attendant's heat detection efficiency.

Conclusion and recommendation

The results of this simple survey indicate that the husbandry and both breeding and health management level applied in most farms is not to the standard and to the physiological need of the animal. Most farmers attribute the situation to the economic affordability of the input costs and the knowledge gap of the immediate care takers. Therefore, detail study supported by laboratory and hormonal assay should be undertaken to put forward appropriate solutions in husbandry and both breeding and health management gaps to minimize risk factors contributing to the reproductive inefficiency of dairy cows in the area.

Reference

Bergsten, C., and B. Pettersson. 1992. The cleanliness of cows in tied stalls and the health of their hooves as influenced by the use of electric trainers. Prev. Vet. Med. 13:229–238.

Beyene Kebede, 1992. Estimation of additive and non-additive genetic effect for growth , milk yield and Reproduction traits of crosses (B. taurus x B. indicus) cattle in wet and dry environment of Ethiopia. Ph.D. Dissertation. Cornell University, USA.

Central Statistical Authority (CSA), 2004. Agricultural Sample survey. Report on Livestock, Poultry and Beehives population Private peasant holding) Statistical Bulletin Vol, 2.

Dhaliwal, G.S., Murry, R.D., Dobson, H., 1996. Effect of milk yield, and calving to the first service interval, in determining herd fertility in dairy cows. Animal reproduction science41 (2), 109-117.

Diskin MG, Mackey DR, Roche JF, Sreenan JM. 2003. Effects of nutrition and metabolic status on circulating hormones and ovarian follicle development in cattle. *Anim Reprod Sci*, 78:345-370.

Ferreira A.M., Sá W.F., Viana J.H.M., Camargo L.S.A., Pereira P.A.C., Fernandes C.A.C., 2005. Feed intake restriction, conception rate and parturition to conception intervalin crossbred Gir-Holstein cows. Anim. Reprod., v.2, n.2, p.135-138.

Ferreira AM. 1997. *Redução do intervalo de partos em fêmeas bovinas*. Goiânia, GO: Sindileite - Sindicato das Indústrias de Laticínio no Estado de Goiás. p.95-116.

Ferguson JD. 1996. Diet, production and reproduction in dairy cows. *Anim Feed Sci Technol*,59:173-184.

Ferreira AM. 1991. *Manejo reprodutivo e sua importancia na eficiência da atividade leiteira*. Coronel Pacheco, MG: Embrapa/CNPGL. 47pp. (Documentos, n.46).

Gebre-Michael Meles and Heinonen, K. 1989. Artificial insemination in Selale and Tegulatina Bulga Awrajas. Proc. Third National Livestock Improvement Conference. 24-26 May 1989, IAR, Addis Ababa, Ethiopia.

Gro□hn, Y.T. and Rajala-Schultz., P.J., 2000. Epidemiology of reproductive performance in dairy cows. Animal reproduction science 60-61(2000), 605-614.

Kinder JE, Bergfelt EGM, Wehrman ME, Peters KE, Kojima FN. 1995. Endocrine basis for puberty in heifers and ewe. *J Reprod Fertil Suppl*, 49:393-407.

Kiwuwa, G.H, Trail, J.C.M, Kurtu, M.Y., Worku, G., Anderson, F. & Durkin, J 1983 Crossbreed dairy cattle productivity in Arsi region. Ethiopia. ILCA Research Report 11. International Livestock Centre for Africa 1-29.

Mekonnin H.Mariam, 1994. Genetic analysis of Boran, Friesian and crossbred cattle in Ethiopia. PhD Thesis. Swedish University of Agricultural Science, Uppsala.

Mureja Shibru, 1994. Milk production and persistency characteristics of Holstein Friesian cattle On the Holota Government dairy farm. MSc. thesis. Alemaya University of Agriculture, Ethiopia.

Pedron O. 1993. Effect of body condition score at calving on performance, some blood parameters and milk fatty acid composition in dairy cows. *J Dairy Sci*, 76:2528-2535.

Perera, O. 1999. Management of Reproduction. In: Smallholder dairying in the tropics. ILRI, Nairobi, Kenya. pp 241-264.

Perkins, B. 1985. Production, Reproduction, Health and Liver Function Following Over conditioning in Dairy Cattle. PhD Thesis.Cornell University.

Philipot, J. M., P. Pluvinage, I. Cimarosti, P. Sulpice, and F. Bugnard. 1994. Risk factors of dairy cow lameness associated with housing conditions. Vet. Res. 25:244–248.

Rey, B. Thorpe, W. Smith, J., Shapiro, B., Osuji, P., Mullins, G., and Agyemang, K., 1993. Improvement of dairy production to satisfy the growing consumer demand in Sub-Saharan Africa. A conceptual Framework. ILCA, Addis Ababa, Ethiopia. Working

Scott T. Willard, 2001. Dairy Farming. In proceedings of 12th annual Mississippi-Louisiana dairy management conference. November 8, 2001. McComb, Mississippi.

Small Holders Dairy Development Project (SDDP), 1995. Annual report. 1995. Addis Ababa, Ethiopia.

Statistical analysis system (SAS) 2000.

Spicer LJ, Tucker WB, Adams GD. 1990. Insulinelike growth factor-1 in dairy cows: relationships among energy balance, body condition, ovarian activity and estrus behavior. *J Dairy Sci*, 73:929-937.

Whitaker DA, Smith EJ, Rosa GO, Kelly JM. 1993. Some effects of nutrition end management on the fertility of dairy cattle. *Vet Rec*, 133:61-64.

Breeding Practices of Indigenous Sheep Breeds of Smallholders for Designing Community Based -breeding Strategies in Ethiopia

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Abstract

In the framework of designing community-based breeding strategies for indigenous sheep breeds of Bonga and Horro of smallholders, a survey of breeding management strategies was conducted in the selected district of Adiyo Kaka and Horro.The collected information included: sheep production objectives, flock size and structure, breeding practices (mating, selection and inbreeding) and breeding objectives. The results indicated that the mean flock sizes for Adiyo Kaka and Horro districts were 11.28 ± 1.27 and 8.20 ± 2.05, respectively. The purpose of keeping sheep identified reflected the multiple objectives in both production systems/areas; with source of income rated highest followed for meat. Breeding was generally uncontrolled. Traits such as size, color and tail were among the most frequently reported selection criteria for breeding rams across the two sites; where as size, color, tail formation and twining rate were mentioned as traits given due emphasis in that order selecting breeding females in Adiyo Kaka. In Horro, farmers considered primarily size, color, pedigree and age at first lambing in that order in the selection of breeding females. Adaptive traits such as disease tolerance and feed shortage tolerance were given low emphasis in selecting replacement stocks in both of the districts. As an input for setting up sustainable community- based breeding strategies, the present survey identified several constraints that should be well addressed. These include: early disposal of breeding stocks, small flock sizes with only a few breeding males; uncontrolled mating, communal grazing in wet season and free roaming during dry season makes controlled breeding very difficult. It is suggested that to reduce early castration and disposal of better breedable animals, farmers need to be convinced and develop interest about the benefits of better genotypes or incentives might be provided for those keeping their best males for breeding purposes. Traditional breeding management schemes such as sharing of breeding rams should be further strengthened. Considering the small flock sizes in both the sites reasonable genetic gain demand the formation of group co-operatives schemes, which in turn require full participation and long term commitment of sheep breeders and other livestock development actors.

Key words: Bonga sheep; Horro sheep; Breeding management; Community-based breeding strategies

Introduction

Past efforts initiated by government and non-governmental organizations for sheep improvement were limited to crossbreeding of indigenous sheep with exotic breeds under experimental station in isolation from environmental constraints and disregarding the multiple functions of animals to the owners (Tibbo, 2006). In most cases those efforts have been unsuccessful in the traditional low input production systems due to incompatibility of the genotypes with the farmers' breeding objectives and the production systems (Kosgey, 2004; Tibbo, 2006). For sustainable genetic improvement and conservation of traditionally managed livestock breeds, development of community-based breeding strategies which takes into consideration the need, knowledge and aspiration of local community and participation of all stakeholders is getting attentions from planners and donor agencies (Sohler-Rollefson, 2003). Designing and implementation of community-based breeding strategies, basically needs detailed understanding of the community's indigenous knowledge of farm animals regarding production objectives of the farmers, breeding practices and

breeding objectives (Baker and Gray, 2003; Sohler-Rollefson, 2003). However, there is little and inconclusive information on sheep breeding practices and objectives in the smallholder areas of Ethiopia in general and in particular for Bonga and Horro sheep breeds. Therefore, the objective of this study was to understand sheep breeding practices and breeding/production objectives of sheep breeders in Bonga and Horro areas in Southwestern and western Ethiopia as the first step towards developing community-based breeding strategies.

Materials and Methods

Study area

The survey was conducted in Adiyo Kaka district of Kaffa Zone of Southern Nations, Nationalities and Peoples' Regional State and in Horro district of Horro Guduro Wellega zone of Oromia Regional State. These districts were chosen for the reason that they are predominantly known for Bonga and Horro sheep breeds, respectively. Adiyo Kaka and Horro are located at 509 km southwest and 310 km west of the capital Addis Ababa, respectively. Adiyo Kaka falls within longitude of 36 ° 47'E and latitude of 7 ° 26 'N with altitude ranging from 500 to 3500 meters. Its extreme temperatures range between about is 36 °C and 3 °C. Its main rainy season extends from April to October while the dry season lasts from November to March (SUDCA, 2007). Horro Guduro's rain occurs between May and September and the dry season lasts from October to April. The altitude ranges from 1800 to 2835 meters (HDARD, 2006). Kafficho and Oromo are the dominant ethnic group in Adiyo Kaka and Horro districts, respectively. The farming system of both sites is predominantly characterized by mixed crop-livestock production.

Sampling procedure and data collection

A multi-stage sampling technique was employed where first districts known for the two sheep breeds in their respective production system were identified, followed by identifying potential PAs and villages. Road accessibility, potential for sheep production and practice of communal grazing system were used as criteria in selecting the sites. Three PAs from Adiyo Kaka and six PAs from Horro were selected fulfilling the above criteria. In selecting the sites, discussions were held with zonal and district agricultural experts and development agents. A set of detailed structured questionnaire were prepared to collect information from a total of 229 sheep owners in both Adiyo Kaka and Horro districts (114 from Adiyo Kaka and 115 from Horro). The questionnaire was carefully designed keeping the purposes of the study in mind and pres-tested and modified before the commencement of the actual administration to check its clarity to respondents and appropriateness of the questions. General information list of FAO (2000) and Oromia livestock breed survey questionnaire (Workneh and Rowlands, 2004) was used as a checklist in designing the questionnaire. The modified and finalized questionnaire was administered by staffs of Bonga and Bako Agricultural Research Centers to gather information focusing on socio-demographic characteristics of the households (age, gender, educational background, family size), flock size and structure, purpose of keeping sheep/breeding objectives and breeding practices.

Estimation of average change in inbreeding

An average increase in inbreeding was calculated or estimated from effective number of breeding animals for both within a closed and open flock (mixing flock). Effective population size (Ne) is used because it is the most common description for assessing the expected inbreeding in a population. Estimates of average change in percentage inbreeding was made with expression:

$$\Delta F = 1 / (2\ Ne)$$

Where,

ΔF = Avg. increase in inbreeding per generation

Ne = the effective population number

$N_{e} = 4 N_m \times N_f / N_m + N_f$

N_m = number of breedable male

N_f = number of breedable female

Statistical analysis

The SPSS statistical computer software (SPSS for window, release 15.0, 2006) was used to analyze the data. Results are presented mainly in the form of descriptive tabular summaries. F-test was carried out as appropriate to assess statistical significance or for particular comparison. An index was calculated to provide overall ranking of the reasons of keeping sheep according to the formula: Index = Σ of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] given for particular purpose of keeping sheep divided by Σ of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all purpose of keeping of sheep. Similar indexes were calculated for ranking selection criteria for breeding females and males.

Results and discussions

Household socio-demographic characteristics

The average family size in the study households were 8.6 ± 4.48 and 7.3 ± 2.47 for Adiyo Kaka and Horro districts, respectively with overall mean of 7.9 ± 3.65. Family size was significantly (P<0.01) different between the two sites. The larger family size in Adiyo Kaka was attributed to polygamy. Average family size of 8.5 was reported in East Wellega and West Shoa zones (Solomon *et al.,* 2005). Figures for both districts obtained in this study were higher than the average values at the national level at 5.2 (CACC, 2003). Of the total interviewed sheep keepers, 96.5% and 93.1% were male headed for Adiyo Kaka and Horro, respectively. This finding agrees with Solomon *et al.* (2005) who reported 94.3% male headed households East Wellega and West Shoa zones. In terms of educational level, in Adiyo Kaka, 22.8% were illiterate, 3.5% could read and write, 70.2% attended primary school and 3.5% reached secondary school. The values for Horro were 19.1, 2.6, 48.7 and 28.7%, respectively. Only 0.9% of the farmers in Horro went to religious schools. In contrast to this report, higher proportion of illiterate (59.7%) and lower level of primary and secondary attendants (21.7 and 5.4 %) were reported in southern Ethiopia (Takele, 2006). This survey result illustrates that the higher proportion of farmers having primary and secondary educational background would be an opportunity to exploit and utilize them in the introduction of new breeding programmes for instance in recording simple records which are of paramount importance in decision making in relation to selection.

Flock size and structure

The mean numbers of sheep in Adiyo Kaka and Horro per household were 11.9 ± 1.27 with the range of 1-50 and 8.2 ± 2.05 with range of 2-50, respectively. The farmers in Adiyo Kaka hold significantly (P<0.01) higher number of sheep than their Horro counterparts. This might be attributed to high death rate in Horro flocks reported in past by disease out break (Personal communication). A lower flock size of An average lower flock sizes of 6.3 ± 7.38, 4.2, 5.0, 6.7 and 6.97 were reported for East Wellega and West Shoa zones (Solomon *et al.,* 2005), southwest parts of Ethiopia (Birhanu, 1995), for Alaba district (Tsedeke, 2006), for Fentale district (Shiferaw, 2007) and around Dire Dawa (Aden, 2003), respectively. Larger flock sizes of 16.02 for Gumuz sheep in Metema (Solomon, 2007) and 24 in central highlands for Menz flocks (Abebe, 1999) were reported. Small flock size investigated in this study (Table 1) was identified as the limiting factor in applying within breed selection at the household level and therefore calls for an approach targeted at designing a selection scheme applicable to the whole village level, which in fact is the overall

objective of the project. Furthermore, it might indicate that the level of inbreeding is high (Jaitner *et al.,* 2001).

Females made up for about 60 and 80% of the total flock in Adiyo Kaka and Horro, respectively (Table 1). The proportion of castrates (5.9%) and intact males older than 1 year (5.8%) were larger for Adiyo Kaka as compared to Horro which are 2.9% and 3.6%, respectively. About 72.2% of females proportion was reported for sheep flocks in East Wellega and West Shoa zones by Solomon et al., (2005). Wilson (1980) reported that female constitute about 92% of the flock in Afar. The high proportion of female sheep in Afar could be associated with the tradition of milking sheep. The proportion of breeding ewes in this particular finding is similar to 47.0% reported by (Solomon *et al.*, 2005). However, lower than reported by Berhanu (1995) at 54.4% in southwestern Ethiopia under farmers management conditions. About 5.8% intact male which was the same as for Bonga flocks was reported for Gumuz flocks by Solomon (2007) and 4% for sheep flocks in Eastern Wellega and in West Shoa zones (Solomon et al., 2005), but lower than the reports by Berhanu (1995) at 8.6%, Agyemang *et al.* (1985) at 22.4% and Abebe *et al.*(2000) at 12.5%. About 2.8%, 2.9% and 2.6% castrates which were similar to the proportion of castrates in Horro, but lower than Bonga, were reported by Birhanu (1995), Niftalem (1990) and Solomon *et al.* (2005) in southwest, central highlands and West of Ethiopia, respectively. According to Nososo *et al.*, 2004), such flock structure arise because farmers know that maintaining a constant flock size depends on keeping the more reproductively active females longer than males.

Table 1. Flock size and composition given as average number in the study areas

Sheep categories	Adiyo Kaka				Horro			
	N	Mean ± SD	Range	% of total flock	N	Mean ± SD	Range	% of total flock
Lambs less than 6 months	460	4.04 ± 1.6	0-10	35.8	222	1.93 ±1.3	0-7	23.5
Weaned lambs between 6 months and 1 year	258	2.26 ± 1.6	0-23	20.1	206	1.79 ±1.9	0-20	20.0
Unsaturated male greater than 1 year	74	0.65 ± 1.5	0-7	5.8	34	0.29 ± 0.8	0-6	3.6
Female greater than 1 year	417	3.66 ± 2.7	0-20	32	454	3.95 ± 2.8	0-16	48.1
Castrates	76	0.66 ± 1.7	0-10	5.9	27	0.23 ± 0.9	0-5	2.9
Total	1285	11. 28 ±1.3	1-50	100.0	943	8.20 ± 2.1	2-50	100.0

Sheep production objectives

The knowledge of reasons for keeping small ruminants is a prerequisite for deriving operational breeding goals (Jaitner *et al.,* 2001). Lack of proper recognition of the purpose of keeping animals by their owners has been a major reason in the failure of past genetic improvement programs (Sölkner *et al.,* 1998). The reasons for keeping sheep are rational and are related to the farmers' needs in the long or short term. The results of this survey revealed that sheep play multi-functional roles in both production systems with similar production objectives. Tables 2 present ranked purposes of keeping male and female sheep, respectively. The results indicated the relative importance of tangible benefits of sheep keeping (such as regular source of income, meat and manure). Functions like ceremony and religion received relatively low ranking among the objectives for keeping sheep in both production systems. Having sheep for manure was ranked higher among farmers in Horro than smallholders in Adiyo Kaka. Similar multipurpose functions of sheep rearing were reported for sheep keepers in the central highland (Abebe, 1999). Kosgey (2004) reported low ranking of small ruminants for breeding purpose among the smallholders and pastoralists in Kenya. Multiple functions are particularly important in low and medium input production environments. Different studies addressed the importance of multiple values of indigenous livestock

breeds in developing countries in low input system (Kosgey, 2004; Mwacharo and Drucker, 2005; Wurzinger *et al*., 2006; Zewdu *et al.,* 2006).

Table 2. Ranked purpose of keeping sheep as indicated by respondents

Purpose of keeping	Adiyo Kaka				Horro			
	Rank 1	Rank 2	Rank 3	Index	Rank1	Rank2	Rank 3	Index
Income	98.9	4.5	2.1	0.72	97.6	13.4	0.9	0.70
Meat	0.9	39.1	50	0.22	4.6	42.8	30	0.22
Saving	0	0.9	15.6	0.03	1.8	16.2	8.3	0.08
Ceremony	0	2.6	15.6	0.03	0.9	0.9	0.9	0.01
Manure	0	0	0	0	1.8	10.5	26	0.09

Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular purpose divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all purpose.

Breeding Management

Mating system and sources of breeding rams

Mating was predominantly uncontrolled. A similar observation was made in East Wellega and West Shoa zones (Solomon *et al.,* 2005). Only 29.6% of the farmers in Horro and about 56.3% in Adiyo Kaka kept their own breeding males. When breeding males were not reared in their flocks, the majority of the farmers got the service from or using neighbors' ram (93.5% for Adiyo Kaka and 34.5% for Horro). The majority (75.8%) of breeding rams for farmers in Horro originated from own flock and 24.28% were purchased from market. Similarly, for Adiyo Kaka, about 84.2% of the rams were born in the own flock and 15.8% purchased from market. On average, a breeding ram was kept for two years with the range of 1 to 4 years for Bonga and 1 to 8 years for Horro. The ratio of rams older than 1 year to ewes in Bonga flocks was 1: 6.4. The corresponding value for Horro flocks was 1:13.4. Male to female ratio of 1:12 which was almost similar to the values for Horro was reported by Solomon *et al*. (2005). A sex ratio comparable to Bonga flock has been reported for thin-tailed Gumuz sheep breed in Metema area (Solomon, 2007) and for flocks under small scale mixed farms in the highlands of Ethiopia (Berhanu, 1995).

Gains from breeding programmes are achieved only when inbreeding depression is well controlled or minimized (Kosgey, 2004). An average inbreeding of 22% and 45% were estimated for Bonga and Horro, respectively under closed breeding management condition. For open flocks (mixed flocks) the estimated change in inbreeding per generation was 6.4% for Bonga and 8.9% for Horro flocks. Mixing of flocks dramatically reduced the inbreeding level in both of the flocks. As stated by Gatenby (1986) inbreeding was higher in small flocks kept by smallholders and in flocks having only limited breeding rams. As indicated by Seleka (2001), the predominance of uncontrolled mating in both production systems and small flock sizes would potentially increase the level of inbreeding, Almost all breeding rams were originated from their respective flocks, which might imply that the relationship of animals within a flock is narrow and inbreeding is wide spread and increasing. The low level of inflow of animals of unrelated population either through purchase or other means may further increase the level of inbreeding within the small flock size. In smallholders of Horro areas, farmers kept males upto 8 years of age which could be increase the chance of mating of own daughters by the rams.

According to Kosgey (2004) and Jaitner *et al.* (2001) inbreeding can be minimized by communal herding which allows breeding female from other flock to mix with breeding male of different flocks, early castration of undesired males and rotational use of breeding males. It was reported that of the total ram owners about 94.4% share their ram to others. In areas such as Horro where most of the community practiced communal sharing of grazing lands; the level of inbreeding could be minimized through the use of unrelated breeding rams. But this appears to be rarely practiced among the farmers in Adiyo Kaka areas. Controlled breeding scheme which involve rotational uti-

lization of breeding males among the smallholders could be an alternative for Bonga flocks. This need strong extension services to organize farmers to use the existing males efficiently.

Selection of breeding animals and trait preferences

Selection of parents of the next generation in both the rams and ewes was very common among the sampled farmers. Overall 79.7% and 94.7% of the farmers practice selection for breeding ram and breeding females, respectively. Males were selected at 7.5 ± 3.0 and 4.39 ± 2.2 months for Bonga and Horro, respectively. The respective figure for females was 7.4 ± 3.01 and 4.5 ± 1.9 months for Bonga and Horro, respectively. The ranking of important traits as perceived by farmers for the breeds in the two study sites are summarized in Tables 3 and 4 for males and females, respectively. Traits like size, color, and tail formation were all considered as important in both of the sites and given due emphasis in selecting breeding rams. Large body size, red or brown coat color, tail with long, broad and twisted at the end are the most preferred traits by most of the farmers in Adiyo Kaka. Similar traits were preferred for males by the farmers in Horro. However, in contrast to Adiyo Kaka, farmers of Horro preferred male with broad and straight pointed tail. Temperament and age were given relatively little emphasis in selecting breeding animals. Like for males, size, color and tail formation were the most highly rated traits in selecting breeding females in both communities. Fortunately, trait related growth is relatively easy to improve through breeding and usually moderate heritability. Lambing interval, mothering ability, age at first lambing and twining rate were also considered in selecting breeding female. Adaptive traits such as tolerance to diseases and feed shortage were given low emphasis in selecting replacement stocks in both of the districts.

Table 3. Ranked selection criteria for breeding rams

Characters	Adiyo Kaka				Horro			
	Rank1	Rank2	Rank3	Index	Rank1	Rank2	Rank3	Index
Body size	40.2	35.4	16.5	0.342	54.4	32.9	16.2	0.415
Color	25.9	31.8	31.1	0.284	11.7	27.6	36.5	0.215
Growth rate	3.6	4.5	16.7	0.060	0	1.3	5.4	0.013
Mating ability or libido	2.7	2.7	2.9	0.027	0	0	1.4	0.002
Tail conformation	27.7	24.5	35.9	0.276	27.9	29.7	24.3	0.283
Temperament	0	.9	.9	0.004	0	0	1.4	0.002
Age	0	.9	.9	0.004	1.5	0	0	0.007
Pedigree	0	0	0	0	4.4	6.8	8.1	0.059

Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular trait divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all traits

Table 4. Ranked selection criteria for breeding females

Characters	Adiyo Kaka				Horro			
	Rank1	Rank2	Rank3	Index	Rank1	Rank2	Rank3	Index
Body size	26.3	37.2	12.8	0.279	63	23.1	6.7	0.403
Tail formation	9.6	10.9	31.2	0.137	6.8	16.7	0	0.089
Pedigree	0.9	0	0	0.004	7.8	13.9	0.9	0.233
Color	30.7	15.5	18.35	0.238	14.6	35.2	26	0.233
Mothering ability	5.3	10.9	7.3	0.075	7.8	0.9	2.9	0.046
Lamb growth	2.6	5.5	4.6	0.039	0	0.9	2.9	0.007
Age at first lambing	2.6	0	4.6	0.020	0	0	60.6	0.101
Lambing interval	7	8	8.3	0.076	0	1.8	0	0.006
Twining rate	13.2	10.9	12.8	0.124	0	7.4	0	0.024
Longevity	0	0.9	0	0.003	0	0	0	0

Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular trait divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all traits

Castration

Castration was practiced by 98.2 % of the farmers in Adiyo Kaka and 58% in Horro. Average ages of castration were 10.8 ± 2.5 months for Bonga and 17.8 ± 8.2 months for Horro sheep. A similar age of selection of 17.6 ± 8.56 months was reported for sheep flocks from East Wellega and West Shoa zones (Solomon *et al.,* 2005). Castration at this age allowed a ram to stay in the flock and breed for a maximum of up to the age of one year and six months. It was primarily practiced to improve the fattening potential (63.31% for Adiyo and 47.37% for Horro) and is a means of getting higher sale prices at a later date. Castration to avoid undesirable males and to control breeding was rarely reported. Usually better rams with good body conformation and having potential for fattening are subjected to castration. This warrant farmer's conveniencing about the importance of improved genotype and or incentives might be provided for those keeping their best rams for breeding purposes.

Conclusions

Breeding strategies targeted at genetic improvement of Bonga and Horro sheep breeds need to incorporate the multi-functional roles that sheep play in these systems and focus on those traits identified as important by the owners of the animals themselves. For setting up sustainable community-based breeding strategies, the present survey revealed several pertinent constraints, which should be well addressed in the design of breeding programs. These among others included: small flock size with only a few breeding males and uncontrolled mating, animals are rarely separated based on their sex and communal grazing in wet season and free roaming during dry season makes controlled breeding or mating very difficult. The influence of farmers' indigenous knowledge on the gene pool of their animals is substantial. Therefore, farmers' knowledge and practices in sheep breeding practices have to be an integral part of the strategies for designing breeding schemes and capacitated through relevant training. Inbreeding and early conception should be avoided and could be achieved by separating animals into sex groups and early castration of male lambs not selected for reproduction. A system by which breeding rams cloud be regularly exchanged between farmers should be created and strengthened to minimize the level of inbreeding and enhance efficient utilization of better breeding males. To avoid early disposal of breeding males, farmers need to be convinced and develop interest about the benefits of better genotypes or incentives might be provided for those keeping their best males for breeding purposes.

References

Abebe Mekoya, 1999. Husbandry practice and productivity of sheep in Lallo- mama Mider woreda of central Ethiopia. An MSc Thesis presented to the school of Graduate Studies of Alemaya University of Agriculture, Dire Dawa, Ethiopia.91p.

Abebe, M., Alemu Y and Hegde, P. B. 2002. Growth performance and mortality of Menz sheep in the traditional sector of Lallo, Mama Mider Woreda, North Shoa.Procedings, Pastoralism and Agro-pastoralism which way forward? 8 th Annual Conference of Ethiopian Society for Animal production (ESAP),25-26 August2002, Addis Ababa, Ethiopia.Pp.

Aden Tekle, 2003. Evaluation of local sheep breed under traditional management around rural areas of Dire Dawa. An MSc Thesis presented to the School of Graduate Studies of Alemaya University, Dire Dawa, Ethiopia.128p.

Agyemang K, Negussie A, Voorthuize A and Anderson FM, 1985. A rapid survey of sheep production in the traditional sector of Deber-Beran, Ethiopian Highlands. Small Ruminants Agriculture 9: 175-185.

Baker, R.L. and Gray, G.D. 2003. Appropriate breeds and breeding schemes for sheep and goats in the tropics: The importance of characterization and utilizing disease resistance adaptation to tropical stress.

In: Sani, R., G.D Gray., R.L. Baker (Eds.), Better worm control for Small Ruminant in Tropical Asia, Australian Center for international Agricultural Research (ACIAR) (in press).

Berhanu Belay, 1995. Traditional sheep management and production in the South Western part of Ethiopia. Proceedings of the 5th Annual Conference of ESAP, IAR, Addis Ababa, Ethiopia. pp. 117-125.

CACC (Central Agricultural Census Commission), 2003. Ethiopian Agricultural Sample Enumeration, 2001/02. Results at country level. Statistical report on socio-economic characteristics of the population in agricultural household, land use, and area and production of crops. Part I. (July 2003), Addis Ababa, Ethiopia.

FAO (Food and Agriculture Organization of the United Nations), 2000. World Watch List for Domestic Animal Diversity. D.S. Beate 3 rd ed. FAO, Rome, Italy. 726p.

Gatenby, R. M. 1986. Sheep Production in the Tropics and Sub-Tropics. Longman Inc., New York, 351pp.

Gemeda Duguma, Takele Kumsa, Ulfina Galmessa, Solomon Abegaz and Gebregziabher Gebreyohannes. 2005. Mortality and Reported Clinical Signs in Horro Sheep at Smallholder Farms in East Wellega and West Shoa Zones, *Ethiopia. Eth. J. Anim. Prod. 5(1) - 2005: 33-42*

HDARD (Horro District Agriculture and Rural Development Office), 2006. Socio-Economic survey report, Horro

ILCA, 1990. (International Livestock Center for Africa). Livestock Research System Manual. ILCA, Addis Ababa, Ethiopia. Part I. 287p.

Jaitner, J., Sowe, J., Secka-Njie, E., Dempfle, L. 2001. Ownership pattern and management practices of small ruminants in Gambia-Implication for a breeding programme.Small ruminant Rumin.Res.40, 101-108

Kosegey I.S. 2004. Breeding objectives and breeding strategies for small ruminants in the Tropics. Ph.D. Thesis, Wageningen University, The Netherlands. (ISBW: 90-5808-990-8) Germany.

Mwacharo, J.M. and Drucker, A.G., 2005. Production objectives and management strategies of livestock keepers in south-east Kenya: Implications for a breeding progrmme. *Tropical Animal Health and Production,*37:635-652.

Niftalem Dibessa, 1990. On farm study of reproductive and growth performance of Menz sheep around Debre Brahan area. An M.Sc Thesis presented to the School of Graduate Studies of Alemaya University of Agriculture, Dire Dawa, Ethiopia.103p.

Nsoso, S.J., B., Podisi, E., Otsogile, B. S., Mokhutshwane and Ahmadu B., 2004. Phenotypic characterization of indigenous Tswana goats and sheep in Botswana: Categorical traits. *Tropical Animal Health and Production,*36: 789-800.

Seleka, T.B., 2001. Determinants of short-run supply of small ruminants in Botswana. *Small Rumin. Res.*40: 203-214.

Shiferaw Garoma, 2006. In-situ phenotypic characterization of Kereyu Cattle type in Fentalle district of Oromia region, Ethiopia . An MSc Thesis presented to the School of Graduate Studies of Alemaya University, Dire Dawa, Ethiopia.90p.

Sisay Lemma, 2002. Phenotypic classification and description of indigenous sheep type in the Amhara National Regional State of Ethiopia. M.Sc. Thesis, University of Natal, Pietermarizburg. 104p.

Sölkner-Rollefson, J. H. Nakimbugwe, and Zarate, A. V., 1998. Analysis of determinants for success and failure of breeding programmes. pp. 273-280. In: Proceedings of the Six World Congress on Genetics Applied to Livestock Production, 11-16 January, 1998, Armidale, Australia

Sölkner-Rollefson, J. 2003. Community-based management of animal genetic resources with special references to pastoralists. In: Proceedings of the Workshop on Community-based Management of Animal Genetic Resources, 7-11 May, 2001, Mbabane, Swaziland, pp. 14-26.

Solomon Abegaz, Gemeda Duguma, Ulfina Galmessa, Berhanu Soboqa, and Fikru Terefe, 2005. Small ruminant production system in East Wellegga and West Shoa zones. Research Report, Oromia Agricultural Research Institute, Bako Agricultural Research Center, Bako, Ethiopia. 31p.

Solomon Abegaz, 2007.In situ Characterization of Gumuz sheep, under farmers management in north western lowland of Amhara region. An M.Sc Thesis presented to the School of Graduate Studies of Alemaya University, Dire Dawa, Ethiopia.128p.

SPSS (Statistical Package for Social Sciences). 2006. Version 15.0, SPSS Inc., USA.

SUDCA(Sustainable Development Consulting Association), 2007. Data collection and Analysis final report, Menjo Woreda

Takele Taye, 2006. On-farm Characterization of Sheko Breed of in Southern EthiopiaCattle. An M.Sc Thesis presented to the School of Graduate Studies of Alemaya University, Dire Dawa, Ethiopia.

Tibbo, M. 2006. Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopia highlands. PhD dissertation. Department of Animal Breeding and Genetics, Faculty of Veterinary Medicine and Animal Sciences, Swedish University of Agricultural Science(SLU), Uppsala, Sweden.

Tsedeke Kocho, 2007. Production and Marketing systems of sheep and goats in Alaba, Southern Ethiopia. An M.Sc Thesis presented to the School of Graduate Studies of Hawassa University, Hawassa, Ethiopia.157p.

Wilson, R.T. 1980. Population and production parameters of sheep under traditional management in Semi-arid areas of Africa. Trop. Anim. Hlth. Prod. 12:243-250.

Workneh Ayalew and G. J. Rowlands (eds), 2004. Designing, execution and analysis of the livestock breed survey in Oromia Regional State, Ethiopia, OADB (Oromia Agricultural Development Bureau, Addis Ababa, Ethiopia, and ILRI (International Livestock Research Institute), Nairobi, Kenya. 260p.

Wurzinger, M., Ndumu, D., Maumung, R. and Drucker, A.G., Okeyo, A. M., Semambo, D.K. and Sölkner, J., 2006. Assessing stated preferences through use of choice experiments: valuing (re) production versus aesthetics in the breeding goals of Ugandan Ankole cattle breeds. In: Proceedings of the 8th World Congress on genetics applied to Livestock production, 13-18 August, 2006. Belo Horizonte, Brazil. pp 1-4.

Zewdu Wuletaw, Workineh, Ayalew and Johan Sölkner, 2006. Breeding Scheme based on Analysis of Community breeding Objectives for Cattle in North-western Ethiopia. *Eth. J. Anim. Prod.* 6(2) 33-66

Participatory approaches for defining breeding objectives in community-based breeding programmes

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Introduction

Livestock keeping forms key components of the livelihood strategies of many of the world's poorest people (Mwacharo and Drucker, 2005; Roessler et al., 2007). In many parts of the world livestock are kept not only for their physical products, but also for insurance, financing, and to display status (Moll, 2005). In developing countries where livestock production is still mostly subsistence-oriented and fulfil manifold functions (Wurzinger et al., 2006; Roessler et al., 2007), a considerable number of livestock breeding programmes have failed (Roessler et al., 2007). This is often due to government policy promoting a small range of specialized 'improved' breeds (e.g. distribution of F1 crossbred heifers) or emphasizing on limited physical products in isolation of environmental constraints and broader livestock system functions and constraints (Drucker et al., 2001; Ouma et al., 2004; Moll, 2005; Moll et al., 2007; Tesfahun, 2008) without the active participation and willingness of the people concerned (Donkin, 2005; Tibbo et al, 2006; Roessler et al., 2007). This was (and still is) perceived as 'the way forward' to improve productivity of indigenous livestock under smallholder conditions (Wollny, 2003). However, the breeding goals of livestock keepers are often multifaceted (Köhler-Rollefson, 2000; Bebe et al., 2003; Moll, 2005; Moll et al., 2007; Kosgey et al., 2006; Roessler et al., 2007). The breeding goals are mainly driven by the underlying production systems (Wollny, 2003; Ouma et al., 2007) and take into account the institutional arrangement and environment. Livestock keepers often value the non-marketable by-products of their animals such as manure, consume part of the produce themselves, and appreciate the intangible benefits of livestock in insurance, financing and display of status (Moll et al., 2007). Moreover, 'improved' breeds often do not have the adaptive attributes required to fulfil their multi-faceted roles (Drucker et al., 2001) as they are not selected for the specific crossbreeding purpose in a different production environment (Wollny, 2003). The comparative studies conducted by Ayalew et al. (2003) also indicated that within their local environments and resource-constrained production systems, local goat breeds can perform better than exotic breeds. This indicates that animal breeding programmes, determined only by short-term market forces, lead to unwanted side effects (Olesen et al., 2000). Thus, efforts to develop local breeds should always take into consideration the multiple breeding goals of the communities and should fully respect cultural preferences of the people (Ayantunde et al., 2007). According to Kominakis et al. (1997), the development of selection schemes in pure breeds has the important advantage of balancing the genetic improvement of traits with other essential traits of adaptation to local environment and production system.

In the past, most breeding programmes were designed by scientists and implemented by development agents without taking into consideration all the needs and wishes of the farmers and the long-term impact of their actions (Kosgey et al., 2006). As a result, many programmes in developing countries have failed: for instance, the Horro Sheep Breeding and Improvement Ranch (1982 – 1999), in Horro Guduru (Western Ethiopia), established in 1982 by the Ethiopian Ministry of Agriculture, has failed causing huge financial and material loses (OADB, 2001). It was after 17 years that the team of experts from Oromia Bureau of Agriculture and Rural Development and Oromia Agricultural Research Institute (the then Oromia Agricultural Research service) identified that the area was unsuitable for sheep production based on the analysis of survey results. The team learnt that the surrounding farmers had voiced the unsuitability of the area for sheep

production before the commencement of the scheme, but their voices were not heard. Kosgey et al. (2006) reported that definition of comprehensive breeding objectives incorporating the specific, immediate, and long-term social and economic circumstances of the target group as well as ecological constraints was found lacking in some projects that failed. Thus, no matter how much effort is put into financial and technological support, the eventual survival of improvement programmes depends on whether the livestock owners understood and agreed with the objectives of the projects (Donkin, 2005; Kahi et al., 2005). Hence, sustainable breeding programme needs to be tailored to the specific needs of the different communities with the active involvement of the target beneficiaries.

Literature report on community-based or village breeding schemes is generally scanty. The report by Sölkner et al. (1998) on determination for success and failure of village breeding programmes could be considered as a pioneer in this regard. Ahuya et al. (2005) reported that two community-based and farmer-led goat improvement programmes have been successfully implemented in Nyeri and Meru regions of Kenya under the stewardships of FARM-Africa. Amer et al. (1998) indicated that sustainable breeding programmes for Africa and Asia can only succeed if breeding objectives incorporate preferences of the livestock producers.

The process of genetic improvement of animals is systematic and follows several important steps: description of the production systems, definition of breeding objectives, development of selection criteria, performance of genetic evaluations, selection of animals and finally design of appropriate mating systems (Rewe et al., 2006a). In this paper we have outlined key factors contributing to participatory approaches of defining breeding objectives for community-based livestock breeding programmes.

Description of production systems

In order to setup a breeding programme, the target production system has to be well characterized in the context of other farming or off-farm activities before any successful community-based programme could be initiated (Wollny, 2003; Mbuku et al., 2006; Kosgey and Okeyo, 2007). Description of the production environment should be detailed and allow for distinction of target groups within the area/region for which the breeding programme is derived, as different target groups may have different perceptions and priorities (Sölkner et al., 1998). Furthermore, farmers' ability to exert effective control over key resources such as land and labour likely differs based on their education levels, age and wealth status. Most farming environments in African developing countries continue to deteriorate due to pressure from human population growth and land degradation. According to Sölkner et al. (1998) and Wollny (2003), livestock improvement programmes have to operate under exiting environmental conditions as the assumed condition that positive environmental changes will be successfully implemented may not be realistic. A site-specific approach utilising the existing resources and taking into account the given constraints appears to be the only reasonable sustainable solution (Wollny, 2003) as farmers use their detailed, location specific knowledge of the production possibilities of their immediate environment (Reece and Sumberg, 2003). Farmers have an intimate knowledge of their local environment, conditions, problems, priorities and criteria for evaluation (Sumberg et al., 2003).

Production systems are determined by agro-ecology and commonly differ in exhibiting various stress factors, such as water shortages, disease and parasites as well as temperature extremes (Ouma et al., 2004). Small and large ruminants depend strongly on their production environment, so the prevailing production conditions largely determine the breeding or production purpose and the suitability of breeds and breeding methods. Climatic zone is also a determinant factor as there are distinct breeds and breed groups suitable for diverse purposes in the different ecological zones. Agro-climatic conditions of an environment partly determine the type of production system and production objectives and priorities since they differ in exhibiting various stress factors (Ouma et

al., 2007). Furthermore, farmers in different production systems may have different trait preferences (Roessler et al., 2007). The strategies followed by resource-poor farmers are as diverse as the highly variable agro-environments within which they practise (Reece and Sumberg, 2003). Thus, site-specific description of production system needs to be performed at the very start by organizing consultation workshops accommodating all relevant stakeholders and introducing the overall objectives of the programme in order that each actor from livestock owners to consumers can view his/her opinion.

Participatory Rural Appraisal (PRA) survey can be conducted to determine the baseline information and to study constraints and opportunities, and communities and livestock populations for the breeding programmes. This also helps to identify the livelihood standards of the targeted communities for latter livelihood change analysis. Direct observation during transect walks often combined with informal interviews provides an indication of a number of important aspects of the local farming system which includes, among others, the health and nutritional status of the livestock, the members of the family responsible for the livestock, livestock housing system, grazing/feeding strategies followed, milking regime, and care of young stock (Kirsopp, 1994). Indigenous knowledge of local calendars regarding availability of feeds, prevalence of diseases, rainfall patterns and labour for the different activities of the specific area (community) could help designing a sustainable breeding programme. Villagers have a greater capacity to map, model, observe, quantify, estimate, compare, rank, score and diagram than outsiders have generally supposed (Chambers, 1994). This could help to get the opinion of individual farmers, as farmers operate under specific natural and socio-economic settings (Bernet et al., 2001) and the breeding objective needs to be tailored to the specific needs of the specific groups of farmers.

Additionally, a structured or semi-structured questionnaire can be used (Wurzinger et al, 2006; Wurzinger et al, 2008a) to record flock/herd size, the ratio of male/female, the number of animals sold each year, purpose of keeping different species of livestock, importance and use of livestock products for each owner. Breeding practices can be identified such as source and breed(s) of males used in the herd/flock, primary reasons for keeping males (e.g. for breeding), quality of traits along with prevalent diseases that occur in the farm, vaccination/preventive treatments given, and traditional methods for disease control. For socio-economic studies, marketing channels and opportunities for animals and animal products, economic valuation of production (production costs, returns from sales); institutional settings that affect breeding and animal management, including marketing (decision mechanisms within the community) could easily be documented. Secondary data, which could are largely available from offices of agriculture and rural development, are useful to complement the production system study.

Definition of breeding objectives

The success of improvement programmes is not only determined by their structure, but by their compatibility with the breeding objective of the farming system and the involvement of farmers (Kosgey et al., 2006). This is partly because the genetic resources of the indigenous livestock breeds have mostly been shaped by producers' preferences (Drucker, 2004). That means knowledge about the merit of traditional breeds is available from farmers that have developed these breeds since long time. A decisive step in the design of breeding programmes is, therefore, the definition of a breeding objective (Sölkner et al., 1998). To realize the benefits of a breeding programme, it is essential that the breeding objectives are appropriately defined for the species or breeds, communities and environments concerned and that the strategies laid out, can be followed in practice (Philipsson et al., 2006). Breeding objectives may be expressed in terms of the traits to be improved, the cost of production and the revenue from product sales related to a genetic change in each trait (Rewe et al., 2006b). Breeding objectives comprise the economic and breeding values of traits a producer would like to improve because of their influence on profitability in the production system. Economic values are an indication of the relative importance of traits in a given sys-

tem and can be derived only if breeding objectives are defined in economic terms (Kahi and Nitter, 2004; Rewe et al., 2006a). It should account for inputs, such as feed, husbandry and marketing costs, as well as for outputs, such as income from sale of products and surplus animals.

Many of these are difficult to quantify under most tropical conditions due to lack of informative recording system, probably owing to illiteracy, lack of records and small flock sizes (Kosgey et al., 2003). Other factors are lack of consistency in recording and sub-optimal animal evaluation (Rewe et al., 2006a). In addition, in developing countries many important functions of livestock are embedded in traits that are not traded in the market (Scarpa et al., 2003) so it is unlikely that farmers would face choice decisions that focus on each trait individually (Tano et al., 2003). The later authors suggested that using hedonic price analysis to estimate cattle owner's preferences in rural Africa can be very difficult due to the following four major reasons. First, most cattle transactions do not take place in formal markets where transactions are transparent and easily recorded. Rather, transactions usually take the form of private agreements between buyers and sellers using cash, barter or exchange. Second, many cattle are never traded or sold, but stay within the farm household or are passed on to other households through traditional practices such as dowry. Third, breeding cattle and young animals are thinly traded in African markets. Fourth, unfamiliar breeds are not traded. In such circumstances, the collection of price data is likely to be incomplete and can suffer from substantial measurement errors. Instead, various types of consultative processes and farm surveys can be used to better understand the preferences of African farmers for cattle traits. Tano et al. (2003) indicated that conjoint analysis permits the analysis of farmer preferences in terms of the benefits that they perceive to result from various genetic traits. Ouma et al. (2007) also reported that approximately 80% of the value of livestock in low-input developing country systems can be attributed to non-income, socio-cultural functions, while only 20% is attributable to physical products such as meat, milk, and wool. This has forced animal breeders in the past to define breeding objectives in purely biological terms (Kahi and Nitter, 2004). In order to define a comprehensive breeding objectives for a specific target group the following core methods can be employed.

Survey

Useful information for defining breeding objectives can be collected using semi-structured questionnaire and informal focus group discussions with livestock keepers in the specific location. Farmers identify traits they consider important in meeting their objectives using their detailed, location specific knowledge of the production possibilities of their immediate environment. Farmers also make selection decisions as they have a clear picture in mind on traits of a good animal. Tesfahun et al. (2006) reported that farmers have clear and consistent trait preferences for their animals and that the evaluation of such traits starts at early age of the animal. Here, categorizing farmers into different wealth categories, education levels and age classes is important as their ability to exert effective control over key resources such as land and labour differs based on their wealth status (Sumberg et al., 2003) education levels and age of the households. With respect to wealth, the assumption is that the higher level of resources enables a farmer to acquire more information and to invest more on the new technologies. According to Besley and Case (1993), farmer wealth and credit-worthiness are apt both to influence and to be influenced by adoption choices taken. Higher education levels are hypothesized to be associated with more access to information while older heads of the head of household is hypothesized to have a negative influence on perception, adoption and investment levels. Furthermore, older heads of households are expected to have shorter planning horizons than younger ones. Farmers should be grouped by wealth groups (Mulatu and Zelleke, 2002) with key informants using major wealth indicators like size of land, house type, oxen, donkey, etc. For the wealth ranking, villagers' names can be printed on a card and using the criteria set, the key informants can sort out the names into three major wealth groups (better-off, medium and poor). Thus, selection criteria are discussed and defined

with the community members (more specifically with key stakeholders) in a participatory manner (community-based and farmer-led) prior to starting the ranking processes.

Choice experiments

Over the years, the research on valuation of non-market goods (Alpizar et al., 2001) has developed into two branches: revealed preference and stated preference methods. In the revealed preference methods, valuation is conditioned on current and previous levels of the non-market good and the impossibility of measuring non-use values (i.e. traits that are not priced or transacted). Thus, research in the area of valuation of non-market goods has seen an increased interest in the stated preference method, during the last 20 years (Alpizar et al., 2001). Stated preference method assesses the value of non-market goods by using individuals' stated behaviour in a hypothetical setting. The method includes a number of different approaches such as conjoint analysis, contingent valuation method and choice experiments (Alpizar et al., 2001). In choice experiments, since preferences are measured directly, and then related to utility, the results are less likely to be adversely affected by traits that are not priced or transactions that do not occur through organized markets (Ouma et al., 2004).

Information gathered from the survey and informal focus group discussions could help to construct choice cards with pictorial profiles describing the differences in traits and the levels to demonstrate each choice set to survey respondents. In a choice experiment, individuals are given a hypothetical setting and asked to choose their preferred alternative among several alternatives in a choice set, and they are usually asked to perform a sequence of such choices. Each alternative is described by a number of attributes or characteristics. A monetary value is included as one of the attributes, along with other attributes of importance, when describing the profile of the alternative presented. Thus, when individuals make their choice, they implicitly make trade-offs between the levels of the attributes in the different alternatives presented in a choice set (Alpizar et al., 2001; Scarpa et al., 2003). The choice experiment has to be thoroughly pre-tested using focus group discussions in order that individuals can clearly make trade-offs between several attributes.

According to Tano et al. (2003), measures of the comparative utility each individual derives from the traits can be estimated by asking individuals how to choose among several different animal profiles, each of which includes the set of traits to be valued in various combinations. Here, data have to be generated through a survey in which respondents are asked to rate products with alternative levels of important characteristics. Trade-offs between characteristics can be studied, including wider variation in relevant variables than might be observed in actual field data. Those data can provide information about the marginal values of the specified levels of traits that can be used to generate preferences of producers for existing or hypothetical products that are described in terms of the levels of traits. This is particularly relevant for assessing the potential overall utility of genetically improved breeds (Alpizar et al., 2001; Tano et al., 2003).

Given the set of attributes and the levels that each attribute would take, experimental design methods (Kuhfeld, 2005; Nielsen and Amer, 2007) are used to structure paired comparisons of animal profiles. A correct selection of traits to be considered in the profile of an animal is essential. Information from survey can be used for choosing these traits (Ouma et al., 2007; Wurzinger et al., 2008b). The number of attributes in the profile and the number of levels each attribute need to be decided about as the complexity of a choice experiment in terms of the number of choice sets and/or the number of attributes in each choice set may affect the quality of the responses (Alpizar et al., 2001). According to the authors, when the number of alternatives in a choice set is high it may exceed the ability of the respondents to select their preferred option. Especially, when the number of attributes in a choice experiment exceeds 4 to 5 attributes in a choice set it may lead to a severe detriment to the quality of the data collected due to the task complexity. Thus, a reduction in the

number of traits presented to the respondents at one time is important when using pictorial representation of the traits (Tano et al., 2003; Nielson and Amer, 2007).

Phenotypic ranking

Rather than relying on pictorial representations of animals alone, phenotypic ranking of groups of animals has been recently added to the repertoire of methods useful for capturing information about selection criteria of stock owners (Ndumu et al., 2007; Wurzinger et al., 2008b). In Ugandan Ankole cattle, 35 cows and 15 bulls were selected from a government owned ranch and randomly sub-divided in to 4 sub-groups of 4 cows each and 2 sub-groups of 5 bulls. The animals were then restricted in a pen to be ranked by those farmers invited from a region ranging from 60 km north to 80 km south of the ranch. Each invited farmer was asked by a well trained enumerator to rank the animals within each pen (1 to 4 for cows and 1 to 5 for bulls) according to his or her own opinion on the basis of their respective perceived values as breeding animals based on phenotype alone. They also gave the major reasons why animals were ranked first, second, and so on in each group. Thereafter, farmers were provided with additional information on each animal in the form of a hypothetical history, which was derived from a questionnaire administered regarding the additional information that would have been required by the farmers in making better rankings. Ndumu et al. (2007) reported that the methodology of preference ranking combining phenotype and a hypothetical life history better provide insight into indigenous selection criteria of stock owners than ranking animals based on phenotype alone. Wurzinger et al. (2008b) who compared three different methods (survey, phenotypic ranking of live animals and a hypothetical choice experiment) also suggested a combination of at least two methods in order to avoid overlooking of any important question for selection. It was reported that these methods are applicable for situations where farmers have low levels of literacy and/or only a few years of formal education (Ndumu et al., 2007; Wurzinger et al., 2008b).

Participatory definition of breeding objectives for four indigenous Ethiopian sheep breeds

A community-based breeding programmes for Horro, Menz, Bonga and Afar indigenous sheep breeds of Ethiopia was proposed jointly by ILRI, ICARDA and BOKU with the objectives of improving productivity and income of smallholder sheep producers through improved management and access to improved breeding stock and market opportunities using decentralized farmer-driven breeding schemes. The project was to be implemented by ILRI, the Ethiopian Agricultural Research Institute (EARI) in Melka Werer for Afar breed, Oromia Agricultural Research Institute (OARI) in Shambu for Horro, Amhara Regional Agricultural Research Institute (ARARI) in Menz for Menz sheep and Southern Agricultural Research Institute (SARI) in Bong areas for Bonga sheep. In each project area, there are two sites covering 60 livestock keepers each where participatory approaches are being used to define breeding objectives traits based on communities preferences. The following methods are being employed.

Survey and workshops

A survey was conducted in Horro, Bonga, Menz and Afar areas to identify breeding objectives traits based on communities' preferences. Secondary data were also collected from the respective district offices of agriculture on sheep population. A single stage observation visit was made to each site to confirm the secondary information gathered. Based on the information from the reconnaissance survey, secondary data collected, and observational visits made, communities were identified that keep about 400 breeding ewes in communal grazing areas. In addition, accessibility to market and availability of common grazing lands were considered when selecting the communities. After selecting the communities, a one day workshop for communities and other stakeholders

was organized by ILRI, the respective research centres and district offices of agriculture to introduce the objectives of the project and to learn their willingness. Then a pre-tested semi-structured questionnaire was posed with trained enumerators, who have good educational background in the language the respondents could communicate without difficulty at each area to 120 livestock owners. The enumerators were selected with active participation of community leaders, the staff of the respective district offices of agriculture of each area, site level project managers and MSc students associated to the project. In one of the study sites, technical assistants and a researcher were also involved in the interviewing the target communities.

Each respondent was interviewed about grazing, housing, breeding, and health management practices, flock ownership patterns, feed resources and feeding management, production constraints, socio-cultural, and economic importance of sheep production and preferred traits. Focused group discussions were also conducted with key informants from community members believed to be knowledgeable about the past and present social and economic status of the area. These discussions focused on the breed's history, utility pattern of the breed, current status and major constraints of the breed, special distinguished feature of the breed and so on.

Choice experiment

Based on information from the survey and key informant discussions, six traits for ewes and five traits for rams, were identified for the design of choice cards except for the Afar sheep breed where one additional trait (milk yield) was used for ewes. In addition, only four traits were used for Horro rams (horn[10] not included). Traits identified for ewes body size (big or small), coat colour (red/brown or black), tail type (good or bad), mothering ability (attached to her lamb or not attached), lambing interval (give birth every eight months or every year) and twining rate (twin bearer or singleton). Important traits for the rams body size (big or small), coat colour (red/brown or black), tail type (good or bad), libido (active or passive) and horn (horned or polled). Each of the traits was grouped into two classes "good" or "bad". The trait categories were described to producers using drawings of hypothetical types of sheep and for those traits that couldn't be described using drawings, trade-offs between the different trait categories were described verbally. There was also an option of not choosing any of them.

Own flock ranking by owners

The owner may have particular preferences to the type of animals s/he raises. So the owner was asked at his home what is his/her best favourite ewe? What is good about the animal? After having detailed information from the owner, the following measurements were taken on each individual animal ranked 1st, 2nd, 3rd and worst: body length, chest girth, heart girth, ramp circumference, ramp height, tail length, tail circumference, body condition, ear length, dentition and pelvic width.

Group ranking

To do group ranking, 15 ewes and 15 rams were randomly selected from the communities' flocks at each study site, marked and randomly assigned into five sub-groups. Each sub-group was held in a pen maintained for this purpose for phenotypic ranking. Reshuffling of animals was done randomly three times during the course of the ranking process. A total of 30 livestock owners from each site were moved to the other site for the phenotypic ranking of animals. Each interviewee was asked by an enumerator to rank the animals within each pen according to his/her own preferences and gave the reasons why s/he chose the animals as 1st, 2nd and 3rd. The ranking experiment was done first based on phenotype alone thereafter the interviewee was provided with additional information on each animal in the form of hypothetical history previously collected from the own-

10 Horn is absent in both sexes in Horro sheep breed

ers. The history for ewes included age, live weight, type of birth, number of lambs born, number of lambs weaned, milk yield, growth of lambs and fertility. While age, type of birth, live weight, libido and temperament were described for rams. This was done to learn whether an individual changes his/her mind after s/he has been introduced to the life history of the animals or sticks to his/her previous decisions.

Heritability of traits

Pair-wise ranking technique was employed to select the relatively highly heritable traits using about 120 farmers at each site, except for Menz breed at Mehal Meda and Molale sites where only 60 farmers, were involved at each site due to production objectives differences. Because, in the former site crossbreeding is practiced while in the later site pure breeding using the indigenous Menz breed is practiced. Nine traits (both production and reproduction traits) were used for the exercise. Two traits were randomly selected at a time among the nine traits and were exposed to the farmers to choose the trait that is relatively more heritable. Then the more heritable trait (based on producers' opinion) was compared to all other traits where after the other eight traits were mixed thoroughly and two more traits again randomly selected for comparison and the procedure repeated until each trait was compared with every other trait.

Conclusions

Comprehensive approach towards designing a sustainable community-based breeding programme demands a number of interrelated steps. Among others, participatory definition of breeding objective traits with involvement of all stakeholders is of paramount importance. There are various methods employed in defining breeding objective traits. In our project on designing of breeding strategies for four (Horro, Menz, Bonga and Afar) indigenous sheep breeds in Ethiopia, in addition to extensive literature consultation, we have used four different methods (survey, choice experiment, group ranking and own flock ranking by owners). Literature reports and our own experience point to the fact that a combination of alternative methodologies needs to be applied to capture the actual preferences and target traits of the specific community.

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References

Ahuya, C.O., Okeyo, M.A., Njuru, M. and Peacock. 2005. Development challenges and opportunities in the goat industry: The Kenyan experience. *Small Rumin. Res.*, 60: 197 – 206.

Alpizar, F., F. Carlsson and P. Martinsson, 2001. Using Choice Experiments for Non-Market Valuation. *Economic Issues*, Vol. 8, Part 1.

Amer PR, Mpofu N, Bondoc O. 1998. Definition of breeding objectives for sustainable production systems. Sixth World Congress on Genetics Applied Livestock Production 27, 470–478. .

Ayalew, W., Rischkowsky, B., King, J.M. and Bruns, E. 2003. Crossbreds did not generate more net benefits than indigenous goats in Ethiopian Smallholdings. *Agricultural Systems*, 76: 1137–1156.

Ayantunde, A.A., Kango, M., Hiernaux, P. Udo, H.M.J. and Tabo, R. 2007. Herders' Perceptions on Ruminant Livestock Breeds and Breeding Management in South western Niger. *Hum Ecol*, 35:139–149.

Bebe, B. O., Udo, H. M. J., Rowlands, G. J., and Thorpe, W. (2003). Smallholder Dairy Systems in the Kenya Highlands: Breed Preferences and Breeding Practices. *Livest. Prod. Sci.*, 82: 117–127.

Bernet, T. Ortiz, O. Estrada, R.D. Quiroz, R. and Swinton, S.M. 2001. Tailoring agricultural extension to different production contexts: a user-friendly farm household model to improve decision-making for participatory research. *Agricultural Systems*, 69:183 – 198.

Besley, T. and Case, A. 1993. Modelling technology adoption in developing countries. *American Economic Review*, 83: 396 – 402.

Chambers, R. 1994. Participatory Rural Appraisal (PRA): Analysis of Experience. *World Development*, 22(9):1253-1268.

Donkin, E.F.2005. Sustainable livestock development in Africa: How do we help Africa to feed itself? In: E.F. Donkin (Ed). *Proceedings of the Annual Symposium, Developing Animal Agriculture Interest Group, South African Society for Animal Science, 30th September to 4th October 2002, held at Jan Kempdorp, South Africa,* pp27-38.

Drucker, A. G., Gomez, V. and Anderson. S. 2001. The economic valuation of farm animal genetic resources: a survey of available methods. *Ecological Economics*, 36: 1–18.

Drucker, A.G., 2004. The economics of farm animal genetic resource conservation and sustainable use: why is it important and what have we learned? Background Study Paper Number 21. Commission on genetic resources for food and agriculture. FAO, Rome, Italy.

Kahi, A.K. and G. Nitter. 2004. Developing breeding schemes for pasture based dairy production systems in Kenya. I. Derivation of economic values using profit functions. *Livest. Prod. Sci.*, 88: 161–177.

Kahi, A.K., Rewe, T.O. and Kosgey, I.S. 2005. Sustainable community-based organizations for the genetic improvement of livestock in developing countries. *Outlook on Agriculture*, 34(4):261–270.

Kirsopp-Reed, K. A review of PRA methods for livestock research and Development. PLA Notes CD-ROM 1988–2001.

Köhler-Rollefson, I. 1997. Indigenous Practices of Animal Genetic Resource Management and their Relevance for the Conservation of Domestic Animal Diversity in Developing Countries. *J. Anim. Breed. Genet.*, 114: 231–238.

Köhler-Rollefson, I. 2000. Management of Animal Genetic Diversity at Community Level. GTZ, Eschborn.

Kominakis, A., Nitter, G., Fewson, D. And Rogdakis, E: 1997. Evaluation of the efficiency of alternative selection schemes and breeding objectives in dairy sheep of Greece. *Animal Science*, 64: 453 – 461.

Kosgey I.S., Van Arendonk J.A.M., Baker R.L. 2003. Economic values of traits of meat sheep in medium to high production potential areas of the tropics. *Small Rumin. Res.*, 50, 187–202.

Kosgey, I.S. and Okeyo, A.M. 2007. Genetic improvement of small ruminants in low-input, smallholder production systems: Technical and infrastructural issues. *Small Rumin. Res.*, 70: 76 – 88.

Kosgey, I.S., Baker, R.L., Udo, H.M.J. and Van Arendonk, J.A.M .2006. Successes and failures of small ruminant breeding programmes in the tropics: a review. *Small Rumin. Res.*,61:13–28.

Mbuku, S.M., Kosgey, I.S. and Kahi, A.K. 2006. Identification systems and selection criteria of pastoral gaot keepers in northern Kenya – Implications for a breeding programme. *Tropentag*, October 11 - 13, 2006, University of Bonn, Bonn, Germany.

Moll, H.A.J. 2005. Costs and benefits of livestock systems and the role of market and nonmarket relationships. *Agricultural Economics*. 32(2):181-193.

Moll, H.A.J., Staal, S.J. and Ibrahim, M.N.M. 2007. Smallholder dairy production and markets: A comparison of production systems in Zambia, Kenya and Sri Lanka. *Agricultural systems*. 94: 593 – 603.

Mulatu, E. and Zelleke, H. 2002. Farmers' highland maize (*Zea mays* L.) selection criteria: Implication for maize breeding for the Hararghe highlands of eastern Ethiopia. *Euphytica*, 127: 11 – 30.

Mwacharo, J.M. and Drucker, A. G. 2005. Production objectives and management strategies of livestock-keepers in Southeast Kenya: implications for a breeding programme. Pre-print version of paper submitted to tropical animal health and production. Paper accepted on 20 January 2005

Ndumu, D.B., Baumung, R., Wurzinger, M., Drucker, A.G., Okeyo, A.M., Semambo, D. and Sölkner, J.. 2008. Performance and fitness traits versus phenotypic appearance in the African Ankole Longhorn cattle: A novel approach to identify selection criteria for indigenous breeds. *Lives. Sci*. 113: 234 - 242.

Nielsen, H. M. and Amer, P. R.. 2007. An approach to derive economic weights in breeding objectives using partial profile choice experiments. Animal, 1:9, pp 1254–1262.

OADB. 2001. OADB (Oromia Agricultural Development Bureau), Project proposal on establishment of Horro cattle breeding and improvement center. Livestock Breeding Centers' co-ordination and pastoral development department. January 2001, Finfinne, Ethiopia.

Olesen, I. Groen, A. F. and Gjerde, B. 2000. Definition of animal breeding goals for sustainable production systems. *J. Anim. Sci*. 78:570–582

Ouma, E., Abdulai, A. and Drucker, Adam. 2007. Measuring heterogeneous preferences for cattle traits among cattle-keeping households in East Africa. *Amer. J. Agr. Econ*. 89(4):1005–1019.

Ouma, E., Obare, G., Abdulai, A. and Drucker, A. 2004. Assesment of farmer preferences for cattle traits in smallholder cattle production systems of Kenya and Ethiopia. Proc. Deutscher *Tropentag*, October 5-7, 2004, Berlin, Germany.

Reece, J.D. and Sumberg, J. 2003. More clients, less resources: toward a new conceptual framework for agricultural research in marginal areas. *Technovation*, 23: 409–421.

Rewe, T.O., Indetie, D. Ojango, J.M.K. and Kahi, A.K.2006b. Breeding objectives for the Boran breed in Kenya: Model development and application to pasture-based production systems. *Animal Science Journal*. 77, 163–177.

Rewe, T.O., Indetie, D., Ojango,J.M.K. and Kahi, A.K. 2006a. Economic values for production and functional traits and assessment of their influence on genetic improvement in the Boran cattle in Kenya. *J. Anim. Breed. Genet*., 123: 23–36.

Roessler, R. Drucker A.G., Scarpa, R., Markemann, A., Lemke, U., Thuy, L.T. and Valle Zárate, A. 2007. Using choice experiments to assess smallholder farmers' preferences for pig breeding traits in different production systems in North–West Vietnam. *Ecological economics*, 66 (1): 184 - 192.

Scarpa, R., Ruto, E.S.K., Kristjanson, P., Radeny, M., Drucker, A.G. and J.E.O. Rege.2003. Valuing indigenous cattle breeds in Kenya: an empirical comparison of stated and revealed preference value estimates. *Ecological Economics*, 45: 409-426.

Sölkner, J., Nakimbugwe, H. and Zarate, A.V., 1998. Analysis of determinants for success and failure of village breeding programmes. In: Proceedings of the Sixth World Congress on Genetics Applied to Livestock Production, 11–16 January 1998, Armidale, NSW, Australia, 25, 273–280.

Sumberg, J., Okali, C. and Reece, D. 2003. Agricultural research in the face of diversity, local knowledge and the participation imperative: theoretical considerations. *Agricultural Systems*. 76: 739 – 753.

Tano, K., Kamuanga, M., Faminow, M.D. and Swallow, B. 2003. Using conjoint analysis to estimate farmer's preferences for cattle traits in West Africa. *Ecological Economics*, 45:393-407.

Tesfahun, G. 2008. Economic valuation of the preferred traits of indigenous cattle in Ethiopia. PhD Dissertation, Christian-Albrechts-Universität, Germany.

Tesfahun, G., Wollny, C.B.A., Abdulai, A., Drucker, A.G. and Ayalew, W. 2006. Farmers' Preferences of Phenotypic Traits in Cattle Production and Marketing: A Case Study in Central Ethiopia. *Tropentag*, October 11 - 13, 2006, University of Bonn, Bonn, Germany.

Tibbo, M., Philipsson, J. and Ayalew, W. 2006. Sustainable sheep breeding programmes in the Tropics: a framework for Ethiopia. *Tropentag*, October 11 - 13, 2006, University of Bonn, Bonn, Germany.

Wollny, C.B.A. 2003. The need to conserve farm animal genetic resources in Africa: should policy makers be concerned? *Ecological Economics*. 45: 341-351.

Wurzinger, M., Ndumu, D., Baumung, R., Drucker, A.G., Okeyo, A.M., Semambo, D.K. and Sölkner, J. 2006. Assessing stated preferences through the use of choice experiments: valuing (re)production versus aesthetics in the breeding goals of Ugandan Ankole cattle breeders. 8th World congress on genetics applied to livestock production, August 13-18, 2006, Belo Horizonte, MG, Brazil.

Wurzinger, M., Iñiguez, L., Zaklouta, M., Hilali, M. And Sölkner, J. 2008a. The Syrian Jabali goat and its production system. *Journal of Arid Environments*. 72: 384 – 391.

Wurzinger, M., Willam, A. Delgado, J., Nürnberg, M., Valle Zárate, A., Stemmer, A., Ugarte, G. and Sölkner. 2008b. Design of a village breeding programme for a llama population in the High Andes of Bolivia. *J. Anim. Breed. Genet*. 125: 1- 9.

Potential threats to Farm Animal Genetic Resources (FAnGR) of Ethiopia

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Abstract

Farm Animal Genetic Resources (FAnGR) are essential elements of agricultural production systems in Ethiopia. For millions of poor rural households, FAnGR remain a key asset, often meeting multiple needs, and enabling livelihoods to be built in some of the harshest environments. This valuable livestock genetic diversity, developed over thousands of years provide greater range of options for meeting future challenges, whether associated with environmental change, emerging disease threats, new knowledge of human nutritional requirements, fluctuating market conditions or changing societal needs. However, this asset is undergoing rapid changes stemming from the absence of well defined breeding program, change in ecosystem due to global climate change, massive live animal trade (both legal and illegal), changing livestock production systems and other which tends to disfavor the importance of adaptive farm animal genetic diversity.

Therefore, this resource has to be wisely managed taking into account their importance in the ever-changing ecosystem, emerging disease threats, socio-economic values, cultural and historic reasons and their role in insuring the poor against unpredictable futures.

Key words: *Livestock genetic diversity, global climate change, breeding program and live animal trade*

Introduction

Documented information shows that in 1992 the Second United Nations Conference on Environment and Development in Rio de Janeiro recognized the importance of the diversity in farm animal genetic resources in Agenda 21 and in the Convention of Biological Diversity (Oldenbroek, 2007). This convention raised global awareness for the conservation and sustainable utilization of genetic resources. This led to increased interest and activities in the sustainable utilization and conservation of threatened breeds of livestock (Oldenbroek, 2007). Yet, many traditional livestock breeds are under threat (Lokhit and Ilse, 2005; FAO, 2007). For instance, already 17% of livestock mammals (over 900 of 5330 breeds) are extinct, and another 29% (1500 breeds) are thought to be endangered. However, FAO (2007) indicated that the total number of breed records in the Global Databank has increased greatly. The total number of entries rose from 6379 in December 1999 to 14017 in January 2006 and in the case of mammalian species the number rose from 5330 to 10512. In any case, adaptive FAnGR deserve attention.

Ethiopia is known to be a home for many indigenous livestock species. Central Statistical Authority of Ethiopia (CSA, 2007) showed that Ethiopia posses 43.1 million heads of cattle, 23.6 million heads of sheep, 18.6 million heads of goat, 616,396 million heads of camel, 34.2 million poultry and 6.5 million equines. There are also a variety of breeds/strains/types within each livestock species contributing to the total genetic pool.

Different sources show that there are around 24 cattle breeds (DAGRIS, 2004), 14 sheep strains (Solomon Gizaw, 2008), 9 goat breeds (DAGRIS, 2004), different ecotypes of chicken and non-descript equines in Ethiopia. However, these genetic resources have not been given adequate attention for sustainable utilization at present and generation to come. As a result, various threats are facing Ethiopian livestock sector such as live animal trade, global climate change, crossbreeding,

change in the traditional production systems, priority for single productive traits and physical destruction of their environments.

Historical process of the current Ethiopian cattle breeds

While uncertainty still surround the existence of some domestication centers for some livestock species, the following geographic areas are important primary centers of origin, and therefore diversity of livestock species: the Andean chain of South America (llamas, alpacas, guinea pigs); central America (turkeys, Muscovy ducks); northeast Africa (cattle, donkeys); southwest Asia including the Fertile Crescent (cattle, sheep, goats, pigs); the Indus valley region (cattle, goats, chickens, riverine buffaloes); Southeast Asia (chickens, Bali cattle); east China (pigs, chicken, swamp buffaloes); the Himalayan plateau (yaks); and north Asia (reindeer). Additionally, the southern part of the Arabian Peninsula is thought to be the region of origin of the dromedary, the Bactrian camel may originate from the area that is now the Islamic Republic of Iran, and the horse from the Eurasian steppes (FAO, 2007).

If the domestication process was the major initiating event in the development of today's livestock diversity, the subsequent dispersion and migration of domesticated livestock species across all five continents was equally important (FAO, 2007). This process played a major role in the emergence of the current geographic distribution of livestock diversity. The main factors at the root of the early dispersion of livestock species were the expansion of agriculture, trade and military conquests (FAO, 2007).

Though earliest reports show that the first domestic cattle are migrated from the center of origin (Southern Asia) to Africa, recent findings show that the earliest African cattle (*Bos primigenius* or hamitic longhorn) originated within the continent, possibly as early as around 8000 B.C. The exact center(s) of domestication remain(s) unknown, but archaeological information suggests that it might have taken place in the northeastern part of the continent (Wendorf and Schild, 1994) and they appeared in Egypt in the fifth Millennium as can be depicted from tomb paintings of the Old Kingdom showing humpless longhorns (Epstein, 1971).

These first African cattle initially dispersed north, as well as south to the borders of the tropical rainforest (FAO, 2007) up to the Nile Valley to Sudan and Ethiopia and rock paintings of the second millennium B.C. depicting them in Harar, Ethiopia (Albero and Haile-Mariam, 1982 I and II). Today, the only remaining descendants of these indigenous African taurine cattle are the trypanotolerant West African breeds (e.g. N'Dama and Baoule), the Kuri and the Sheko breed from Ethiopia. All these populations are now being intensively crossbred with Zebu cattle (*Bos indicus*), and their unique genetic make-up is disappearing through unbalanced genetic admixture (FAO, 2007).

Zebu cattle, which are characterized by having a large hump and a large hanging dewlap, arrived in Africa much later than the native African breed. The earliest evidence for the presence of humped cattle is provided by Egyptian tomb paintings dating from the Twelfth Dynasty of the second millennium B.C. (FAO, 2007). It is probable that these animals were brought to Egypt in limited numbers as war treasure and, therefore are not connected to the latter presence of Zebu cattle in Africa. It is however thought that the Zebu was present in small numbers in the eastern part of the continent perhaps as early as 2000 years ago as a result of early Arab contacts or long-distance sea trade and this initial arrival resulted in the first introgression of Zebu genes into African taurine cattle (FAO, 2007) and the result were the Sanga cattle, a name given by Oromo tribe meaning well developed giant horned cattle (Albero and Haile-Mariam, 1982 I and II). From Ethiopia, their place of origin, they spread south.

The second zebu invasion (brachyceros or short-horned), smaller than the previous zebu entered northeast Africa in the fourth century and displaced the Sanga breeds from large areas of Ethiopia (Epstein, 1971). In some Ethiopian regions, they could not completely absorb the Sanga and formed instead intermediate breeds such as Horro and Fogera (Alberro and Haile-Mariam, 1982 I and II). A classification of the Ethiopian cattle based on the above evolutionary process is depicted in Table 1. Certain groups have well-defined characteristics and areas of location so that they are recognized as breeds. Their breed name is mainly derived from their area of origin or tribal owners. Moreover, recent breed survey by ILRI (DAGRIS, 2004) showed that numbers of breeds found in the country are dramatically raised to more than 24 with many more yet to be discovered.

Table 1. Classification of the indigenous cattle breeds of Ethiopia

Major group	Breeds	Areas of location	Main tribal owner	Distinctive features
Humpless	Sheko	Humid southwestern Ethiopia (Bench Maji zone)	Sheke tribe	Traypanotolerant
	Kuri	Illu Aba Bora Region by the Baro River around Djikao district		Traypanotolerant, large sized
Sanga	Danakil (known by common names as Afar and Kereyu)	Found in the semi-desert areas of the large Danakil region and extends along the Awash river from Eastern Shoa to Harar, Eastern Eritrea and adjacent Djibouti	Afar and Oromo,	Survival in harsh and low input environments. Along with the Raya-Azabo and Abigar, the Danakil constitute the only surviving true type Sanga cattle in Ethiopia
	Abigar	Along the Nile Valley in the Sudan and in the adjacent lowlands of southwest Ethiopia, Akobo area	Nuer tribe	Traypanotolerant
	Raya Azabo/Oromo Azabo	Around Lake Ashange in Tigrai and adjoing Wello	Tigre and Amhara	Large sized and long lyre horn, sometimes curved and joined
Intermediate Sanga/zebu	Horro	Horro Guduru in Eastern Welegga and extends up to Western Shoa, Ilu Ababora and SNNP	Mainly Oromo	Mainly red coat color and fine skin
	Fogera	Area around Lake Tana plain in Gojjam and Gonder	Amhara	Large dewlap, resistance to foot rout and good milk production potential
Small east African Zebu	Adwa	Adwa, Central Tigrai	Tigre	?
	Smada	Highlands of south Gonder (Gaint and Smade up to mount Guna)	Amhara	?
	Hammer	South Omo zone, Southern Ethiopia	Hammer tribe	?
	Guraghe	Guraghe and Hadiya highlands	Gurghe and Hadiya tribes	?
	Gofa	Sawla in South Omo, Southern Ethiopia	Goffa	?
	Ogaden zebu	Almost similar to Borana and there is no distinctive features between them	Somali	On-going debate whether it belongs to Borana or large or small east African zebu
	Black zebu (Jem-Jem)	Highland plateau of Sidama	Sidama and to some extent Oromo	Black color occasionally spotted Adapted to high altitude
	Small zebu (Jijjiga)	Similar to Harar and found north of Ogaden desert	Somali	Survival in harsh and low input environments
	Shorthorn (Harar)	Harerghe highland plateau in Eastern Ethiopia	Oromo	Known for their good quality meat
	Highland zeru (Bale)	Bale highlands	Oromo, Sidama	Adapted to wet high altitude

Major group	Breeds	Areas of location	Main tribal owner	Distinctive features
Large east African zebu	Arsi	Arsi region extending up to eastern Shoa and Bale	Oromo	Small and compact body size, aggressive
	Begait	Northern Tigrai (Shire)	Tigre	Very aggressive
	Borana	Borana region of southern Ethiopia extending up to Somalia, Kenya and Tanzania (trans-boundary breed)	Oromo Somali and to some extent in SNNP	Multipurpose animal especially for tender meat
West African Zebu	Fellata (Red Bororro)	Gambella Regional State, Western Ethiopia	Fellata tribesmen	Long-lyre-horned probably derived from Fulani (West Africa) come into the area in search of pasture and water

Abstracted from: DAGRIS (2004), Alberro and Hailemariam (1982 I and II)

The Sheko are believed to be the last remnants of the original Humpless Shorthorn (*Bos taurus*) cattle in eastern Africa. They were first reported in 1929 from southwestern Ethiopia, and later in 1982. At present some of the Sheko manifest small humps that they inherited from zebu introgression.

Threats to FAnGR of Ethiopia

Global climate change: The world's climate is continuing to change at rates that are projected to be unprecedented in recent human history (Thornton et al., 2006). Some reports indicated that the global average surface temperature increased by about 0.6^0 C during the twentieth century, and that most of the warming observed over the last 50 years is attributed to human activities (IPCC, 2001). The IPCC climate model projections for the period between 2001 and 2100 suggest an increase in global average surface temperatures of between 1.4 and 5.8, the range depends largely on the scale of fossil fuel burning within the period and on the different models used.

The impacts of climate change are likely to be considerable in tropical regions (Thornton et al., 2006) and between the early 1970s and the mid 1990s the African Sahel experienced one of the most dramatic long-term changes in climate observed anywhere in the world in the twentieth century, with rainfall declining on average by more than twenty per cent (Hulme et al., 2001). This period of climatic desiccation was associated with a number of very severe droughts, most notably in the early 1970s and 1980s, during which hundreds of thousands of people and millions of animals died (Glantz, 1976, 1996).

Figure 1. The impact of climate change on FAnGR in pastoral areas (Picture from Pastoralist Forum Ethiopia)

Overall, crop yields may fall by 10 to 20% by the year 2050 because of warming and drying, but there are places where yield losses may be much more severe (Jones and Thornton, 2003). Developing countries are generally considered more vulnerable to the effects of climate change than more developed countries, largely attributed to a low capacity to adapt in developing world (Thomas and Twyman, 2005) and of the developing countries, many in Africa are seen as being the most vulnerable to climate variability and change (Slingo et al., 2005).

Ethiopia is one of the most vulnerable countries to global climate change. Pastoral and agro-pastoral areas, which are found below 1500m elevations comprises 61-65% of the countries land (Biruk and Tafesse, 2000). The population of these area are estimated at 7.7 million (13% of the total population) and carry about 28% of the cattle, 66% of the goats, 26% of the sheep and almost all the camels (Biruk and Tafesse, 2000). With close link to global climate change, Ethiopia suffered three major droughts between 1980-81 and 1999-2000 and during this time, the Borana pastoralist alone in southern Ethiopia lost 35 to 67% of their livestock (Biruk and Tafesse, 2000) (see Figure 1 above). Thus, global climate change is one of the main driving forces to the lose of the reservoir of cattle genetic resources of Ethiopia.

Live animal trades: Export of live animals to the Middle East market, especially Saudi Arabia, has been an important source of foreign exchange for Ethiopia. Many other developed countries like Australia and New Zealand are also exporting live animals to the open Middle East market. Mohammed et al. (2007) indicated that other countries are taking an increasingly large share of the market over Ethiopia. However, developed countries like Australia and New Zealand and Latin American countries (e.g. Argentina) have well developed breeding program for export market. Export in these countries come from central beef ranches/stations exclusively set up for export purpose, with special focus on replacement stock.

The situation in Ethiopia is different for three reasons: First, there is no well-defined breeding program set up for beef production. Second, animals from individual households are brought to the local markets, purchased and trekked from local market to principal domestic consumption centers, processing centers and export outlets indiscriminately without considering their breed and risk status. Third, live animal export is mainly focused on few breeds, which command premium prices (e.g. Borana) though now it becomes indiscriminate. Strategies that ensure sustainable supply are almost non-existent.

According to a study conducted by Mohammed et al. (2007), live animals are exported via three main routes-via Somalia, Somaliland and Djibouti to the Gulf States, the southern border to Kenya and the northwestern border to Sudan. The study showed that accurate and complete statistics on the volume of official export of live animals and meat are rather difficult to get mainly because separate records of such data are not maintained. However, studies show that in 2005–06, 163,380 animals (75% of which were cattle) were officially exported to Egypt, Yemen, the United Arab Emirates (UAE) and Saudi Arabia (Mohammed et al., 2007). In the same period, 8000 t of meat (primarily shoat carcasses) worth USD 18.5 million was exported to Saudi Arabia, UAE and Egypt by airfreight (Mohammed et al., 2007).

Though there is no consistent figure on the number of live animals exported through informal trade, Mohammed et al. (2007) Quoting MEDaC (1998) reported unofficial export of 260 000 cattle and 1.2 million sheep and goats in 2001. Somali ports (Berbera and Bosasso) were reported to be the main unofficial export ports of live animals in Eastern Ethiopia.

The second largest source of cross-border trade of livestock (mainly cattle) occurs through the southeastern Ethiopia/southwestern Somalia/northeastern Kenya triangle (Mohammed et al. (2007)). Mohammed et al. (2007) quoting Shank (1997), Ahrens (1998) and Nin Pratt et al. (2005) reported that about 28 thousand cattle and 145 thousand sheep and goats crossed the border to Kenya from the Somali region of Ethiopia in the mid 1990s. A Kenya Government estimate

showed that the proportion of Kenyan beef output derived from animals coming from cross-border trade has been increasing in recent years and reached about 26% of beef output in 2000 (Mohammed et al. (2007).

More recently, cross-border trade of only cattle has been taking place through the northwestern border with Sudan. Exports have been taking place through five important outlets or posts located along the Sudan–Amhara border (Mohammed et al. (2007). These are: Metema Yohannes, Shinfa-Tiha, Berkete Nur, Abrehajira and Abdurafi export points. Official export takes place through the Metema Yohannes quarantine post and the other points are used only for unofficial trade. Mainly bulls and steers from North Gondar lowlands and other nearby areas are exported, eventually reaching large urban markets in Sudan including Khartoum. Importers buy cattle in bulk and take them for slaughter in slaughterhouses and processing plants in Khartoum or re-export them through Port Sudan to Egypt or elsewhere (Mohammed et al. (2007). Many more illegal exports are foreseeable through other uncovered corridors. If live animal export is not properly designed and focus is not given to replacement stock, there is no doubt that indiscriminate live animal export poses negative effect on FAnGR of Ethiopia. An independent study has to be conducted to evaluate off taking rate for export and replacement rate to ensure sustainable supply.

Crossbreeding: Associated with the drivers of change, indigenous genetic resources are undergoing replacement by a narrow range of high performing animal breeds. Moreover, crossbreeding local cattle with exotic breeds is one of the development interventions promoted for increased output. However, crossbreeding, if not properly designed, becomes a major threat to FAnGR. Replacement by exotic breeds or extensive crossbreeding result in faster growth rate, high milk production potential, but at the expense of constant flow of high quality feed, health care and improved management. Moreover, it eliminates most of the diversity from breeds and creates uniformity, which is risky. It should be noted that livestock keeping is also an important element in the livelihoods of many small-scale producers and enabling poorer livestock keepers to improve their livelihoods remains an important objective. Sustainable patterns of utilization must be established. Any development interventions should not ignore their role or neglect their needs. Equitable arrangements for benefit sharing are needed and broad access to genetic diversity must be insured. Therefore, though genetic improvement for increased milk and meat output is inevitable, such development interventions should operate within crossbreeding policy framework without affecting genetic diversity. To bring a genetic gain, it is well accepted that local animals must be safeguarded to maintain its purity, records must be kept to evaluate best animal and highly productive cows should not be crossbred with exotic breeds. In Ethiopia such precaution are not in place and crossbreeding is non-systematic and uncoordinated. With the present increasing trend for high-out animals, unorganized crossbreeding program and absence of crossbreeding policies would put a threat to FAnGR of Ethiopia in the future.

Agricultural intensification and land shrinkage: Changes in cropping patterns are a major factor leading to the elimination of diversity of indigenous farm animals (Sadri and Rajasthan, 2005). Land holding and cropping pattern is rapidly changing in the central highlands of Ethiopia. Grazing lands are gradually shifting towards cropping fields and land holdings are reduced. This resulted in shrinking of grazing lands and the switch to certain cash crops such as chat (*chata edulis*) in Hararghe highlands of Eastern Ethiopia and to cereal crops in the central highlands. Reduction in grazing lands will force livestock keepers to reduce their livestock number and consequently loss of farm animal genetic diversity.

Changes in demand*:* Consumption of meat and milk worldwide has been rapidly growing since the early 1980s and developing countries have accounted for a large share of this increase (FAO, 2007). The study showed that between 1980s and the late 1990s, total meat and milk consumption in the developing world grew at 6 and 4 percent *per annum*, respectively (Figure 2). In 1980, the human population of developing countries made up three-quarters of the world's population,

and consumed one-third of the world's meat and milk (FAO, 2007). It is estimated that by 2030, developing countries may account for 85 percent of the world's population and two-thirds of direct consumption of meat and milk. Increasing demand strongly stimulates production. For the 1999-2001 to 2030 period, FAO (2006a) estimates that production growth rates will be 2.4 percent *per annum* for both meat and milk, in developing countries; while the growth rates for the whole world will be 1.7 percent for meat and 1.4 percent for milk (Table 2 and 3). This surging demand tends to prioritize use of high-yielding dairy and beef breeds, which in turn puts increasing pressure on low producing local breeds.

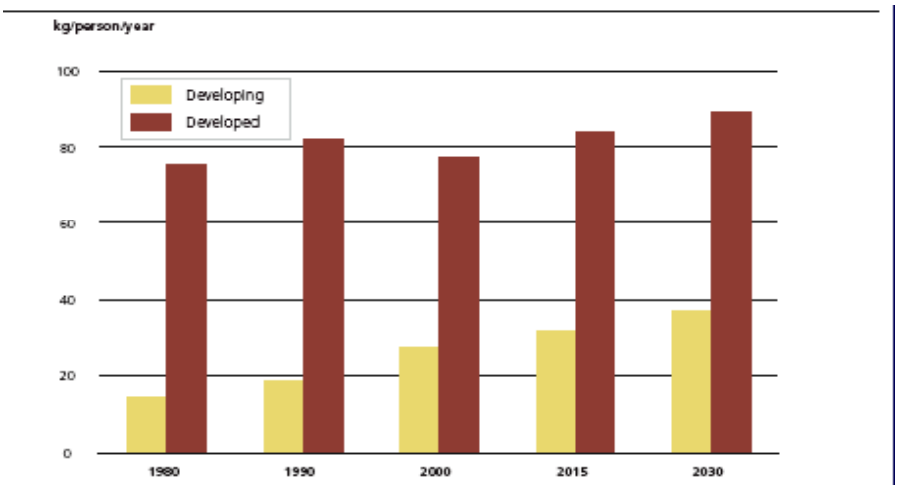

Figure 2. Changes in the meat consumption of developing and developed countries

Sources: Adapted from 1980, 1990 and 2000 figures from FAOSTAT; 2015 and 2030 figures from FAO (2002a)

Therefore, precaution has to be made to ensure sustainability of domestic animal diversity.

Table 2. Projected trend in meat consumption from 2000 to 2050

Region	Production			Consumption per capital		
	1999-2001	Growth rate 1999-2001 to 2030	Growth rate 2030 to 2050	1999-2001	Growth rate 1999-2001 to 2030	Growth rate 2030 to 2050
	[1000 tones p.a.]	[% p.a.]	[% p.a.]	[kg p.a.]	[% p.a.]	[% p.a.]
Sub-Saharan Africa	5564	3.3	2.8	9.5	1.2	1.4
Near East/North Africa	7382	3.3	2.1	21.9	1.6	1.1
Latin America and the Caribbean	31608	2.2	1.1	59.5	0.9	0.7
South Asia	7662	3.9	2.5	5.5	2.7	1.9
East Asia	73251	2.1	0.9	39.8	1.5	0.9
Developing world	125466	2.4	1.3	26.7	1.2	0.7
World	229713	1.7	1.0	37.6	0.7	0.5

Sources: Adapted from FAO (2006a)

Table 3. Projected trend in milk consumption from 2000 to 2050

Region	Production			Consumption per capital		
	1999-2001	Growth rate 1999-2001 to 2030	Growth rate 2030 to 2050	1999-2001	Growth rate 1999-2001 to 2030	Growth rate 2030 to 2050
	[1000 tones p.a.]	[% p.a.]	[% p.a.]	[kg p.a.]	[% p.a.]	[% p.a.]
Sub-Saharan Africa	16722	2.6	2.1	30.6	0.5	0.6
Near East/North Africa	29278	2.3	1.5	88.5	0.6	0.6
Latin America and the Caribbean	58203	1.9	1	122.4	0.7	0.5
South Asia	109533	2.8	1.5	82.3	1.5	0.9
East Asia	17652	3	0.6	13.1	2.1	0.7
Developing world	231385	2.5	1.4	53.1	1.3	0.7
World	577494	1.4	0.9	94.2	0.4	0.4

Sources: Adapted from FAO (2006a)

Other factors: Other factors that stimulate use of narrow range of high-performing dairy and beef breeds include increasing purchasing power, rural to urban demographic changes (urbanization) and consumer-shifting preferences towards value added foods of animal origin. Moreover, newly emerging diseases, natural disasters and physical destruction of the environment are expected to pose catastrophic effects on indigenous animal genetic diversity.

Conclusion

Ethiopia is a home for many diverse animal genetic resources. These diverse resources play vital role and are essential component of agricultural production systems in varying agro-ecologies. They deliver a wide range of products and services to the local community, serve as insurance against future changes in loss of resources, maintain socio-economic and cultural aspects and contribute to meeting future market demands. Despite their massive contribution, these resources are under threat emerging from various sources. Change in ecosystem such as loss of water, feed and forage resulting from climate change, development and commercialization of few breeds/lines due to their perceived economic competitiveness, rapid shrinkage of grazing lands and other factors associate with indiscriminate and illegal live animal export is expected to increase the risk of the threat. Until standardized structures of slaughterhouse will be built, exporting live animal as a means of foreign currency earning export is inevitable, but policy makers should design ways to ensure sustainable supply without affecting the existing domestic genetic diversity.

References

Biruk, Y. and Tafesa, M. 2000. Pastoralism and Agro-pastoralism: Past and Present. *In*: Proc. of 8th Annual Conference of the Ethiopian Society of Animal Production (ESAP). Ethiopian Institute of Agricultural Research. 24-26 August, 2000.Addis Ababa, Ethiopia.

CSA (Central Statistical Authority). 2007. Statistical Report on Farm Management Practices, Livestock and Farm Implements. Part II. CSA, Addis Ababa, Ethiopia.

DAGRIS 2004. Domestic Animal Genetic Resources Information System (DAGRIS). (eds. J.E.O. Rege, W. Ayalew and E. Getahun). International Livestock Research Institute, Addis Ababa, Ethiopia.

Epstein, F. 1971. The origin of the domesticated animals of Africa. 1: Cattle. New York, Africana.

FAO. 2007. The State of the World's Animal Genetic Resources for Food and Agriculture, edited by Barbare Rischkowsky and Dafydd Pilling. Rome.

FAO. 2006a. A review of environmental effects on animal genetic resources, by S. Anderson. Rome.

Glantz, M. 1996. Drought follows the Plough: Cultivating marginal areas. In Ribot et al. (eds), Climate Variability, Climate Change and Social Vulnerability in the Semi-arid Tropics, Cambridge University Press, pp 125-128.

Glantz, M. (Ed.) 1976. The Politics of Natural Disaster. Praeger Publishers.

Hulme, M., Doherty, R., Ngara, T., New, M. and Lister, D. 2001. African climate change:

1900-2100. Climate Research 17, 145-168.

IPCC, 2001. "Human Health", McMicheal, A.J., and Githeko, A., in McCarthy, j., Canziani, O.F., Leary, N.A., Dokken, D.J., AND White, K.S., (eds). Climate Change 2001, Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Third Assessment report of the Intergovernmental Panel on Climate Change, Cambridge: Cambridge University Press.

Jones, P.G. and Thornton, P.K. 2003. The potential impacts of climate change in tropical agriculture: the case of maize in Africa and Latin America in 2055. Global Environmental Change 13, 51-59.

Lokhit P. P. S. and Ilse K.R. 2005. Indigenous Breeds, Local Communities, Rajasthan, India.

M. Alberro and S. Haile-Mariam. 1982. Part I. The indigenous cattle of Ethiopia. World Animal Review. No. 41. Rome.

M. Alberro and S. Haile-Mariam. 1982. Part II. The indigenous cattle of Ethiopia. World Animal Review. No. 41. Rome.

Mohammad Jabbar, Asfaw Negassa and Taye Gidyelew. 2007. *Geographic distribution of cattle and shoats populations and their market supply sheds in Ethiopia.* Discussion Paper No. 2. Improving Market Opportunities. ILRI (International Livestock Research Institute), Nairobi, Kenya. 54 pp.

Slingo J.M., Challinor A. J., Hiskins B.J. and Wheeler T.R. 2005. Introduction: food crops in a changing climate. Philosophical Trasactions of the Royal Societ, Series B 360, 1983-1989.

Thomas D S G and Twyman. 2005. Equity and justice in climate change adaptation amongst natural-resource-dependent societies. Global Environmental Change 15, 115-124.

Thornton, P.K., Kruska, R.L., Henninger, N., Kristjanson, P.M., Reid, R.S, Atieno, F., Odero, A.N. & Ndegwa, T. 2002. *Mapping poverty and livestock in the developing world.* Nairobi. International Livestock Research Institute.

Utilization and Conservation of farm animal genetic resources. 2007. (ed.) Kor Oldenbroack, Wageningen Academic Publishers, The Netherlands.

Wendorf, F. and Schild, R. 1994. Are the early Holecene cattle in the Eastern Sahara domestic or wild? Evolutionary Anthropology, 3: 118-128

Sheep breeding practices and trait preferences in the smallholder and pastoral production systems of Ethiopia

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Abstract

This study aimed at understanding of existing sheep breeding practices and identifying sheep breeding goals of smallholder and pastoral sheep breeders as a step towards developing sustainable sheep breeding strategies. The survey revealed that the mean sheep flock size was 31.5 in Menz and 23.0 in Afar area. Nearly half of the pastoralists and one-fifth of smallholder farmers had no breeding ram. The survey revealed the predominance of uncontrolled mating; small flock size and less proportion of breeding male (especially in Afar sheep). Higher chance of mixing sheep flocks was reported in most of the seasons. When flocks are mixed, the inbreeding coefficient could be reduced by 86% in Menz and 78% in Afar sheep flocks. Castration of breeding ram was practiced at the age of 1.7 and 1.5 years for Menz and Afar sheep, respectively. Conformation was the most important trait in choosing of breeding ram for both Menz and Afar sheep owners. Lambing interval and mothering ability in both crop-livestock and pastoral systems; and milk yield in pastoral system were important traits for the choice of breeding ewes. The purpose of keeping sheep in Menz area was to generate income followed by meat, manure, coarse wool and as means of saving, in that order. For Afar milk production, meat consumption and to generate income are the purposes for keeping sheep. Based on the reasons for keeping sheep, the main breeding goal for Menz sheep has been defined as increasing meat production (improve growth rate and conformation), and fleece yield. For Afar sheep, increasing milk yield and meat production is the main breeding goal. It was concluded that genetic improvement programmes targeting smallholder farmers in mixed crop-livestock and pastoralists in the pastoral production system need to incorporate existing traditional herding and breeding practices, trait preference of farmers/pastoralist, multipurpose role of sheep and other foregoing issues

Keywords: Breeding practice; Indigenous selection criteria; Menz sheep; Afar sheep; Community-based

Introduction

Sheep are able to adapt to a broad range of environments and are found in all agro-ecologies of Africa (Rege, 1994). Ethiopia is home for an estimated 25 million (CSA, 2007) sheep and about 14 traditional sheep breeds (Solomon *et al.,* 2007). Their multipurpose role as source of income, meat, skin, manure and coarse wool or long hairy fleece, means of risk avoidance during crop failure and their cultural function during festivals are well documented (Abebe, 1999; Jaitner *et al.,* 2001; Kosgey *et al.,* 2008). This makes them suited to the low input smallholder and pastoral production system. Despite low level of productivity due to several technical (genotype, feeding and animal health), institutional, environmental and infrastructural constraints (Tibbo, 2006) indigenous sheep breed has a great potential to contribute more to the livelihood of people in low input, smallholder and pastoral production system (Kosgey and Okeyo, 2007). It is very urgent to boost low productivity in order to satisfy the large population of the country estimated at 79.2 million in July 2007 with an annual growth rate of 2.5% (CSA, 2007). Unfortunately, attempts to improve

small ruminants in the tropics so far faced several constraints mainly due to weak planning, poor involvement of livestock owners and implementing livestock improvement programmes without taking into consideration all the needs of farmers (Sölkner, 1998; Tibbo, *et al.,* 2006; Kosgey *et al.,* 2006). There is, therefore, need for a new thinking and developing breeding programs with the consultation and involvement of all stakeholders from the planning to implementation. One such approach is a community based breeding programme proposed by Sölkner *et al.* (1998). This community based approach is being tried in quite few places; genetic improvement of the quality of fleece of Chiapas sheep in southern Mexico through the utilization of the indigenous Tzotzil selection criteria (Perezgrovas, 1995; Castro-G´amez *et al.,* 2008) and in Uganda, identification of the objectives of Ankole cattle breed has been practiced with the community (Ndumu *et al.,* 2008). The International Livestock Research Institute (ILRI) jointly with the University of Natural Resource and Applied Sciences (BOKU), International Centre for Agricultural Research in the Dry Areas (ICARDA) and national Agricultural Research Systems in Ethiopia is designing community-based sheep breeding strategies for some Ethiopian sheep breeds including Menz and Afar sheep breeds. To design a community based breeding strategy, detailed information on the breed and production system need to be available. Unfortunately, information available on Ethiopian sheep breeds is scanty (Workneh *et al.,* 2004) and available information so far have been based on on-station managed flocks and numerical measurements. Looking at a breed from this perspective only does not consider the keepers priorities (Kosgey, 2004) so that assessing the production system, indigenous knowledge of managing the breed, identifying list of important traits for selection with full participation of farmers are prerequisite to set up genetic improvement at smallholder and pastoral level (Sölkner *et al.,* 1998; Kosgey *et al.,* 2006; Tibbo, 2006). Thus, this study was aimed at assessing traditional sheep breeding practices, herding system and identifying trait preference of smallholder farmers and pastorals in Menz and Afar area.

Materials and methods

Description of the study area

The survey was conducted in the cool highlands (Menz) and arid and semi-arid lowlands (Afar) of Ethiopia, representing mixed crop-livestock and pastoral production systems, respectively. In Menz area the survey included two woredas (districts) namely, Menz Gera and Menz Mamma. The study area is located at an altitude above 2800 meters above sea level and about 280 km north of Addis Ababa. This area is characterized by bi-modal rainfall with long rainy season (June to September) and erratic and unreliable short rainy season (February to March). Based on the meteorological data obtained from Debre Berhan Research Centre for the years 1985 to 2004, the annual rainfall at Mehal Meda town (the capital of the Menz Gera woreda) is about 900 mm and the minimum and maximum average temperatures are 6.8 °C and 17.6 °C, respectively. The area is intensively cultivated. In Afar area the survey was conducted in Amibara woreda, part of the zone 3 of the Afar regional state. The study was conducted at altitude ranges from 750 to 812 m above sea level and located between 240 km to 300 km east of Addis Ababa on the way to Djibouti. Based on the meteorological data from Werer Research Centre for the years 1965 to 2006 the annual rainfall was 588 mm and average daily temperature was about 27.6 °C with a maximum approaching 38 °C in June and a minimum of 15.4 °C in November. Crop cultivation is rarely practiced in some areas along the Awash River.

Selection of the study sites

Menz Mamma and Menz Gera woredas for Menz sheep and Amibara woreda for Afar sheep community-based breeding program were selected using a rapid survey conducted by a team of researchers from Debre Berhan (in Menz area) and Melka Worer (in Afar area) Agricultural Research Centers. Then after specific study site one in each of Menz Mamma and Menz Gera and 3 in Amibara woreda were selected with the assistance of the respective area woreda Agricultural

office professionals. Study sites were selected purposely based on their suitability for sheep production, influence of crossbreeding, market and road access and willingness of the farmers or pastoralists to participate on the program. A total of 228 households (120 in Menz and 108 households Afar area) were sampled from the selected site and the surrounding kebele households having similar production system.

Data collection and analysis

Data were generated by administrating a structured questionnaire to the randomly selected household head or representative by a team of enumerators recruited and trained for the purpose with close supervision of the researcher. The questionnaire was designed to obtain information on general household information, sheep flock size and structure, herding and breeding practices, selection criteria of breeding rams and ewes and purpose of keeping sheep. Data collected through questionnaire were entered into Statistical Package for Social Sciences (SPSS 13.0 for window, release 13.0, 2004). The same statistical package was used to summarize the data and results are presented mainly in the form of descriptive tabular summaries for the two farming systems. Chi-square or t-test was employed when required to test the independence of categories or to assess the statistical significance. Indices were calculated to provide ranking of the reasons of keeping sheep and calculated as Index = Sum of (3 for rank 1 + 2 for rank 2 + 1 for rank 3) given for an individual reason divided by the sum of (3 for rank 1 + 2 for rank 2 + 1 for rank 3) for overall reasons. The effective population size for a randomly mated population was calculated as $N_e = (4N_m N_f) / (N_m + N_f)$ (Falconer and Mackay, 1996). Where, N_e = effective population size, N_m = number of breeding males and Nf = number of breeding females. The rate of inbreeding coefficient (ΔF) was calculated from Ne as $\Delta F = 1/2N_e$.

Results and Discussion

General household information

Mixed crop-livestock production was the predominant practice in Menz area. Average land holding of farmers in Menz area was 1.1 hectare of which 0.3 hectare is for grazing land indicating that only a quarter of the land was used for grazing. Out of the total crop land about 64% was used for main season cropping and the remaining 36% was used for short rain cropping. Wheat, bean, barley, pea, lentil, grass pea, chick pea and rarely flax and fenugreek. Wheat, bean and barley were cultivated in Menz area. Among these crops wheat, bean and barley were the major crops during the main rainy season in their order. While during the short rainy season barley was the predominant crop followed by wheat and lentil. Sheep are the predominant species of livestock that accounted for 84.81% of the total population owned followed by cattle (9.85%). Pastoralists in Afar area depend almost entirely on livestock as means of income and food source for the family except for some pastoralists (37%) who reported that they cultivated some crop mainly cotton and vegetables along the Awash River. Among the livestock species goat, sheep, cattle and camel in that order contributed for food and income generation. The survey revealed that the majority of the households in both production systems were headed by males which accounted for 89.2% in crop-livestock (Menz) and 92.6% in pastoral production system (Afar). About 35.9% of household heads in Menz were literate (grade 4-10), 30.8% were able to read and write either from religious school or from adult education and the remaining 33.3% of the smallholder farmers in Menz area were illiterate. The majority (97.2%) of the household heads in Afar was illiterate, 1.9% of them were able to read and write and the remaining few proportions (0.9%) were literate. Thus, better educational background obtained in Menz smallholder farmers might be a good potential for adoption of improved technologies and facilitate performance and pedigree recording (Holst, 1999; Kosgey and Okeyo 2007). It is also mandatory to consider upgrading of the education status of pastoralists for the successfulness of sheep breeding strategies and other development interventions.

Sheep flock structure

Flock size and structure of Menz and Afar sheep breeds are indicated in Table 1. The average flock size of sheep per household was 31.5 (range of 7 to 69) in Menz and 23.0 (range of 5 to 80) in Afar pastoral system. The breeding ewes take a major portion (46.8%) in Menz followed by lambs (19.2%) and ewe lambs (14.3%). Similarly breeding ewes were also predominant in Afar pastoral system which accounted 49.2% followed by lambs (23.6) and ewe lambs (18.1). Larger proportion of breeding ewe obtained in this study was comparable with previous results reported ranging from 41.4% to 49% for Menz sheep (Agyemang *et al.,* 1985; Niftalem, 1990; Abebe, 1999). Flock size obtained in this study for Menz is higher than the results obtained for Kenyan smallholders while the flock size of Afar pastoralist was lower than the Kenyan pastoral/extensive farmers (Kosgey *et al.,* 2008). Many reports on sheep flock size other than the two extreme environments (cool highland and arid lowland) of the country are in a range from 2.9 to 9.6 (Solomon *et al.,* 2005; Takele, 2005; Solomon, 2007; Tsedeke, 2007; Mengistie, 2008). In the lowlands, larger flock size of 16.0 for Gumuz sheep and (19.2) for Blackhead Somali sheep were reported (Solomon, 2007; Fekerte, 2008) was reported. Similarly larger flock size of 24 was reported for Menz sheep in the cool highlands of Ethiopian (Abebe, 1999). The result obtained in this study and previous reports on sheep flock size showed that sheep flock size gets higher when we go to the cool highlands and the lower arid areas from the mid altitude areas. This might be due to the highly degraded areas which could not support crop production as well as large ruminants like cattle (Rancourt, 2006; Tibbo, 2006). Relatively the larger sheep flock size than other parts of the country obtained in this study indicated that the area favours sheep (Tibbo, 2006) and shows higher dependency of farmers/pastoralist on sheep (Verbeek *et al.,* 2007) implying the higher chance of success and acceptance of village level sheep breeding strategy if planned carefully.

Table 1. Flock size and structure of Menz (N = 74) and Afar (N = 68) sheep flock

Class of sheep*	Menz		Afar	
	Mean (SD')	%	Mean (SD')	%
Lambs	6.3 (4.22)	19.90	5.43 (4.70)	23.62
Ram lambs	3.0 (2.04)	9.48	1.25 (0.86)	5.43
Ewe lambs	4.49 (2.81)	14.25	4.17 (4.00)	18.12
Breeding ram	1.78 (1.24)	5.65	0.65 (0.82)	2.83
Breeding ewe	14.74 (8.56)	46.80	11.32 (7.84)	49.20
Castrates	1.24 (1.32)	3.92	0.18 (0.60)	0.80
Total sheep	31.45(15.15)		23.00(16.50)	
All livestock	37.09		96.22	

* Class of Sheep: Lamb = Both sexes below 6 months age, Ram lamb = Male >6 and < 12 months, Ewe lamb = Female >6 and < 12 months, Breeding ram = Ram above 12 months and Breeding Ewe = Female above 12 months. 'SD = Standard deviation.

Herding practices

In both smallholder farmer and pastoral systems each sheep flock of a household had their own herder. As usually children herd animals and might not take their task very serious there is a high possibility of mixing with other adjacent sheep flocks within a village. Table 2 shows the percentage of households mixing their sheep flock with other flocks in mixed crop-livestock and pastoral production systems. In Menz area, at the beginning of the main rainy season usually on the 12th July locally known as *'Hamle Abo',* animals are restricted to graze on private pasture land till the grown pasture is grazed or harvested by the landholder. In this area, during the rainy season sheep of the surrounding farmers graze on communal uplands known locally as *'serege'*. This land could be stony and locally known as *'korakor'* and/or having very shallow soil depth locally known as *'set lib'*. During this rainy season 62.5% of the sheep owners stated that their sheep flock had a possibility of mixing with 6.8 flocks of sheep. Immediately after the rainy season (September to November) and during crop harvesting time (November to January) more than 85%

of the smallholder farmers in Menz area herd their sheep on their private land in order to exploit natural pasture grown by the rain and crop aftermath. After the crop aftermath was picked from the cultivated land, sheep are free to graze everywhere and nearly 82% of smallholder farmers in Menz area stated that their sheep flock had a possibility of mixing on average with 8.4 sheep flocks within the village.

Mobility is practiced by the entire interviewed pastoralists in search of feed and water for their animals. Mobility time, place and which species of livestock to move were determined by tribe leaders after careful assessment of the new area. Pastoralists settled in a village were usually relatives lived and they moved and settled together at the new place. In Afar pastoral system, grazing land is used communally throughout the year. During the rainy season, animals graze on the uplands and 64.8% of the pastoralist stated that their flocks had a possibility of mixing on average with 4.5 flocks. After cotton harvesting time, pastoralists migrate with their animals to pick the aftermath. They stay there till the cotton aftermath is completed, which is usually up to the end of January. Then large animals (cattle and camel) are moved to the Hallidegi plain (a vast grassland) while small ruminants move near the Awash river to feed on pods and leaves of trees till short rainy season, locally known as *'Sugum'*. If '*Sugum'* comes small ruminant are moved to the Hallidegi plain and stay there till the main rain *'Kerma'* comes. During the dry season, only 33.6% of the pastoralists reported that their sheep flock mix with others flocks. During '*Kerma'* all animals are again moved to the upland wet season grazing land.

Table 2. Percentage of households mixing their sheep flock with other flock in mixed crop-livestock and pastoral production systems

Grazing season	Mixed crop-livestock		Pastoral	
	N	%	N	%
During the rainy season	119	62.5	105	64.8
After the rainy season	120	14.7	-	-
During crop harvesting time	119	11.8	-	-
Dry season after crop aftermath picked up	120	81.7	107	33.6

Breeding practices

Breeding was generally uncontrolled in both (Menz and Afar) areas, except only to some extent in Afar area. The majority of the Afar sheep owners reported that they try to avoid dry season lambing (86%) and indiscriminate mating (11.1%). Methods like ram isolation, castration and tying of a cord around the neck of the scrotum and looped over the prepuce to prevent extrusion of the penis of the ram (Figure 1) were used to control mating in Afar. Menz and Afar rams were castrated at age of 1.7±0.06 and 1.5±0.06 years, respectively. Out of all Menz sheep owners 20.6% had no breeding ram, 17.6% owned one ram and 61.8% owned more than one breeding ram with average of 1.8 breeding ram per flock. Whereas 51.7% of Afar sheep breeders did not had breeding ram, 36.7% owned one ram and 11.6% had more than one breeding ram with average of 0.65 breeding ram per flock of a household. Sheep breeders without a breeding ram indicated that they use neighbouring ram or their ewes mated with breeding ram from other flock in communal grazing land. Major reasons for keeping more than one ram within a flock were for the purpose of fattening and sale (80%), due to large flock size (20%) for Menz sheep breeders and due to large flock size (57.3%) and for the purpose of sale (26.3%) for Afar sheep. The majority of the breeding rams (90%) in Menz were born in the flock and 7.1% were purchased from the market. In Afar area all the breeding rams were originated from within the flock. The ratio of breeding ram to ewe was 1:8.3 in Menz and 1:17.4 in Afar sheep flocks. The value obtained for Menz sheep was comparable with the previous report by Abebe (1999) for Menz sheep and Solomon (2007) for Gumuz sheep. About 62.5% of the interviewed smallholder farmers in Menz area and 77.4% of pastoralist in Afar area stated that they were able to identify the sire of the lamb by relating lamb with the colour and ap-

pearance/conformation of rams. Majority of the smallholder farmers (68%) and pastoralists (89%) were not aware about the disadvantage of inbreeding. In both areas castration of ram age of about 1.7 years might help to avoid/reduce the very intense form of inbreeding (sire-daughter mating). Castration and fattening practices by Afar pastoralists is not as common as for Menz farmers. In Afar, they tend to sell more male sheep at their early age. Because of this a severe ram shortage was observed (lower male to female ratio).

Absences of breeding rams in many of the sheep flocks affect the biological and financial performances of the flock (Galal *et al.,* 1996). As has been alluded to, reason for low proportion of breeding rams in Afar pastoral system as stated by pastoralists was due to the sale of males before breeding age. The reason for selling males early was because of their social regulation that considers male sheep as the property of the tribe so that when anybody from that tribe has an economic problem he has the right to pick up and sale any male sheep (except marked as breeding ram) from any flock within his tribe. In addition to inbreeding, sale of ram lambs at early age might result in negative selection as rams having good quality/fast growing male could be sold for slaughter as they reach market weight faster than others (slow growers). In contrary to this many farmers in Menz area had surplus ram in their flock and this might hamper selection. Thus, larger effort should be put on the selection and identification of breeding ram before market age to increase the proportion of breeding male in pastoral system and demonstration of early age finishing technologies and method of controlling unwanted mating using methods like wearing of apron (a flat piece of leather or plastic) just behind the front legs or tying of the penis to the base of the scrotum to prevent mating in Menz area.

Figure 1. A mature Afar breeding ram whose penis is tied to the base of the scrotum to prevent mating

The observed male to female ratio of 1:8.3 in Menz and 1:17.4 in Afar sheep flocks may be sufficient if we consider only the capacity of males to mate. But as revealed in this study utilization of breeding ram/s born within the flock, uncontrolled mating, and lack of awareness about inbreeding together with less male to female ratio may lead to accumulation of inbreeding and decreased genetic diversity (Falconer and MacKay, 1996; Jaitner *et al.,* 2001; Kosgey, 2004). However, communal herding practiced by most sheep owners in both production systems allows breeding females to mix with males from other flock and this can minimize the risk of inbreeding (Jaitner *et al.,* 2001) by increasing the effective population size.

The Ne and ΔF calculated for Menz and Afar sheep flock considering the existing flock size and practice are indicated in Table 3. Under random mating and when sheep flock of a household are closed effective population size and inbreeding coefficient for Menz sheep were 6.35 and 0.079, respectively. For Afar, the effective population size was much lower (2.46) and inbreeding coefficient

was higher (0.20). In both cases the level of inbreeding was higher than the acceptable level of 0.063 and could be reduced by mixing different sheep flocks. Based on the result obtained in this study most of the sheep flocks (on average 7.3 and 4.6 in Menz and Afar area) are mixed together. When flocks are mixed the inbreeding coefficient is reduced by 86% in Menz and 78% in Afar sheep flocks.

Table 3. Effective population size and level of inbreeding for Menz and Afar sheep flocks

Production system	When flocks are not mixed				When flocks are mixed			
	Male	Female	Ne	ΔF	Male	Female	Ne	ΔF
Crop-livestock	1.78	14.74	6.35	0.079	12.99	107.62	46.38	0.011
Pastoral	0.65	11.32	2.46	0.200	2.99	52.07	11.31	0.044

Keeping older rams for prolonged time was more practiced in pastoral system than in mixed crop-livestock system. The proportion of older breeding rams having 3 or above pair of permanent incisor to the total mature ram having 1 or above pair of permanent incisor was almost half 48.0% in Afar sheep flocks whereas only 9.6% in Menz sheep flock. Keeping breeding ram for prolonged period of time in Menz area was practiced only when the breeding ram is perceived to have special features (good appearance, preferred coat colour, large size, large and broad tail and true to breed type). In such a case it is good to advice sheep owners to reduce intense inbreeding by avoiding the mating of the sire to own daughter.

Majority (65.5%) of the farmers in Menz area keep breeding rams for the purpose of breeding and fattening, 24.1% for breeding only, 3.5% for breeding and socio-cultural benefit and 6.9% for breeding, fattening and socio-cultural purposes. In Afar, almost half (49%) of the Afar pastoralists maintain breeding rams for the purpose of breeding only, 32% for breeding and fattening, 7.0% for breeding and socio-cultural benefits and 11% for breeding, fattening and socio-cultural benefit (Table 4). There was significant association (Chi-square = 19.83, $p<0.01$) between purpose of keeping breeding ram and production system. Menz farmers had better interest to keep breeding ram for the purpose of fattening along with breeding purpose than the Afar pastoralists.

Table 4. Purpose of keeping breeding ram in Menz crop-livestock and Afar pastoral production system

Reason	Mixed crop-livestock		Pastoral	
	N	%	N	%
Breeding only	21	24.1	49	49.0
Breeding and fattening	57	65.5	33	33
Breeding and socio-cultural	3	3.5	7	7.0
Breeding, fattening and socio-cultural	6	6.9	11	11.0

Selection criteria for breeding ram and ewes

Ranking of farmers and pastoralists for the selection of breeding rams and ewes are indicated in Table 5. Appearance and/or conformation of breeding ram ranked first in both Menz and Afar sheep owners with the index of 0.29 and 0.35, respectively. Fast growth , coat colour and tail size and shape were ranked second, third, fourth and fifth with index of 0.24, 0.20, 0.18, and 0.04, respectively in Menz area. In Afar area tail size and shape, fast growth , coat colour and mating ability were ranked second, third, fourth and fifth important traits with index of 0.20, 0.17, 0.15 and 11, respectively. Based on results obtained from group discussions in the Afar area, the tail of sheep is used to treat malaria, constipation and other abdominal problem. They believed that the disease will be expelled with diarrhoea after drinking the fat from the tail. Appearance/ conformation of ram for Menz farmers include traits like body size, chest and pelvic width (‘*gane sefi*’), length and straightness of the back (‘*shint*’), tail width and size (‘*chebeta*’) and body condition of the ram. For the Afar pastoralist appearance/conformation of a ram were assessed based on body size, strength and straightness of the legs, length and straightness of the back; and tail

size. Generally large body size with large horn, large ear, larger tail size and white or red colour were preferred traits of a ram for Menz sheep breeder. While Afar sheep breeder prefers polled ram, short eared, ram having a colour of white with light red at the back, medium tail fat and ram having good conformation.

Most of the Menz sheep breeders consider lambing interval, mothering ability, ability to give multiple birth and coat colour type as the first four reasons for ewe selection in that order with an index of 0.31, 0.22, 0.16 and 0.12, respectively. In contrast to the rams, fitness and reproductive traits were more important for ewes in Menz area. This is because of their strong perception that the growth of the lamb depends mainly on the mothering ability of the dam. Furthermore they consider that ewes might have a chance of giving lambs with preferred coat colour, good appearance and fast growing lamb if mated with best ram. Similarly, Afar sheep breeders consider milk yield, mothering ability, appearance or ewe conformation and lambing interval as the first four more important traits with an index of 0.22, 0.16, 0.15 and 0.12, respectively. In the Afar pastoral system milk has a significant role for home consumption.

Table 5. Selection criteria for breeding ram and ewe in Menz Mixed crop-livestock and Afar Pastoral system

Class and selection criteria	Production system							
	Crop-livestock				Pastoral			
	Rank 1st	Rank 2nd	Rank 3rd	Index	Rank 1st	Rank 2nd	Rank 3rd	Index
Breeding ram								
Apearance/conformation	47	26	18	0.290	63	11	17	0.350
Colour	17	30	30	0.200	3	30	29	0.150
Horn	0	7	8	0.030	0	0	4	0.006
Ear	1	2	7	0.020	0	0	3	0.005
Fast growth	38	24	13	0.240	17	24	11	0.170
Fleece yield	0	1	1	0.004	-	-	-	-
Mating ability	2	4	11	0.040	6	22	10	0.110
Tail size and shape	15	26	32	0.180	18	21	32	0.210
Breeding ewe								
Appearance/size	9	6	16	0.080	11	24	8	0.150
Coat colour	11	14	19	0.120	1	16	28	0.100
Mothering ability	18	34	29	0.220	16	16	17	0.160
Age at first lambing	4	5	1	0.030	4	2	2	0.030
lambing interval	42	33	17	0.310	11	14	12	0.120
Twining	25	13	9	0.160	10	10	2	0.090
Tail size and type	4	4	15	0.050	4	10	21	0.090
Milk yield for family	-	-	-	-	43	1	1	0.220
Ear size	0	2	3	0.010	0	0	8	0.000
Longevity	1	3	3	0.020	1	6	2	0.040

Index= sum of (3 for rank 1 + 2 for rank 2 + 1 for rank 3) give for each selection criteria divided by sum of (3 for rank 1 + 2 for rank 2 + 1 for rank 3) for all selection criteria for a production system.

This result showed that both farmers and pastoralist gave more attention for the coat colour of their animals. Majority of Menz sheep breeders prefer plain white, pure red; and white and red with patchy pattern in that order. Sheep having plain black, black with red/white belly *('tazma')* and dark grey or mixture of different colours with wild (hyena) pattern *('jibma')* were not preferred. Pastoralists prefer creamy/white colour with light red patch at the back and plain light red colours. Dark red and plain white were less preferred colours. Pastoralists perceive that dark red coloured sheep gave more milk but are more affected by drought. White sheep are less preferred because dust/soil makes them unclean and reduces their attractiveness. Qualitative traits other than coat colour have got less rank in this study though all of the respondents considered them in their choosing decision. Report by Ndumu *et al.* (2008) indicated that beauty traits like coat colour and pattern as well as horn length play significant role in ranking decision of Ankole cattle. Thus,

consideration of coat colour type and pattern in both systems should be considered when defining breeding goal traits.

Reasons for keeping sheep

Knowledge of reasons for keeping animals is a prerequisite for deriving operational breeding goals (Jaitner *et al.,* 2001). The primary reason for keeping sheep for the Menz sheep owners was to generate income followed by meat consumption, manure, hair and as means of saving in that order with an index of 0.47, 0.22, 0.13, 0.09 and 0.07, respectively. However, the primary reason of keeping Afar sheep breed was for the purpose of milk yield followed by meat consumption and to generate income with an index of 0.45, 0.24 and 0.23, respectively. The emphasis among smallholder farmers was much more intended to regular cash income than pastoralists. In contrast to this, consumption (milk and meat) was highly ranked by pastoralists. Manure and hair/fleece received better rank by Menz smallholder farmers. Purpose of keeping sheep recorded in this study for the Menz smallholder farmer is in agreement with the Kenyan smallholder farmers (Kosgey *et al.,* 2008). Purpose of sheep keeping for the Afar pastoralists is different from that of the Kenyan pastoral farmers in that the Kenyan pastoral farmers gave higher ranking for regular cash income than milk and meat (Kosgey, 2008). Sheep production contributed to a great extent in the diets of pastoralists is documented for Ethiopian Somali pastoralists (Solomon, 2008). Based on the reasons for keeping sheep, the main breeding goal has been defined as increasing meat production (improve growth rate and conformation), and fleece yield for Menz sheep and increasing milk yield and meat production for Afar pastoralists.

Table 16. Ranking of the sheep production objectives by smallholder farmers and pastoralists

Production objective	Production system							
	Crop-livestock				Pastoral			
	Rank 1st	Rank 2nd	Rank 3rd	Index	Rank st	Rank 2nd	Rank 3rd	Index
Meat	5	49	40	0.22	1	50	47	0.24
Hair	1	16	26	0.09	-	-	-	-
Religious	0	0	1	0.00	-	-	-	-
Ceremony	0	2	3	0.01	2	1	0	0.01
Wealth	1	0	1	0.01	6	6	2	0.05
Skin	0	0	3	0.00	1	0	1	0.01
Manure	1	27	34	0.13	-	-	-	-
Saving	1	20	10	0.07	-	-	-	-
Income	109	4	0	0.47	10	35	43	0.23
Milk	-	-	-	-	84	12	7	0.45

Index= sum of (3 for rank 1+2 for rank 2+1 for rank 3) give for each purpose divided by sum of (3 for rank 1+2 for rank 2+1 for rank 3) for all purpose of keeping sheep in a production system.

Constraints to sheep production

Among the constraints feed shortage/frequent drought and disease were considered as more important problem in both Menz and Afar areas with varying intensity. In Menz crop-livestock system feed shortage/frequent drought and disease ranked first and second with index of 0.37 and 0.35, respectively. However, feed shortage/drought ranked first with higher index (0.55) and disease ranked second with index of 0.33 in Afar. Shortage of capital to start or expand sheep production and lack of improved genotype were the third and fourth constraints with index of 0.15 and 0.08, respectively in Menz, whereas water shortage ranked third with index of 0.07 in Afar area.

Feed shortage in Menz area was due to the shortage of grazing land, degradation of the land and failure of short rain. In Afar area feed shortage as reported by pastoralists was mainly due to the expansion of the fast growing tree encroaches the grazing land. Pasteurolosis, liver fluke, coenurosis, and sheep pox were the major reported sheep disease in that order. Similarly, pastoral-

ists identified liver fluke, skin disease (dermatological problems) and pasteuorolosis as the major diseases affecting sheep productivity in that order.

Conclusion and recommendation

The results from the present survey revealed constraints and opportunities to be considered when designing and implementing community based sheep breeding programmes. Small flock size, uncontrolled mating, indiscriminate mating resulting from maintaining ram lambs till castration age mainly in Menz sheep flocks, low level of literacy especially in Afar area, flock mobility in Afar area, absence of breeding ram in many of the flocks mainly in Afar area makes the designing of breeding program difficult. However, mixing of flocks reported by many of the farmers has a good potential in the efforts for solving absence of breeding ram and reduce the risk of inbreeding. Thus, strengthening the existing practice by organizing farmers/pastoralists utilizing common grazing land based on their interest is prerequisite to start breeding programme.

Larger effort should be put on the selection and identification of breeding ram before market age to increase the proportion of breeding male in the Afar pastoral system and demonstration of early age finishing technologies and method of controlling unwanted mating in Menz crop-livestock system.

Appearance/conformation was considered as the most important trait for breeding ram in both mixed crop-livestock and pastoral system. Based on the reasons for keeping sheep, the main breeding goal has been defined as increasing meat production (improve growth rate and conformation), and fleece yield for Menz sheep and increasing milk yield and meat production for Afar pastoralists. Furthermore other qualitative traits like coat colour type and pattern, horn size; ear size should be taken into consideration. In order to minimize the failure of breed improvement programme it is important to consider the existing breeding practices, management system and trait preferences of the community and the multi-purpose role of targeted animals.

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References

Abebe, Mekoya, 1999. Husbandry practice and productivity of sheep in Lalo-mama Midir woreda of central Ethiopia. An M.Sc Thesis presented to the School of Graduate Studies of Alemaya University of Agriculture, Dire Dawa, Ethiopia. 99p.

Aden, Tekle, 2003. Evaluation of local sheep under traditional management around rural area of Dire Dawa. An M.Sc Thesis presented to the School of Graduate Studies of Alemaya University, Dire Dawa, Ethiopia. 128p.

Agyemang, K., Negussie, Akalework, Voorthuizen, A., and Anderson, F.M., 1985. A rapid survey of sheep production in the traditional sector of Debre Berhan, Ethiopian Highlands. pp 175-178. In: R.T. Wilson and D. Bourzat (ed). Proceeding of Small Ruminants in African Agriculture. 30 Sep. - 4 Oct., 1985, ILCA (International Livestock Center for Africa) Addis Ababa, Ethiopia.

CSA (Ethiopian Central Statistics Agency), 2007. Livestock sample survey, 2006-2007 (1997 E.C). (AgLVS2006), Version 1.1, December, 2007. Addiss Ababa, Ethiopia.

Falconer, D.S. and Mackay, T.F.C., 1996. Introduction to Quantitative Genetics. 4th ed. Harlow, England, Longman. 438P.

Fekerte, Ferew, 2008. On-farm characterization of blackhead Somali Sheep breed and its production system in Shinile and Erer districts of shinile zone. An M.Sc. Thesis Presented to the School of Graduate Studies of Alemaya University of Agriculture, Dire Dawa, Ethiopia. 115p.

Galal, E.S.E, Metawi, H.R.M., Aboul-Naga, A.M., and Abdel-Aziz, 1996. Performance of and factors affecting the small-holdersheep production system in Egypt. Small Rumin. Res. 19: 97-102.

Holst, P.J., 1999. Recording and on-far evaluation and monitoring: breeding and selection. Small Rumin. Res. 34(1999) 197-202.

Jaitner, J., Soweb, J., Secka-Njieb, E., and Demp, L., 2001. Ownership pattern and management practices of small ruminants in The Gambia-implications for a breeding programme. Small Rumin. Res. 40: 101-108

Kosgey, I.S., Rowlands, G.J., van Arendonk, J.A.M., Baker, R.L., 2008. Small ruminant production in smallholder and pastoral/extensive farming systems in Kenya. Small Rumin. Res. 77: 11–24

Kosgey, S., Baker, S, R.L., Udo, H.M.J. and Var Arendonk, J.A.M., 2006. Successes and failures of small ruminant breeding programmes in the tropics: a review. Small Rumin. Res. 61: 13-28.

Kosgey, I.S., 2004. Breeding objectives and breeding strategies for small ruminant in the tropics. Ph.D. Thesis, Animal Breeding and Genetics Group. Wageningen University, the Netherlands.

Kosgey, I.S., and Okeyo, A.M., 2007. Genetic improvement of small ruminants in low-input, smallholder production systems: Technical and infrastructural issues. Small Rumin. Res. 70: 76–88

Ndumu, D.B., Baumung, R., Wurzinger, M., Drucker, A.G., Okeyo, A.M. Semambo, D. and Sölkner, J. 2008. performance and fitness trait versus phenotypic appearance in the African Ankole longhorn cattle: A novel approach to identify selection criteria for indigenous breeds. Livestock science. 113: 234-242.

Niftalem, Dibissa, 1991. On-farm study of reproductive and growth performance of the Menz sheep in Debre Berhan-Ethiopia. An M.Sc. Thesis Presented to the School of Graduate Studies of Alemaya University of Agriculture, Dire Dawa, Ethiopia. 93p.

Rancourt, M., Fois, N., Lavin, M.P., Tchakerian, E. and Vallerand, F., 2006. Mediterranean sheep and goat production: An uncertain future. Small Rumin. Res. 62: 167-179.

Rege, J.E.O., 1994. Indigenous African small ruminants: a case for characterization and improvement. In: S.H.B. Lebbie, B.Ray and E.K. Irungu (eds.). Small Ruminant Research and Development in Africa. Proceedings of the Second Biennial Conference of the African Small Ruminant Research Network, AICC, Arusha, Tanzania, 7-11 December 1992. ILCA (International Livestock Center for Africa) and Technical Centre for Agricultural and Rural Co-operation (CTA), Addis Ababa, Ethiopia. 268p

Sölkner, J., Nakimbigwe, H. and Valle-Zarate, A., 1998. Analysis of determinants for success and failure of village breeding programmes. Proc. 6th World Congr. Genet. Appl. Livestock Prod., 25: 273 – 280.

Solomon, Abegaz, 2007. In situ characterization of Gumuz sheep under farmers management in north western lowland of Amhara region. An M.Sc. Thesis Presented to the School of Graduate Studies of Alemaya University of Agriculture, Dire Dawa, Ethiopia. 89p.

Solomon, Gizaw, Van Arendonk, J.A.M., Komen, H., Windig, J. J. and Hanotte, O., 2007. Population structure, genetic variation and morphological diversity in indigenous sheep of Ethiopia. Animal Genetics, 38: 621–628.

Solomon, Gizaw, 2008. Sheep resources of Ethiopia: genetic diversity and breeding strategy. PhD thesis, Wageningen University, The Netherlands

SPSS for windows, 2004. Statistical Package for Social Science (SPSS). Release 13.0. The Apasche software foundation.

Tibbo, M. 2006, Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopian highlands. Doctoral Thesis, Swedish University of Agricultural Sciences. Uppsala, Sweden.

Tibbo, M., Philipsson, J., and Workneh, Ayalew, 2006. Sustainable sheep breeding programmes in the tropics: A frame work for Ethiopia. Conference on International Agricultural Research for Development, University of Bonn, 11-13 October, 2006. Bonn, Germany.

Tsedeke, kocho, 2007. Production and marketing systems of sheep and goats in Alaba, Southern Ethiopia. A thesis submitted to the Department of animal and range sciences, Awassa College of Agriculture, School of Graduate Studies, Hawassa University Awassa, Ethiopia. 157p.

Verbeek, E., Kanis, E., Bett, R.C. and Kosgey, I.S., 2007. Socio-economic factors influencing small ruminant breeding in Kenya. Livestock Research for Rural Development. 19(6). http://www.cipav.org.co/lrrd/lrrd19/6/verb19077.htm.

Workneh, Ayalew, Ephrem, Getahun, Markos, Tibbo, Yetnayet, Mamo and Rege, J.E.O., 2004. Current State of Knowledge on Characterisation of Farm Animal Genetic Resources in Ethiopia. Proceedings of the 11th Annual conference of the Ethiopian Society of Animal Production, Pp: 1-22.

Efficiency of deep setting and shallow pan cream separation and butter-making techniques at different temperature and storage conditions

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Abstract

The efficiency of deep setting and shallow pan cream separation methods was evaluated at Holetta Research Center at different standing conditions. Butter fat obtained as percent fat recovery (PFR) and weight of butter recovered were considered as efficiency measures. Percent fat recovery was higher for the deep setting than for the shallow pan method. The highest and lowest percent fat recovery were recorded for milk stood at average room temperature of about 23°C (80.37%) and refrigerator adjusted at 10°C (70.3%), respectively. Percent fat recovery decreased with decreasing standing temperatures. The overall mean churning time using plastic canister and electric churn was 31 and 23 minutes, respectively. Deep setting and shallow-pan cream separation methods are easily affordable and more efficient in terms of the time required for the existing situations of smallholder milk production and processing. Similar research efforts are needed to further validate these methods and to look for more efficient and affordable methods to concentrate milk fat at smallholder settings.

Key words: *Efficiency, cream separation, butter-making, cow's milk, Ethiopia*

Introduction

Milk is not only desirable for human beings but also an ideal medium for the growth of spoilage microorganisms, which shorten its shelf-life and make it unsafe for direct consumption and unfit for further processing. Under the prevailing level of understanding of milk handling and dairy infrastructure under on-farm condition, milk is subjected to contamination in any of the channels from the time of production up to consumption (O'Connor, 1993; Zelalem, 2003).

Processing milk in to other dairy products is an important way of extending its shelf-life. Fermented milk for instance can be stored for about 20 days as compared to less than a day for fresh milk (O'Connor, 1994). This product is the basis of smallholder milk processing in tropical areas in general and in Ethiopia in particular due to a number of prevailing situations such as high ambient temperatures, small quantities of daily milk produced, consumer preference, improved keeping quality of fermented milk (O'Mahony, 1988; O'Connor, 1994), and the type and capacity of locally available processing materials and techniques.

Milk processing exploits one or more of the major milk solids (O'Mahony and Peters, 1987). In the Ethiopian context, milk fat is the most valuable component of milk solids in economic terms as butter is the most expensive dairy product. Fat can be removed from milk in a more concentrated form through a process known as creaming. So far gravity and centrifugal separation methods are the most known broad categories of cream separation. Although centrifugal separation is more efficient, it is unaffordable by most smallholder producers, when affordable it is not available. The low amount of daily milk production in the majority of households also doesn't justify its use. Gravity separation methods (deep-setting and shallow-pan), however, could be appropriate technologies at small-scale level.

Traditional milk processing technologies are reported to be inefficient in terms of the time involved in the processing and the amount of final products obtained per unit of raw material used (Fekadu and Abrahamsen, 1994; O'Connor, 1994; Zelalem 1999). Further information on efficien-

cy of different locally available and affordable cream separation and butter-making methods is essential for making efficiency improvement interventions. Therefore, this study was conducted to determine the efficiency of deep setting and shallow pan cream separation methods at different temperature and storage conditions.

Materials and methods

***Study area*:** The study was conducted at Holetta Agricultural Research Center: altitude, 2400 masl; annual rainfall, 1100 mm; average minimum and maximum temperatures, 6°C and 24°C.

Study procedures: Two standing conditions, deep-setting (deep can of small diameter fitted with a tap at the bottom) and shallow pan (40 cm in diameter and 15 cm deep) were used to separate the cream. The collected milk was allowed to stand over night (12 hrs), 18 hrs and 24 hrs each under room temperature, standing cold water filled in metal containers, inside refrigerator adjusted at 10°C and inside incubator adjusted at 30°C. At the end of the standing time, the skim milk was drained through the tap fitted at the bottom of the deep plastic can for the deep setting method, and was ladled out for the shallow pan method. The cream was then allowed to ferment and was churned to recover the butter using a plastic canister and an electric churn. For the plastic canister, sour cream was introduced in the container with the screw cup on the top and then the content was agitated from right to left, back and forth and /or up and down by holding the two ends.

***Sampling*:** Fresh milk was sampled after the collected milk was thoroughly mixed. In addition, samples of skim milk were collected from each method for determination of fat and total solids and butter samples were also collected for determination of total solids. Standard procedures of BSI (1989), Marth (1978), and O'Connor (1994) were followed for determination of total solids percent of whole milk, skim milk and butter; and fat percent of whole milk and skim milk collected from each treatment.

***Measurements*:** Volume of milk for each method of cream separation, standing time, percent fat recovery, weight of butter recovered, volume of skim milk and churning time were measured at different stages of the experimental period. The following mathematical formula was used to calculate percent fat recovery (O'Connor, 1994):

PFR= [(FPWM – FPSM)/ FPWM] x100. Where PFR= Percent Fat Recovery; FPWM= Fat percent in whole milk; FPSM= Fat percent in skim milk

Statistical analysis: The data collected on percent fat and total solids of milk products, percent fat recovery and weight of butter recovered, volumes of whole and skim milk and churning time were analyzed using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS) (2002).

Results and Discussion

As the same milk was used for the different standing and keeping temperature conditions, milk fat content was similar between the two standing conditions and among the four standing temperatures. However, the fat percent of skim milk separated with deep setting method was markedly ($p<0.01$) lower than that separated using shallow pan method. This was more explained by the significantly ($p<0.01$) higher percent fat recovery obtained using deep setting than shallow pan cream separation method. This implies that deep setting method was more efficient in cream separation than shallow pan method, which might be attributed to the possible mixing up of the cream with skim milk during ladling out the cream layer in the shallow pan method. The use of tap fixed at the bottom of the deep setting method to drain the serum or skim milk leaves the cream layer on top undisturbed and reduces the possibility of mixing of cream with skim milk which possibly may increase efficiency of deep setting cream separation method. Similarly, O'Connor (1994) has

reported 0.2 or 0.3% fat left in skim milk after 24hr of standing in deep setting method indicating its better efficiency, while 0.5 to 0.6% fat was left in skim milk in the case of shallow pan method after 36hr standing. As standing time didn't show any significant effect on fat percent in cream and percent fat recovery, results are not presented.

Table 1. Fat percent of whole and skim milk, percent fat recovery, Total solids percent of whole milk, skim milk and butter under different standing conditions and temperatures.

Observation	Treatments								CV	Overall mean
	Standing Condition			Standing temperature						
	DPS	SP	LSD	INC	RT	Ref	CW	LSD		
N	36	36		18	18	18	18			72
FPWM	4.15±0.03	4.15±0.03	0.08	4.18±0.03	4.18±0.03	4.12±0.05	4.09±0.05	0.12	9.41	4.16
FPSM	0.87±0.03	1.04±0.03**	0.09	0.86±0.03bc	0.82±0.06c	1.20±0.06a	0.93±0.03b	0.13	43.55	0.94
PFR	78.74±0.97**	74.60±0.97	2.31	79.19±0.99ab	80.37±1.52a	70.30±1.52c	76.82±1.52b	3.35	13.38	76.92
TSPWM	12.88±0.08	12.88±0.08	0.29	13.20±0.08a	12.67±0.13b	12.88±0.13b	12.75±0.13b	0.29	6.99	12.79
TSPSM	9.57±0.20	9.98±0.02	0.71	10.27±0.21a	9.71±0.32ab	9.84±0.32ab	9.28±0.32b	0.71	22.18	9.89
TSPBPC	81.53±0.35	81.68±0.35	1.20	84.31±0.35a	80.76±0.54c	79.11±0.54d	82.23±0.54b	1.20	4.54	81.70
TSPBEC	81.32±0.29	81.12±0.29	1.00	83.07±0.29a	81.25±0.45b	78.62±0.45c	81.94±0.45b	1.00	3.80	81.26

**=p<0.01. a,b,c=p<0.05. Means with different superscripts across the same raw differ significantly. N=Number of observations. DPS= deep setting. SP=Shallow pan. LSD=Least significant difference. INC= Incubator (30°C). RT= Room temperature (23°C). Ref= Refrigerator (10°C). CW= Cold water (19°C). CV= Coefficient of variation. FPWM and FPSM= Fat percents of whole milk and skim milk. PFR= Percent fat recovery. TSPWM and TSPSM= Total solids percent of whole milk and skim milk. TSPBPC and TSPBEC= Total solids percent of butter produced by plastic churn and electric churn.

The highest and lowest percent fat recovery were recorded for standing temperatures of room temperature (80.37%) and refrigerator (70.3%), respectively (Table 1). This might be attributed to the nature of fatty acids of milk which are solid at room temperature (Campbell and Marshall, 1975). This helps the fatty acids to readily rise and coalesce during creaming allowing easier collection of milk fat. Percent fat recovery tended to increase with standing temperature considered (Table 1).

Total solids content was markedly higher for milk kept in incubator. This might be due to the possible evaporation of moisture from milk kept in incubator, which was the highest keeping temperature (30°C). However, the difference was not apparent among the remaining three standing temperature conditions. The highest and lowest total solids content of skim milk was recorded for standing temperatures of incubator and cold water, respectively (Table 1). Standing condition, however, didn't have any effect on total solids of whole milk, skim milk and butter.

Churning efficiency is measured in terms of the time required to produce butter granules and by the loss of fat in the buttermilk (O'Connor, 1994, O'Mahoney and Bekele, 1985, Zelalem, 1999). Generally weight of butter recovered didn't differ significantly among the three standing times considered using both types of churns. However, butter yield tended to increase as standing time increases with the difference being 8g between 12hr and 24hr standing times using plastic canisters. Using electric churn however, it tended to decrease with the increase of standing time by the difference being 16g between 12hr and 24hr standing times. Though not significant, using electric churn resulted in 33, 22 and 9 g of more butter after 12, 18 and 24hr of standing, respectively as compared to the plastic canister (Table 2).

Standing temperature also markedly affected churning time and weight of butter obtained (Table 2). Generally, higher butter yield was obtained from cream separated from milk kept at room temperature (23°C) and in cold water using both churns. Churning the cream separated from milk kept at room temperature resulted in 50g more butter as compared to that kept at 30°C when plastic canister was used as a churn. By using the electric churn on the other hand, 64g more but-

ter was recovered from the cream separated from milk kept at room temperature as compared to that kept at 10°C (Table 2).

The overall mean churning time for the plastic canister and the electric churn was 31 and 23 minutes, respectively. Using electric churn has resulted in shorter churning time at all standing temperature conditions as compared to the plastic canister. The shortest and longest churning times were observed for cream kept at 19°C and 30°C, respectively using the churn of plastic canister. However, the shortest and longest churning times were recorded for standing temperatures of 10°C and 30°C, respectively using the electric churn. The highest butter yield was obtained from the cream stood at room temperature using both churning methods. This might be because of most fatty acids of milk, as indicated by Campbell and Marshall (1975), are solid at room temperature which helps them to readily coalesce during churning rendering faster and easier collection in the form of butter.

Table 2. Volume of whole milk used, weight of butter recovered and churning time for the different standing conditions, time and temperature

Observations	Treatments												Overall mean	CV
	Standing condition			Standing time				Standing temperature						
	Deep Setting	Shallow Pan	LSD	12hr	18hr	24hr	LSD	RT (23oC)	CW (19oC)	Ref (10oC)	INC (30oC)	LSD		
N	36	36	-	24	24	24	-	18	18	18	18	-		
MV (l)	5	5	-	5	5	5	-	5	5	5	5	-		
TVM (l)	180	180	-	120	120	120	-	90	90	90	90	-		
BPC (g/l)	215.8±5	217.6±4.8	12.16	213.2 ±6.2	219.0 ±6.0	221.0 ±5.8	14.8	246.4 ±4.8a	225.0 ±5.8b	203.4 ±8.8c	196.2 ±7.8c	18.8	227.58	15.7
BEC (g/l)	215.8±5	217.6±4.8	12.16	246.0 ±9.2	241.0 ±9.0	230.6 ±8.8	22.0	266.4 ±7.0a	232.2 ±11.6b	202.8 ±13.0c	227.6 ±8.8bc	28.0	249.26	21.3
TPC (min)	32.32±1.54	31.00±1.50	3.70	27.14 ±1.86b	32.16 ±1.90a	35.44 ±1.82a	4.4	28.0 ±2.6b	26.6 ±1.4b	36.0 ±2.4a	36.0 ±1.80a	5.6	31.00	36.0
TEC (min)	22.13±0.52	21.22±0.50	1.24	23.00 ±1.28ab	22.02 ±1.24b	25.06 ±1.22a	3.0	22.4 ±1.8b	23.0 ±1.6b	19.4 ±0.8b	28.4 ±1.2a	3.88	23.00	32.0

a,b,c=p<0.05. Means with different superscripts across the same raw differ significantly (p<0.05). N= Number of observations. MV (l) = volume of milk used at a time. TVM (l) = Total volume of milk used. BPC (g/l) = Weight of butter obtained after manual churning using plastic canisters. BEC (g/l) = Weight of butter obtained using electric churner. TPC (min) = Churning time required while using plastic canisters. TEC (min) = Churning time required during electric churn. INC= Incubator (30°C). RT= Room temperature (23°C). Ref= Refrigerator (10°C). CW= Cold water (19°C)

Conclusion

Deep setting and shallow-pan cream separation methods are efficient and easily affordable methods. Equipments used for these methods can be made from locally available materials. Due to reduced mixing up of skim milk with cream, deep setting method can be preferred over shallow pan cream separation method. This method tended to be more efficient in terms of percent fat recovery and volume of cream separated. Although the electric churn was time efficient and resulted in more percent fat and butter recovered, the plastic canister is readily available, affordable and practical especially for farmers producing small quantities of daily milk. Similar research efforts should be undertaken to further validate these methods and to look for more efficient and affordable methods to concentrate milk fat at smallholder settings.

Reference

BSI, 1989. Determination of fat content of milk and milk products (Gerber Method). British Standard Institute (BSI). British standard, BS 696. Part II.

Campbell, R. J. and Marshall, T. R. (1975). The science of providing milk for man. McGraw-Hill Inc. New York, USA.

FAO, 1990. The technology of traditional milk products in developing countries. FAO Animal Production and Health Paper 85. Food and Agriculture Organization of the United Nations, Rome, Italy. 333 pp.

Fekadu B and Abrahamsen R K 1994. Present situation and future aspects of milk production, milk handling and processing of dairy products in Southern Ethiopia. Farm-made milk products in Southern Ethiopia: 1. Chemical and microbial quality. PhD thesis. Department of Food Science. Agricultural University of Norway. Norway.

O'Connor, C. B. 1993. Traditional cheese making manual. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia

O'Connor, C.B., 1994. Rural Dairy Technology. ILRI training manual No.1. International Livestock Center for Africa. Addis Ababa, Ethiopia 133 pp.

O'Mahony, F. and Bekele E. (1985). Traditional butter making in Ethiopia and possible improvements. Addis Ababa, ILCA. ILCA Bulletin No. 22.

O'Mahony, F. and Peters, J., 1987. Sub-Saharan Africa-Options for smallholder milk processing. Food and Agriculture Organization the United Nations. World Animal Review, 62: 16-30.

O'Mahony, F., 1988. Rural Dairy technology-Experience in Ethiopia. ILCA Manual No. 4. Dairy Technology unit. International Livestock Center for Africa (ILCA). Addis Ababa, Ethiopia. 64 PP.

O'Sullivan, A.C., 1973. Milk processing with emphasis on product processing interactions. Technical bulletin series. An Foras Talunatais, Dublin, Ireland.

SAS, 2002. User's Guide: Statistics, Version 9, SAS Institute. Statistical Analysis System (SAS). Inc. Cary, NC.

Zelalem Yilma. 1999. Smallholder milk production systems and processing techniques in the central highlands of Ethiopia. MSc. Thesis. Upssala, Sweden.

Zelalem Yilma. 2003. Sanitary conditions and microbial qualities of dairy products in urban and peri-urban dairy shed in the Ethiopian central highlands. MSc. Thesis. Lyon, France.

Community-based sheep breeding: a new approach to genetic improvement

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Abstract

Community based sheep breeding considers proper consideration of farmers breeding objectives, infrastructure, participation and ownership. In this new approach, the community is involved from the inception of the project to implementation and then ownership. There are no many literature reports on community based breeding strategies. However, the limited available information is compiled and essentials to design community breeding program are outlined. Practical example of such scheme is also indicated.

1. Introduction

Small ruminants play an important role to the livelihood of resource-poor farmers in Ethiopia. The current level of on-farm productivity of the indigenous Ethiopian sheep genetic resources in the smallholder production systems is low (Tibbo, 2006). Off-take rates are about 33% with 10 kg of carcass output (FAO, 2005) and a net output of 3.7 kg meat per animal in a flock. In parallel, the demand for sheep products (mutton and sheep skins) has increased due to increased human population and urbanization. There is therefore, an urgent need to increase productivity to improve smallholder farm income and to meet the demand of the growing human population for livestock products.

While considering productivity improvement for market targeting, recent assessments of farmers' and R&D views in the highlands of Ethiopia showed that breeding issues receive similar priority as feeding issues (Tibbo, 2000). Thus, there is a clear need to develop efficient means to facilitate the access by farmers to improved germplasm.

Genetic improvement is usually viewed as a complex task that needs a high level of organisation and sophistication. In Europe, animal breeding has been traditionally supported by the state and large national breeding programmes are the rule rather than the exception. Data recording, channeling of the recorded data towards a data processing centre, estimation of "breeding values" with complex statistical methods and central decisions about the use of male breeding animals are ingredients of such breeding programmes.

Transfer of this approach to developing countries has been unsuccessful. Centralized breeding schemes, entirely managed and controlled by governments with minimal, if any, participation of farmers, were developed as an alternative and implemented in many developing countries through a nucleus breeding unit limited to a central station, usually run by a governmental organization, attempting to follow the complex procedures described above. These plans were entirely managed and developed without the active involvement of the community of farmers who played a passive role in the collection of information or allowing government staff to collect data on the basis of a contractual agreement. Thus the centralized schemes designed and managed by governments, failed to provide improved males continuously and also failed to engage the participation of the end users in the process. Another alternative widely followed by many countries or individuals

was the import of European germplasm via live animals, semen or embryos, in most cases without having previously tested the suitability and adaptability of these breeds and their crosses to the conditions they will be reared. This approach is questionable if the adaptation of these animals to the harsh conditions they will be placed is not assessed. Also, indiscriminate crossbreeding with the local populations tends to genetically erode the adapted local population.

A new thinking and approach is therefore required. One such approach that had recently stimulated global interest is a community based breeding strategy. These programs take into account, from inception, the farmers' decisions and participation which were determinant for their success These include proper consideration of farmmers' breeding objectives, infrastructure, participation and ownership (Sölkner *et al.,* 1998). Designing a community based breeding program is much more than genetic theories and increased productivity. It is a matter of infrastructure, community development and an opportunity for improved livelihood of livestock owners through better animals and markets for their products. This paper outlines essentials for implementing community based breeding programs and documents practical example of such schemes with focus on the so called ICARDA-ILRI-BOKU project on designing community based sheep breeding programs for Ethiopia.

2. Constraints of genetic improvement under subsistence livestock production systems

Attempts to improve livestock in the tropics have in the past focused on 'upgrading' with temperate breeds in crossbreeding. Although it is recognized that improved livestock have been successfully produced or introduced in favorable areas of the tropics, e.g. in some highland areas and in relatively intense peri-urban production systems, many attempts have failed. Analyzing the reasons for failures in different reports reveals some common problems, which include the following.

- For many of the developing nations, lack of clearly defined breeding policy is the major obstacle to genetic improvement;
- In many of the attempts made at genetic improvement livestock owners were not involved in planning, decision making and ownership of improvement initiatives;
- The breeding programmes have been too complicated in terms of logistics, technology and requirements of resources without considering the infrastructure available.
- Indiscriminate crossbreeding of indigenous breeds with exotic breeds without enough consideration of environmental conditions for production. Lack of plans on how to maintain a suitable level of 'upgrading' or on how to maintain the pure breeds for future use in crossbreeding contribute to non-sustainability.
- Lack of analysis of the different socio-economic and cultural roles that livestock play in each situation, usually leading to wrong breeding objectives and neglect of the potentials of various indigenous breeds of livestock.
- Lack of comprehensive approaches to design simple, yet effective breeding strategies in low-input environments.
- Lack of awareness of what genetic improvement schemes may achieve in both the short and long terms with different methods and species.

3. Essentials for designing effective genetic improvement programmes

An important feature of a genetic improvement programme, contrasting to an external input effect, is that the effects of selection accumulate over time. The economic benefits of selection also accumulate. Breeding programmes should therefore be seen as investments for sustainable improvements of the animal stock and its potential to produce food or other goods (Phillipson *et al.,* 2006). To realize the benefits of a breeding programme, it is essential that the breeding objectives

are appropriately defined for the species or breeds, communities and environments concerned, and that the strategies laid out can be followed in practice.

There are many important circumstances that determine the scope of opportunities and constraints of the breeding programme. Agricultural policy and market, environmental conditions, characteristics of animal populations and infrastructure available are examples of such factors. This section highlights some of these key elements which need to be considered before the final design of a breeding programme at breed level.

The agricultural development policy

Animal breeding programmes should be seen in the context of long-term development programmes contributing to both more food and other livestock commodities produced and to improved resource utilisation and livelihood of the livestock owners (Phillipson *et al.,* 2006). Thus, livestock breeding programmes would make up an important part of national agricultural policies, aiming at improving the food and income of a country, region or locality and of livestock keepers. In fact, in most cases, the agricultural development policy sets the scene. The long-term vision of the national interests and the breeding objectives must coincide, although there might be some discrepancies between short-term political goals and the more long-term breeding goals. Some compromises might be necessary and interim solutions applied, while maintaining the long-term goals. Food imports may, for example, be necessary, while awaiting the domestic production to increase through whatever means.

Environment, production system and the market

Any breeding programme is totally dependent on environmental conditions, the production system and the culture for which the animals are bred. Village breeding programmes for smallholder farmers will be different from large-scale farming systems. Intensive crop–livestock systems, with good feed and health care facilities available, enable more opportunities for rapid improvement programmes than harsh rangeland systems do. Whatever the environment, to be sustainable the breeding programme must be market-oriented, i.e. demand driven, yet considering the multipurpose use of the animals and the long-term benefits to the farmer. Developing a programme that considers both the present circumstances and possible future situations, including market conditions, is quite challenging. This is because there is a considerable time lag between implementation of the programme and when the benefits of genetic gains are realised. Therefore, breeding programmes should be somehow flexible and responsive to variable scenarios for future needs of the programmes.

Infrastructure and role of farmers

Breeding programmes usually assume some kind of cooperation between the participants, e.g. by common ownership of some valuable breeding stock for wide use, conducting testing schemes involving many herds or employing trained people for artificial insemination services and other activities. The initial developments of breeding programmes are generally made by government organisations in most developing countries because of the national benefits of improving the livestock for food production and other purposes. In that way, basic investments and structures can be put in place. However, experience shows that it is extremely important that farmers get involved early in the process to ensure that their needs are taken into account and that they provide the support needed for the programme to work (Ahuya *et al.,* 2004; Ahuya *et al.,* 2005; Kosgey *et al.,* 2006). Breeding programmes in the hands of farmers' cooperatives, often with government support have, throughout the world, been successful for several livestock species (Ahuya *et al.,* 2004). Specialised breeding companies, however, have evolved under certain commercial conditions, especially for poultry and pig breeding and, to a lesser extent, for cattle breeding. Such companies have often been able to produce high quality breeding stock for industrialised production systems.

In these cases, it is important, from a farmer's and government's perspective, to ensure that the most suitable animals are developed in relation to the real needs, environmental, socio-economic and other resources given.

Infrastructure includes a broad range of essential inputs, which must be available for the breeding programme to succeed. These include trained staff, facilities for breeding animals and logistics for dissemination of germplasm, methods and means for recording, handling of data and evaluation of animals, decision-making bodies, finances etc. One often over-looked assumption is the required integration of all activities constituting a breeding programme. This applies both at the government level as much as at the practical organisational level. Another potential problem in developing countries is lack of or an inadequate number of people with appropriate training or incentives to successfully run a breeding programme. Lack of required infrastructure is one of the most serious constraints preventing development of indigenous breeds in tropical countries.

4. What is community based breeding?

Genetic improvement of livestock during the last few decades has focused on crossbreeding of the indigenous genetic resources with improved temperate breeds. While there are success stories in genetic improvement, many of the attempts were expensive failures. Recently, as has been alluded to, there is a shift in thinking. It is now understood and it appears reasonable to start by trying to understand the present practices rather than prescribing a scheme from above. This way of thinking has brought in an approach called community based breeding.

A community is a group of people bound together by social, cultural and economic relations based on common interests, goals, problems or practices shared interests & living in a well defined area. Geographically, a community can be defined as of any size comprising of a village area, an ethnic group or an eco-regional zone. Communities are not homogeneous; there may be differences between sub-groups (e.g. families) & individuals in a community. However, shared interests in cooperation outweigh competing interests that serve as the glue linking members together.

Communities and citizens' groups provide the easiest means for people to take socially valuable action as well as to express their concerns. When they are properly empowered and informed, communities can contribute to decisions that affect them and play an indispensable part in creating a sustainable society. As local communities have a vested interest in all the natural resources (including AnGR) on which their livelihoods depend, and have the most to lose in the event of loss of these resources, they are best placed to develop and conserve them. Moreover, they have a better understanding than any other group of what it takes to manage their traditional resources sustainably. The literature on community based breeding is scanty (Sölkner *et al.,* 1998). However, it is defined as an improvement programs carried out by communities of smallholder farmers (villagers), often at subsistence level. The fact that the role of community-based breeding has received increasing attention derives from the realization that most creative and productive activities of individuals or groups in society take place in communities. Indeed, the dynamic processes that characterize the evolution of agricultural systems necessitate that the communities should themselves also be dynamic in their aspirations and strategies for managing their livelihoods. Community-based development approaches recognize, and respond appropriately to, the dynamism of the systems involved.

Community based livestock breeding considers proper consideration of farmers breeding objectives, infrastructure, participation and ownership.

5. What does it take to implement CBBS?/Operational strategies

Design and implementation of a community based breeding program involves a number of activities summarized below.

Description of the production system

Information on the broad production system is available from secondary sources. The characterization of production systems will therefore concentrate on complementary issues, including:

- Phenotypic characteristics (supplementary data on weights, body measurements for adult male and female animals and animals at marketing age)
- Reproduction data - e.g. ewe fertility, lambing rates
- Current breeding practices (management of males and females, herd structure, gene flows, including exchange and/or acquisition of new breeding animals)
- Marketing channels and opportunities for animals and animal products
- Economic evaluation of production (production costs, returns from sales)
- Institutional settings that affect breeding and animal management, including marketing (decision mechanisms within the community)

This information needs to be collected by standard methods of Rapid Rural Appraisal and Monitoring of farms, with active participation of farmers. Participatory workshops with focal groups need to be held to design more precisely the surveys and to validate the information collected.

Selection of community

Successful selection of the right community has been recognized as key to success of community-based programs. Some of the essentials that need to be considered in the selection of a community for community based sheep breeding include the following.

Prioritized Criteria for community selection

A. External aspects (which can be looked upon while considering areas to work)

1. Market access: distance to market, transportation of products, quality of roads. This is also critical as the market is the driving force of improvement projects
2. Guard against possible impacts by other projects e.g. Irrigation might result in more cropping and less livestock activities. A crossbreeding program could jeopardize a breeding plan as farmers will see impacts in the short term that trigger their interest and cause them abandoning or disregarding the plan
3. Synergies with other projects
4. Important to see that other concurrent stakeholders could be involved and let them also take part in the plan. For instance a Development program, that could actually provide the enabling environment for the realization of the project' ideas
5. Government support
6. Although this one applies to the whole sector and not to a specific community, consider also what are the locally developments occurring in relation to Policies, credits, following Government priorities. For instance the development of abattoirs, feed producing plants, etc.
7. NGOs support

B. Community aspects (now zooming into the communities within selected area)

1. Sheep as priority: how much of the income comes from sheep? Set a minimum % for selection. It would be nice that a substantial portion of income is contributed by small ruminants
2. The community have sheep (greater than or equal 400 ewes): consider distribution of the flock size within farms of community; preferable nearly equal distribution (avoid disparities: e.g. a farmer with 400 animals few farmers with 10)

3. Communal/common grazing: communal grazing indicates that already some collective activities exist. Look a little into it to see the institutional setup that could be used to jump into it
4. Existing communal champion: very important in social and traditional structures in the region. He/she should be identified as the inside community-based facilitator to work closely with the project's community-based facilitator. It would be critical to identify this person as early as possible. That is why former discussion with extension people, researchers that worked in the area before and NGOs working in the area are consulted. It is likely that these people will know who are who.
5. Willingness/interest to participate in the project: This is fundamental and would be centered on the discussion with the community collective activities like collection of milk, processing, marketing. For this there is a need to conduct a participatory workshop to establish a discussion with the community (an opportunity also to see how the potential champion perform)

Suggested steps to follow

1. Consult with Extension people, researchers that work in the area, former livestock specialist that had knowledge of the area, NGOs and development projects. It would be nice to have an inventory of stakeholders. Let these people suggest the potential or candidate communities to visit. This will cover part A.
2. If possible along with some of these people that already developed a trust (provided they agree with our goals) visit the communities and organize a participatory workshop. This will serve to get info on part B
3. Not to forget to document the whole process.

Definition of breeding goals (breeding objectives)

Selection criteria will be discussed and defined by the community members. To this end, a host of participatory methods for evaluating indigenous selection criteria developed by BOKU in a joint project with ILRI (Wurzinger *et al*., 2005; Ndumu *et al*., 2005) could be applied, along with others that may be relevant to the local conditions. These will include:

- Workshops and focal group discussions to cover the following issues: important traits for selection; pure breeding vs. crossbreeding; genetic parameters (e.g. heritabilities of, and correlations among, traits) and how these come to play in breeding program design; and animal management and behaviour
- Phenotypic ranking of animals (both own and group) according to producers and consumers (markets) preferences
- Contingent valuation of important traits via a hypothetical choice experiment

Assessment of alternative breeding strategies and implementation of a breeding programme

Based on the information obtained, different scenarios for selection programmes will be developed. These will vary in terms of complexity and requirements of data and parentage recording in accordance to the institutional arrangements, capacities and preferences of the community and the baseline performance of the existing genotypes. The simplest scenario may include a selection programme for one or two traits measured on the candidates for selection. This does not require parentage control or external data analysis.

Other schemes, including a decentralized nucleus owned by the community to fit into the specific conditions, would also be considered. This approach has been well documented in Latin America (Mueller *et al*., 2002; Taddeo *et al*., 2001; Abad *et al*., 2002). A more complex breeding programme will involve several selection criteria, measurements of traits not only on selection candidates but

also on relatives, detailed data recording and external analysis of data involving technical support from extension services run by the government, NARS or NGO. Depending on the situation of the community, all members might be actively involved in the breeding programme or only part of the community will do active breeding and supply neighbours with rams at negotiated conditions, including cash prices or some other 'in-kind compensation'. Depending on the result of the initial discussions with the communities, only section (i.e. the top 20% of the flock or the ones that the owners value most) of the flocks may be routinely recorded in detail. This approach is a form of a decentralised nucleus programme. The strategy will be restricted to pure-breeding, but with room for out-crossing.

The consideration of the breeding program will not only include the community's institutional setting but also the government's plans and other key stakeholders such as ongoing development plans and technical support services.

As project periods are usually too short to allow the testing of all options, a combination of simulation/modelling and analysis of previous case studies from the literature need to be used to make initial decisions on which options should be tried based on and the circumstances and the outcome of stakeholder consultations. Deterministic simulation programs (ZPLAN, SelAction) would be employed to evaluate predicted genetic gains in different traits as well as cost versus benefit of such programmes. Where possible, the communities will be engaged to provide inputs (suggestions and information), based on their experiences and perceived targets. These will be included in the models. The essence of the results of these different simulations will then be presented to the communities to provide points for further discussions on the various options, their advantages and disadvantages, challenges and risks of each. The communities would then make "informed" decisions. The decisions could be the acceptance of one of the proposals, modification of one of the proposals or development of an alternative strategy. Modified or alternative strategies will again be evaluated with the simulation model.

Finally, the community will take the first steps of implementation of the new breeding scheme together with the team of professionals. This will include the joint execution of the first cycle of ram selection. Procedures of tagging or marking animals will be defined and, depending on the scheme chosen, recording and flow of data and results will be designed and tested. Community regulations, responsibilities for the execution and a discipline to be followed will be worked out in early planning meetings with communities.

Recording

Success in genetic improvement to a larger extent depends, among others, on accurate recording of the farm operations and periodic analysis of the data to design future plans and take corrective measures as appropriate. The goal of record keeping is basically to provide farmers and other stakeholders with information about individual animals for management and for breeding purposes. The type of record to be kept depends on the available infrastructure, including physical and human resources. The recording scheme to be adopted will differ considerably depending on the farming structure and production system. The initial stages of implementation of a breeding program need to adopt simple recording formats to be sustainable. As the experience develops the scheme could be modified to capture more information. In any case, it is mandatory to engage the community in these activities. It should be noted that contrary to many claims, routine recording of performance (including health and fertility) is possible in "developing" countries; constraints are institutional and can be overcome (Sölkner et al., 2008).

Monitor the breeding programme to show impact

Success in genetic improvement to a large extent depends on designing a simple yet effective breeding strategy. Once the breeding plan is in place there has to be a follow up of the whole operation. Part of a breeding program has to do with regular analyses of the outcome of the program. Such analyses should demonstrate the genetic improvements obtained in all important traits and also the effects on total output of products and per unit of measurement, e.g. per animal, per hectare etc. and the economic impacts at both farm and national levels. Baseline information will be adequately taken during the description of the production system so that the information collected could serve as a reference base for further comparisons. Outputs should be related to inputs and the status of natural resources utilised. These change with time and must be revised accordingly. By regularly monitoring the breeding programme, corrective measures can be taken to improve the programme. Showing the impact of the breeding programme may also be essential for future support of the programme. If regular monitoring cannot be conducted, similar studies could be done as research projects at certain intervals, whereby data of the recording scheme are used to analyse the genetic changes in different traits and to study population structure. Additionally, the more technical issues relating to the implementation of the breeding operations need to be monitored at regular intervals and corrective measures taken when problems occur.

Impact of genetic change at individual and systems level

Genetic improvement of a population by selection implies not only changes in terms of increased output but also changes in nutrient requirement and, more generally, an altered physiological status of the animal. The relationship between genetic improvement and eventually resulting changes need to be studied at several levels:

- The consequences of an improved genetic potential on the individual animal (nutrient and energy requirement, probability for a negative energy balance in certain stages of the production cycle, production outcome etc.) should be studied (mainly through application of literature data to physiological models; Emmans and Fisher, 1986; Emmans *et al*., 1988; Emmans and Oldham, 1988)
- On the flock and community level, expected changes (such as flock size, amount of temporary and permanent external inputs, nutrient cycles, and efficiency of utilization and potential degradation of the land available) also needs to be studied.

6. The ICARDA-ILRI-BOKU community based sheep breeding project

The International Centre for Agricultural Research in the Dry Areas (ICARDA), International Livestock Research Institute (ILRI) and the animal breeding group at University of Natural Resources and Applied Life Sciences (BOKU) in Vienna have designed a research project to investigate the conditions and constraints of community-based sheep breeding programs in Ethiopia. The project is implemented in close collaboration with the Ethiopian Institute of Agricultural Research (EIAR), Oromiya Agricultural Research Institute (OARI), Amhara Regional Agricultural Research Institute (ARARI) and Southern Agricultural Research Institute (SARI). Four breeds: Horro (Bako - Shambu areas), Menz (Mehal-Meda areas), Afar/Adal (Werer areas), Bonga (in the Bonga areas) are involved in the project. Two communities each in the four regions were chosen after intensive consultation with national research organizations, local administration, and the communities. The project started with phenotypic characterization of the sheep populations and description of the production systems. Selection criteria of farmers are investigated using the tools described above. Alternative breeding schemes, differing in the level of recording, will be developed. Communities will decide which approach to implement. The implementation will be monitored continuously and after the end of the project.

Representative communities are being actively involved in the project, from the definition of breeding goals and selection criteria to the identification of the most appropriate and acceptable strategy. The project has a capacity building component targeted at improving the ability of communities to manage the breeding programs. Additionally, two PhD and six MSc Ethiopian graduate research students are being trained.

7. Conclusions

The conventional approaches to livestock genetic improvement in developing countries through importation exotic germplasm have in most cases failed. Among the many reasons often sited for the failures, lack of consultation with and involvement of the community keeping the animals has been singled out as the main reason. In the new approach named community based breeding, the community is involved from the inception of the project to implementation and then ownership. It is important to recognize that farmers are innovative in finding ways to combine production and adaptation to their breeding stock. They are also open to opportunities to develop approaches for sustainable improvement. It is important, though, that researchers are not only interested in conducting a study and then leaving. Continuous feedback, during and after the project is of paramount importance.

8. References

Ahuya, C.O., Okeyo, A.M., Mosi, R.O. and Murithi, F.M. 2004. Growth, survival and milk production performance of Toggenburgs and their crosses to East African and Galla goat breeds in the Eastern slopes of Mount Kenya. In: Smith, T., Godfrey, S.H., Buttery, P.J. and Owen, E. (eds.), *The contribution of small ruminants in alleviating poverty: communicating messages from research.* Proceedings of the third DFID Livestock Production Programme Link Project (R7798) workshop for small livestock keepers held at Izaak Walton Inn, Embu, Kenya, 4–7 February 2003. Natural Resources International Ltd, Aylesford, Kent, UK. pp. 40–47.

Ahuya, C.O., Okeyo, A.M, Mwangi-Njuru and Peacock, C. 2005. Developmental challenges and opportunities in the goat industry: The Kenyan experience. *Small Ruminant Research* 60:197–206.

Abad, M., Arrigo, J., Gibbons, A., Lanari, M., Morris G., Taddeo, H. 2002. Breeding scheme for Angora goat production in North Patagonia. 7th World Congress on Genetics Applied to Livestock Production held from 19-23 August 2002 in Montpellier, France.

Emmans, G.C., Fisher, C. 1986. Problems in nutritional theory. In: Fisher, C. and K.N. Bookman (editors), Nutrient Requirements of Poultry and Nutritional Research 9-39. Butterworths, London, UK.

Emmans, G.C., Oldham J.D. 1988. Modelling of growth and nutrition in different species. In: Karver, S. and J.A.M. van Arendonk (editors), Modelling of Livestock Production Systems. Kluwer Academic Publishers, Dordrecht. 13-21.

Emmans, G.C., Land, R.B., Bulfield, G., Hill, W.G. 1988. Genetic components of potential and actual growth. In: Land, R.B., G. Bulfield and W.G. Hill (editors), Animal Breeding Opportunities, Occasional Publication no. 12, 153-181. British Society of Animal Production, Edinburgh, UK.

FAO. 2005. FAO Global Information and Early Warning System on Food and Agriculture World Food Programme (http://www.fao.org/docrep/007/J3958e/J3958e00.htm).

Kosgey, I.S., Baker, R.L., Udo, H.M.J., van Arendonk, J.A.M. 2006. Successes and failures of small ruminant breeding programmes in the tropics: a review. *Small Ruminant Research* 61:13–28.

Mueller, J.P, Flores, E.R., Gutierrez, G. 2002. Experiences with a large-scale sheep genetic improvement project in the Peruvian highlands. En Proceedings VII World Congress on Genetics Applied to Livestock Production, Montpellier, Francia 19-23 de agosto, Communication 25-12 4 p.

Ndumu, D., Wurzinger, M., Baumung, R., Drucker, A., Mwai, O., Sölkner, J. 2005. Size versus Beauty: Farmers`Choices in a Ranking experiment with African Ankole Long-horned Cattle. 56th Annual Meeting of the European Association of Animal Production (EAAP) held from 5–8 June 2005 in Uppsala, Sweden.

Philipsson J, Rege JEO and Okeyo AM 2006. Sustainable breeding programmes for tropical farming systems. *In:* Animal Genetics Training Resource, version 2, 2006. Ojango, J.M., Malmfors, B. and Okeyo, A.M. (Eds). International Livestock Research Institute, Nairobi, Kenya, and Swedish University of Agricultural Sciences, Uppsala, Sweden.

Sölkner, J., Nakimbugwe, H., Valle Zárate, A., 1998. Analysis of determinants for success and failure of village breeding programmes, Proceedings of the 6th World Congress on Genetics Applied to Livestock Production, Armidale, Australia, 12-16 January 1998.

Sölkner, J., M. Wurzinger and L. Iñiguez, 2008. The preliminary basis for community-based breeding plans. Proceedings of a Small Ruminant Production Diversification and Genetic Diversity Workshop on Research Results. March 1-2, 2008, ICARDA, Aleppo, Syria.

Taddeo, H., Arrigo, L., Gibbons, A., Lanari, M.R., Abad, M. 2001. Programa de mejoramiento genético para el sistema de producción de cabras de Angora de Patagonia Norte. 24º Congreso Argentino de Producción Animal. Asociación Argentina de Producción Animal. Septiembre de 2001.

Tibbo, M. (ed.) 2000. Agricultural constraints identification survey for research and development options in Gera Keya Woreda, North Shoa. Survey Report. Jointly organised by the Integrated Food Security Programme (IFSP) of United States Agency for International Development (USAID) and Sheno Agricultural Research Centre. 109 p.

Tibbo, M. 2006. Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopian highlands. PhD dissertation. Department of Animal Breeding and Genetics, Faculty for Veterinary Medicine and Animal Sciences, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden. Available at web: epsilon.slu.se/archive/00001142/01/Markos_Tibbo_corrected.pdf

Wurzinger, M. Ndumu, D., Baumung, R., Drucker, A., Mwai, O., Sölkner, J. 2005. Indigenous selection criteria in Ankole cattle and different production systems in Uganda. 56th Annual Meeting of the European Association of Animal Production (EAAP) held from 5–8 June 2005 in Uppsala, Sweden.

The Genetics of Adaptation in Domestic Farm Animals: A Review

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Introduction

Adaptability of an animal can be defined as the ability to survive and reproduce within a defined environment (Prayaga and Henshall, 2005). Adaptability to the immediate environment is important for the long term sustainable production. Smallholders, pastoralists and their animals often live in harsh environments which may be hot and dry, hot and humid, or high altitude and cold. Such harsh environments are usually characterized by scarce feed and water resources and high disease pressure with large seasonal and between years variations (Sölkner *et al.,* 1998). Adaptation to these factors is largely based on genetics, but animals can "learn" to live under such stressful conditions. Generally, animal keepers can follow two alternative strategies: adapt the environment to the need of the animals (used in industrial animal production) or keep animals adapted to the respective environment (usually employed by smallholders and pastoralists). The physical environment greatly differs between locations and production systems differ according to available resources and economic conditions. Because of this, smallholders and pastoralists need different animal species and diverse types. A much larger variety of livestock breeds with diverse and unique traits that have been created as a result of thousands years of adaptation to region specific environmental conditions and more recent domestication exists than is used in commercial agriculture (NRC, 1993).

There is ample evidence that indigenous livestock that have evolved over the centuries in diverse, often stressful tropical environments, have a range of unique adaptive traits (e.g. disease resistance, heat resistance, water scarcity tolerance, ability to cope with poor quality feed, etc) which enable them to survive and be productive in these environments (Fitzhugh and Bradford, 1983; Devendra, 1987; Baker and Rege, 1994; Baker and Gray, 2004). Marked genetic distinction between taurine and zebu cattle has been reported by McHugh *et al.* (1997) through phylogenetic analysis of microsatellite polymorphisms and the divergence between the two subspecies was estimated to be of the order of 610,000-850,000 years. A prudent conservation and utilization of the diverse genetic resources is of special concern to livestock breeders so that their special characteristics may be adapted to unforeseen social/commercial needs, changing climate, and also to researchers who could study them and expand society's understanding of domestication, selection, genetics and evolution (NRC, 1993).

The Australian beef industry provides one of the best examples of production systems where adapted zebu breeds are utilized through crossbreeding mostly with taurine cattle and formation of synthetic breeds that is evolving as an efficient tool to improve the productive (meat quality) and reproductive (fertility rates) performances of zebu cattle (largely Brahman based herds) as their ability to tolerate the harsh tropical climatic conditions has been well recognized (Prayaga and Henshall, 2005). In the dairy industry emerging problems related to decline in average fertility and health of dairy cows associated with increased genetic merit for milk yield (e.g. Pryce *et al.,* 2004) have attracted the attention of animal breeders to the neglected topic of adaptability of livestock to its environment and production system. Inclusion of functional traits (functional longevity, persistency, fertility, calving ease, still birth and somatic cell count) in a total merit index has been reported to have a positive effect on the annual monetary genetic gain (Sölkner *et al.*,

1999; Willam *et al.*, 2002; Veerkamp *et al.,* 2002; Philipsson and Lindhe, 2003; Samore *et al.*, 2003; Weigel, 2006). Tick counts, fecal worm egg counts (FEC), rectal temperatures and coat scores have been used as indicator traits of adaptability of beef cattle to assess the suitability of particular genotypes to tropical environment (Prayaga and Henshall, 2005). In some cases (e.g. Silanikove, 2000) the physiological basis of adaptation has been investigated in great detail. However, more commonly this detailed assessment is not available, but it is still possible to infer 'adaptability' by measuring total herd or flock productivity, efficiency or net benefits of different breeds (e.g. Fitzhugh and Bradford, 1983; Bosman *et al.,* 1997; Workneh Ayalew *et al.,* 2003). Generally, there is lack of information on the genetic parameters for adaptive traits in livestock populations managed in tropical environments (Prayaga and Henshall, 2005). The purpose of this paper is to review the current state of knowledge on domestication and genetics of adaptation in major livestock species with emphasis on small ruminants. The genetic information available on breeds of sheep and goats that are resistant or resilient to a variety of disease infections, feed and water scarcity and climatic stressors are reviewed.

Domestication

Keeping and breeding animals were practiced by ancient societies before the recorded history of animal domestication in which our present civilization has its roots. To domesticate means to adapt the behavior of an animal to fit the needs of people i.e. it involves adaptation particularly to man and the environment he provides. Thus, domestication is defined as a process by which a population of animals becomes adapted to man and to the captive environment by some combination of genetic changes occurring over generations and environmentally induced developmental events reoccurring during each generation (Price, 1984). Domestication is the first step of selection and has to be distinguished from taming, in that domestication means that breeding (by choice of the reproducers and isolation from wild counterparts), care (shelter, food, protection against predators) and feeding of animals are more or less controlled by humans (Hale, 1969). During the early times, the most important decisive factor for selection is believed to be adaptation (live/survive, reproduce and produce) to a given environment (Gillespie, 1997). The small number of domesticated species can be explained by the characteristics required for domestication including traits such as diet, reproduction, social relationships and behavior toward man (Mignon-Grasteau et al., 2005). Among these characteristics the most important are a strong gregariousness, feeding regimes that can be easily supplied by humans, and precocious young. High maternal ability increases animal autonomy and behavioral plasticity enables them to adapt to captivity constraints and to a wide range of environments and are thus desirable traits (Mignon-Grasteau et al., 2005).

Consequences of domestication could be investigated using methods such as comparison of wild and domestic stocks, longitudinal analysis of wild animals kept in captivity, and molecular genetics techniques (Mignon-Grasteau *et al.,* 2005). The consequences of domestication that resulted in modifications of many traits determining the capacity of adaptation of animals including behavior, physiology and morphology include: proportion of white color has increased in domestic population as a result of attraction to humans and relaxation of natural selection on predation (Pielberg *et al.*, 2008); size has been increased in small species to boost meat quantity but reduced in larger species to make them easier to handle; fat location has been modified (it is stored under the skin and around kidneys in wild animals, and in muscle and around the tail in domestic animals); head or brain size has decreased in most domestic species; behavior has changed quantitatively rather than qualitatively (behavior traits did not appear or disappear, but the threshold of their expression changed (Price, 1999) indicating that if the opportunity is offered to them, domestic species can revert to behaviors observed in related wild species, as the genetic variability is still present in domesticated populations); relaxation of natural selection and natural selection in captivity are partially controlled by humans through determining environmental conditions (Mignon-Grasteau *et al.,* 2005).

Adaptation to the environment and production system

The North Ronaldsay, a breed of sheep indigenous to an island in the northeast coast of Scotland possesses unique adaptive characteristics. This sheep survive exclusively on a diet of seaweed and obtain all nutritional requirements from limited freshwater and abundant kelp beds along the shore; mastered the physiological challenge of handling elements present in excess (e.g. sodium) and hence are very salt tolerant in the face of very limited supply of freshwater; and are adapted to the very low concentration of copper present in *Limnaria* (their most preferred feed). Other breeds found in Scotland, which normally feed on grass or hay, would die from lack of copper if fed *Limnaria* (NRC, 1993). Thus, preserving unique qualities in such and many other livestock breeds will ensure a wealth of genetic resources for future use in basic scientific research and the advancement of the agricultural sciences.

Workneh Ayalew *et al.* (2003) compared productivity of indigenous breeds of goats (Hararghe Highland and Somali) with that of crossbred (Anglo-Nubian x Somali) goats in Ethiopia and concluded the crossbred did not improve households' income in the mixed crop-livestock production system. The authors calculated the net benefits of goats to a household by aggregating the value added by physical products (meat, manure and milk) to socio-economic benefits (saved interest/premium on credit/insurance) and deducting purchased inputs. The result was then expressed as net benefit to each main limiting resource of a household including flock metabolic size, land and labor. There were increased net benefits per unit of land or labor from mixed flocks (i.e. those with both indigenous goats and Anglo-Nubian crosses) under improved management compared with indigenous goats under traditional management. In flocks using the improved management package the crossbreds did not produce more net benefits than indigenous goats either in mixed or separate flocks per unit of flock metabolic weight, per unit of land or per unit of labor. These findings explained the low adoption rate of the exotic crosses by the smallholder farmers. However, the improved management package was successful in improving the net benefits to farmers with indigenous goats which demonstrated the superior adaptability of indigenous goats in this production system and the importance of assessing this adaptability, not just in terms of physical products (i.e. meat, milk and manure) but also accounting for socio-economic benefits. This is in agreement with other studies that emphasize more use could be made of adaptive characteristics, such as parasite resistance (Preston and Allonby, 1979) and disease tolerance (Trail *et al.,* 1988).

Adaptation to humans

The process of animal domestication involves adaptation particularly to man and the environment he provides. Adaptation to humans is reflected by showing low reactions to humans (short flight distance for instance) and low fear reactions; low flight times indicate animals with poor temperaments and high flight times indicate desirable docile temperament (Prayaga and Henshall, 2005). Defensive reactions against humans are still observed in domestic ruminants even though reduced fear of humans is generally considered to be a major component of domestication as routine management procedures (e.g. shearing, castration, tail docking, dehorning, vaccination, herding and transportation in cattle and sheep) can still trigger negative emotions, such as fear, which are generally considered to affect animal welfare negatively (Boissy *et al.*, 2005). Excessive fear may reduce productivity. For instance, fear-related reactions affect sexual and maternal behaviors and social dominance ability in cattle and sheep (Boissy *et al.*, 2005). Lankin (1997), using 467 rams and 1617 ewes of the Soviet meat-and-wool breed at various ages studied the influence of environmental factors on the manifestation and diversity of withdrawal from man in sheep, and also investigated the polymorphism of domestic behavior in 11 breeds. He found that the manifestation and population variability of withdrawal reactions in sheep are under the influence of farming factors which affect their feeding behavior. The author concluded that the common direction of development of adaptive domestic behavior in different breeds presupposes the existence of a universal physiological mechanism of ontogenetic inhibition of fear of man in animals.

Boissy *et al.* (2005) summarized estimates of heritability of fear in dairy and beef cattle and sheep. The estimate ranged between 0.09-0.53 for dairy cattle while a moderate heritability of 0.22 was estimated for reactions to handling in beef cattle. It ranged between 0.28-0.48 in sheep. Thus, genetic selection in ruminant livestock based on reduced fearfulness to increase their adaptive abilities could be as significant for their welfare as the systems in which they are managed. Genetic selection programs for reducing fear responsiveness to handling could be implemented without adverse effect on other desirable productive traits rather could possibly improve some other adaptive behavioral traits such as maternal behavior.

Behavior towards predators

As domestication involves human protection of animals from predators, they express a lower incidence of anti-predator behaviors, probably due to relaxed selection on these traits. Consequently, it might be expected that there would be greater losses than wild animals when faced with predation (Mignon-Grasteau *et al.,* 2005). A few studies in birds have confirmed this hypothesis. Hill and Robertson (1988) showed that captive-reared pheasants were three times more susceptible to predation than wild birds. White Leghorn chickens also showed less anti-predator behavior than Jungle Fowl. Berejikian (1995) demonstrated that wild steelhead trout were less susceptible to predation than farmed trout if they were naive (death rates 12% and 23% in wild and farmed, respectively), and also if they had experienced predation before (death rate 9% and 17% in wild and farmed, respectively). These differential susceptibilities may be linked to greater risk-taking by domesticated animals. Juveniles of steelhead trout have also been found to take more risks with natural predators than their wild counterparts (Johnsson and Abrahams, 1991).

Adaptation to available feed resources

Adaptation to periods of feed scarcity can be in one or more of the following ways: developing low metabolic requirement, ability to reduce metabolism, digestive efficiency and ability to utilize high fiber feed, and deposition of nutrients in the form of fat as feed reserve.

Low metabolic requirements: Having low metabolic requirements is an advantage if feed quality and/or quantity are low. The improved temperate breeds produce more than indigenous tropical breeds if supplied with high quality feed; however, they lose weight and fail to survive when fed poor quality grass or straw, whereas adapted indigenous animals still grow, give some milk and reproduce. It has been deduced that tropically adapted animals generally recycle nutrients more efficiently than do improved temperate breeds (Bayer and Feldmann, 2003) and they can also reduce their basic metabolism during periods of weight loss. The energy requirement of a mammal which is a function of body mass$^{0.75}$ implicates the requirement per kg weight of body tissue in small mammals are relatively greater than that in large mammals. This means their metabolic requirements cannot be met by diets rich in cellulosic matter because anaerobic fermentation is a relatively slow process and bio-energetically less efficient than other forms of digestion (Van Soest, 1982). Small ruminants, therefore, have to balance their comparatively higher energy requirements by eating more food of a higher nutritional value (Demment and Van Soest, 1985). However, small desert breeds such as the black Bedouin goat have been found to be the most efficient exploiter of high-fiber low quality roughage among ruminants and their energy requirement is lower than that predicted from their mass particularly in comparison to relatives from non-desert areas (Silanikove *et al.*, 1980, 1993; Silanikove, 1986a, b, 2000). Silanikove (2000) indicated that the energy requirements of five desert goats weighing each 20 kg are at about the same level as those of goats from a European breed, weighing 100 kg. Thus, the ability to maintain a larger amount of animals on the same area provides an obvious advantage in terms of survival to the desert goats.

Ability to reduce metabolism: Ability to reduce metabolism has been revealed by the ability of most mammals to maintain steady body weights on energy intakes less than they would take voluntarily (Harvey and Tobin, 1982). For instance, the capacity of non-desert Saanen goats is restricted to a level which is 20-30% below their voluntary intake on high quality roughage whereas the Bedouin goats are able to do so with an intake that is 50-55% lower than their voluntary consumption (Silanikove, 2000). Similarly, their fasting heat production under food restriction was 53% lower than predicted by interspecies relationship (Silanikove, 1987). A similar capacity to adjust to a low energy intake by reducing energy metabolism was found in other herbivores, such as zebu cattle and llama, which are annually exposed to long periods of severe nutritional conditions in their natural habitats (Silanikove, 1987, 2000).

Digestive efficiency and ability to utilize high fiber feed: The digestive efficiency of ruminants and their ability to utilize high fiber feed has been extensively reviewed by Silanikove (2000). Ruminants may be classified into a flexible system of three overlapping morphophysiological types: concentrate selectors, grass and roughage eaters and intermediate, opportunistic, mixed feeders (Hofmann, 1989). Grass and roughage eaters are considered to be the most efficient exploiters of lignocellulosic material while concentrate selectors are the least in this regard and base their diet on selection of low-fiber high-quality forage. Domestic goats are a classical example of intermediate feeder with a strong preference for browse feeding (Hofmann, 1989). Goats have better digestive efficiency than other ruminants with high-fiber low-quality forages, and one of the main reasons is the longer mean retention time in the rumen (Devendra, 1990; Tisserand *et al.*, 1991).

Breeds of goats indigenous to semi-arid and arid areas are able to utilize low quality high-fiber feed more efficiently than other types of indigenous ruminants, or exotic breeds of goats (Tisserand *et al.*, 1991; Silanikove *et al.*, 1993). The digestive efficiency of desert black Bedouin goats fed on roughage diets under controlled environment in comparison with Swiss Saanen goats (Silanikove *et al.*, 1980, 1993; Silanikove 1986a, b) and under exposure to the full impact of their natural environment, i.e., heat load and infrequent water regimens (Brosh *et al.*, 1986a, b, 1988; Silanikove and Brosh, 1989) was found to be superior even when good quality hay (alfalfa) was provided. It was more pronounced when medium quality hay and a poorer quality feed (wheat straw) were offered (Silanikove *et al.*, 1980, 1996a, b). The digestibility of the structural carbohydrates (cellulose and hemicellulose) and nitrogen were also higher than in the Saanen goats (53-55% for dry matter and for structural carbohydrates approximately 60% in hydrated animals and 70% in goats given water once in every four days). Such digestive efficiency found in Bedouin goats fed wheat straw has been observed in other ruminants only after chemical processing of the straw (Silanikove, 1986a; Silanikove and Brosh, 1989). In Bedouin goats fed on low-quality roughage, lignin undergoes extensive modification, degradation and absorption during its passage through the gastrointestinal tract enhancing the release and microbial fermentation of structural carbohydrates. The digestive capacity of Bedouin goats enables them to utilize efficiently high-fiber low nitrogen desert pastures. This characteristic is an important asset for their capacity to exist and produce in extreme arid areas and in the face of changing climate (Rischkowsky *et al.*, 2008; Tibbo *et al.* 2008a, b).

Fat deposition as feed reserve: Ruminants store energy in adipose tissues when the quality and quantity of feed is 'adequate', and mobilize it to meet energy demands during periods of scarcity (Geay, 1984; Aziz *et al.,* 1992; Ball *et al.,* 1996; Ørskov, 1998; Eniyew Nigussie *et al.,* 2000; Ewnetu Ermias *et al.,* 2002). In a tropical environment, where wet seasons alternate with dry seasons that are long and generally characterized with low quantity and quality of pasture, the ability to store fat during 'favorable' seasons, and its subsequent use for maintenance, pregnancy and lactation during 'unfavorable' season is an essential strategy for survival. The ability of sheep to survive in hill environments had been associated with greater fat deposition in the internal fat depots (Kempster, 1980).

Eniyew Nigussie *et al.* (2000) compared the patterns of fat deposition in Horro and Menz sheep breeds of Ethiopia and found that subcutaneous fat and gut fat were the major fat depots in Menz and Horro, respectively. Genotype variation in amount of carcass and non-carcass fat was also found: the former represented the largest proportion of total fat in Menz while the later represented the largest proportion in Horro. However, proportion and distribution of tail fat was similar in both breeds (Eniyew Nigussie *et al.,* 2000; Ewnetu Ermias *et al.,* 2002). Comparing the different stages of growth and maturity, Eniyew Nigussie *et al.* (2000) indicated that the growth phase at six months of age that represented the period where a loss in body condition and reserves occurred in both breeds coincided with a marked reduction in the proportion of tail fat compared to all the body fat depot types, indicating its selective mobilization in order to fill the gap of prevailing energy deficiency. Also, the two breeds did not significantly differ in average daily weight gain and feed utilization efficiency for the feeding periods covered by the study (Ewnetu Ermias *et al.,* 2002). However, the weights of the dissected and ether extracted adipose depots and the total body fat were significantly higher in Menz indicating breed differences in composition of gain (i.e., the Menz deposited more fat per unit of gain). Both breeds probably differ less with regard to fat deposition to anticipate fluctuation in nutrient supply, but more in their adaptation to climatic factors. Both may be suited to environments where there is periodic feed fluctuation but Horro is better suited to warmer climates than Menz. As tail and rump fat depots are the most responsive ones to nutritional changes, the mass of these depots relative to the others, may be the 'best' indicator of variations in adaptation to periodic feed fluctuations in fat-tailed sheep breeds. Ewnetu Ermias *et al.* (2002) reported a heritability estimate of 0.72±0.19 for the combined weight of tail and rump fat in Menz breed indicating opportunities for selective breeding.

Adaptation to severe (hot/cold) climates

When animals are exposed to heat stress the biological functions affected include depression in feed intake and utilization, disturbances in the metabolism of water, protein, energy and mineral balances, enzymatic reactions, hormonal secretions and blood metabolites (Habeeb *et al.*, 1992; Marai *et al.*, 2000, 2003, 2006a, 2007), resulting in the impairment of production and reproduction performances. The effect is aggravated when heat stress is accompanied by high humidity. Evaluation of the level of adaptation to heat stress based on the lowest rectal temperature, respiratory frequency and physiological variables as the main parameters under high temperatures was found to be insufficient (Cardoso *et al.*, 2002). However, McManus *et al.* (2008) comparing Santa Inês (with three different coat color – brown, black and white), Bergamasca and Santa Inês x Bergamasca breeds of sheep in Brazil used physiological traits (sweating, respiratory, and heart rates, rectal and skin temperatures) and blood parameters (PCV, total plasma proteins, red blood cell count, and hemoglobin concentration). The authors reported significant differences between animals due to breed, skin type and time of the day and concluded the Santa Inês (hair sheep) with white color were shown to be better adapted to higher environmental temperatures while Bergamasca, wool sheep, were least adapted. Finocchiaro *et al.* (2005) reported the genetic correlation between the general additive effect and the additive effect of heat tolerance to be negative (r = -0.8) for daily milk and fat-plus-protein yields during all periods considered indicating that selection for increased milk production will reduce heat tolerance.

Turner (1980) extensively reviewed the genetic and biological aspects of zebu adaptability and attributed their unique suiting to hot climates to coat, hide, skin, hematological characteristics, form, growth, and physiological aspects which are unique genetic attributes of zebu compared to *B. taurus* cattle. Zebu cattle are smooth coated, have primary hair follicles, have better developed sweat and sebaceous glands than *B. taurus* cattle and can lose more moisture by evaporation and hence have the ability to maintain thermal equilibrium that is a necessary factor for normal function and performance (Turner, 1980).

Cold adaptation involves physiological responses affecting the thermoregulation of animals by making them more able to maintain euthermia during a subsequent cold challenge (Young *et al.*, 1989). The development and retention of a long, thick-winter hair coat evident in many species contributes to thermal insulation. In cattle seasonal changes in hair cover are influenced by daily photoperiod and ambient temperature (Young *et al.*, 1989). In temperate environment, the rate of growth of new hair is inversely related to day length while the rate of shedding hair is associated with thermal status of the animal (Webster, 1974). Morphological modifications (shorter legs and smaller ears) were observed in growing sheep (Young *et al.*, 1989) and swine (Dauncey and Ingram, 1986) probably due to reduced blood flow in peripheral tissues of animals in the cold. Alterations in the distribution of body fat with enhanced subcutaneous deposition have been reported to occur during cold stress to increase peripheral insulation (Webster, 1974). It has been well documented that sheep originating and living in cold areas deposit more of their body fat under the skin compared to those adapted to warmer areas where the degree of heat load is higher (Kempester, 1980; Farid, 1991; Bhat, 1999; Eniyew Nigussie *et al.,* 2000; Ewnetu Ermias *et al.,* 2002).

Eniyew Nigussie *et al.* (2000) and Ewnetu Ermias *et al.* (2002) in their studies that compared Horro and Menz breeds of sheep reported that the combined weight of tail and rump fat accounted for a large proportion of total body fat in the Horro, while the subcutaneous and intramuscular depot accounted for a large proportion of fat in the Menz confirming preferential deposition of fat in specific depots as a result of adaptation to specific environmental conditions in which the animal lives. Hence, the greater deposits of subcutaneous and intermuscular fat in the Menz may be adaptation mechanisms, by which this breed overcomes the lower temperature of its typically cooler highland environment compared to the warmer environment at the slightly lower altitude of the Horro habitat. On the other hand, sheep adapted to arid conditions often deposit less fat under the skin and almost all of the fat deposited is in one area of the body analogous to the hump of the camel, i.e. on the rump and/or the fat tail (Bhat, 1999), also an adaptation strategy to overcome thermal stress since the relative positions of these depots (tail and rump fat) do not impede heat loss from the body. It has also been reported that animals adapted to cold climates have increased circulating erythrocytes and plasma concentration of substrates (glucose and free fatty acids) and hormones (catecholamines and thyroid) associated with energy metabolism (Young *et al.*, 1989).

Adaptation to water scarcity

Breeds of ruminants native to arid lands are known for their ability to withstand prolonged periods of water deprivation and graze far away from watering sites at times 50 km or more far apart (Silanikove, 1994; Bayer and Feldmann, 2003). Livestock which need little water and do not have to go back to a water point every day have the advantage to access larger areas of pastures and thus get more feed. Camels can undergo as long as 15 days of water deprivation (Macfarlane *et al.*, 1963; Kay and Maloiy, 1989); there are also donkey, goat, sheep and cattle breeds that can get along without drinking for several days (Bayer and Feldmann, 2003). Such animals drink large amounts of water quickly but their overall water intake is lower than that of animals which are watered daily. Reduced water intake reduces feed intake and metabolic rate; hence, livestock can survive longer during a drought, when feed is very scarce. Desert goats have been reported to be the most efficient among ruminants concerning their ability to withstand dehydration (Silanikove, 1994). The black Bedouin and the Barmer goats, herded in the extreme deserts of Sinai (Middle East) and Rajasthan (India), often drink only once in every four days (Khan *et al.*, 1979a, b, c; Silanikove, 2000). The small black Moroccan goats use a low water turnover as a mechanism to economize on water (Hossaini-Hilali *et al.*, 1993). The strategy they adopt is a combination of maintaining a frugal water economy and the capacity to endure severe dehydration and rapid rehydration. The water economy of the ibex and of the bighorn sheep are typical examples of such strategy (Silanikove, 1994). The Bedouin goats are able to produce about 1 liter of milk/day while eating low-quality sparse desert pasture (Maltz and Shkolnik, 1984b) and when fed high quality feed, they produce above 2 liters (10% of their body weight) of milk/day (Maltz *et al.*, 1982). Total

milk yields of Bedouin goats subjected to four days of dehydration followed by two days of rehydration were ~70% of normal yields and normal growth of the young was not disturbed (Maltz and Shkolnik, 1984b). Knight and Garcia (1977) suggest that most breeds of goats indigenous to the tropics and subtropics are able to do much better than the Moroccan goats.

A relatively high milk yield is associated with a significant burden on the water economy in lactating goats. The physiological mechanism that enables desert goats to cope with severe water deprivation is their ability to withstand dehydration, and to minimize water losses via urine and feces. The water losses of Barmer and Bedouin goats by the fourth day of dehydration may exceed 40% of their body weight (Khan *et al.*, 1979a, b; Silanikove, 2000); however, when maintained under an intermittent or a partial watering regimen during the summer, the Barmer goats usually gain in body weight at the end of the season. The authors argue that Barmer goats perform better than the Marwari sheep which under similar water restriction conditions lost 6% of their body weight/day (Purohit *et al.*, 1972; Ghosh *et al.*, 1976). Silanikove (1994) concluded that the gut (mostly the rumen) provides the major portion of the water lost during dehydration, which explains their capacity to withstand a higher level of weight loss during dehydration than most mammals. The role of the rumen as a water reservoir is more pronounced in desert species and breeds, particularly in goats.

Disease tolerance/resistance

Genetic diversity in livestock is important with respect to disease resistance as disease-causing organisms continue to evolve. If a new strain of a disease or a new disease occurs in a country, animals with a narrow genetic base may all be affected whereas in genetically diverse livestock, the chances that some animals survive, when others die, increase. Native livestock are less affected by ticks and worms than imported ones. In tsetse infested areas of Africa, indigenous cattle have developed some tolerance to tsetse and trypanosomosis challenge, whereas imported livestock die, if not treated with chemicals. In West Africa, local cattle, sheep and goats have developed resistance to heart water, a deadly disease for imported animals or crossbreds (Bayer and Feldmann, 2003). In this review, we are limited to presenting some genetic evidences of tolerance to or resistance against parasitic and bacterial diseases.

Parasitic diseases: Resistance to infections with endoparasites is defined as the initiation and maintenance of responses provoked in the host to suppress the establishment of parasites and/or eliminate parasite burdens (Baker and Gray, 2004). Resilience (or tolerance) is the ability of the host to survive and be productive in the face of parasite challenge (Albers *et al.,* 1987; Woolaston and Baker, 1996; Baker and Gray, 2004) and in New Zealand it has been defined as the number of anthelmintic treatments needed over a given period of pasture challenge (usually several months) with nematode parasites (Bisset and Morris, 1996). For livestock challenged with gastro-intestinal (GI) nematode parasites the degree of resistance has usually been assessed in terms of worm counts at necropsy or fecal egg counts (FEC) during an infection period in live animals. In lambs it is well documented that FEC are highly correlated with worm counts (Woolaston and Baker, 1996). Packed red cell volume (PCV) and mortality rates have also been used as proxies for resilience (Baker *et al.*, 2003). When sheep are infected with the blood-sucking parasite *H. contortus* they become anemic and this is measured by PCV, which is a good indication of how the animal is managing to cope with the pathogenic effects of the parasite and to survive when infected. Albers *et al*. (1987) treated both FEC and PCV as two different measures of resistance.

As extensively reviewed by Bishop and Morris (2007), genetic differences between host animals in nematode parasite resistance have been observed in all major production environments and for a variety of parasite species including H. contortus, T. colubriformis, T. circumcincta and various Nematodirus species. In most cases, it is the impact of nematode parasites on the growing lamb or kid that is of interest. However, nematode infections are also problematic for reproductive females

undergoing the stress of late gestation and early lactation and some attention has been given to host genetic variation in resistance during the peri-parturient period.

In Africa, several studies that compared sheep breeds for resistance to GI nematodes have been carried out (Preston and Allonby, 1978, 1979; ILCA, 1991, Baker *et al.,* 1994, 1998, 1999, 2002, 2003); most of these were done by the International Livestock Research Institute. Main findings indicate that the Red Maasai breed is both resistant and resilient to endoparasites, particularly to *H. contortus* than Dorper lambs as reflected by their significantly higher PCV (ability to control anemia), lower FEC (lower worm burden), and lower lamb mortality (Baker *et al.,* 1994, 1998). In another report, Baker *et al.* (2002) concluded that there is little difference between the two breeds in overall output or efficiency in semi-arid conditions with a low parasite challenge; however, under humid conditions where parasite (*H. contortus*) challenge is high, the more resistant Red Maasai has an output per hectare three times greater than the Dorper and is five times more efficient. Baker *et al.* (1994, 1998) also compared four crossbred sheep genotypes and found an additive genetic breed effect for both PCV and FEC indicating that crossbreds with higher proportion of Red Maasai blood are more resistant, but no heterosis was reported in their study for either PCV or FEC.

Other tropical breeds considered resistant based on anecdotal evidences that they survive and thrive in the stressful environments where they are found under severe disease challenge include the West African Djallonke sheep which may be resistant to both endoparasites and trypanosomosis (Baker, 1995; Osaer *et al.*, 1999) and the Garole sheep in India (Ghalsasi *et al.*, 1994). Nimbkar *et al.* (2003) compared the resistance to *H. contortus* of F_1 Garole crossbred lambs with that of Bannur, Deccani and 50% Bannur/50% Deccani lambs in India and found that lambs with 50% Garole genes were significantly more resistant than the other breeds and crosses tested. Boyce *et al.* (1987) found significant breed differences in FEC and fluke counts after five breeds of sheep were experimentally infected with *F. hepatica*. Barbados Blackbelly sheep were the most susceptible to infection while St. Croix and Florida Native sheep were the most resistant. Wiedosari and Copeman (1990) reported relatively high resistance to *F. gigantica* in Javanese Thin Tail sheep, although there was no contemporary breed comparison. Roberts *et al.* (1997a, b) compared the resistance to *F. gigantica* of Indonesian Thin Tail (sampled from Java and Sumatra) with St. Croix, F_2, and F_3 crosses between these breeds and concluded that the Indonesian Thin Tail were more resistant than St. Croix. The authors also stated that resistance may be controlled by a major gene with incomplete dominance. In contrast, the Indonesian Thin Tail sheep were as susceptible to *F. hepatica* as the Merino sheep that they were compared with (Roberts *et al.*, 1997a).

Studies by ILRI that evaluated Menz and Horro sheep in the central highlands of Ethiopia have shown that, under natural pasture challenge, there was no difference in resistance to endoparasites between the two indigenous breeds (Baker *et al.*, 1994, 1998; Tembely *et al.*, 1998; Rege *et al.*, 2002). However, under artificial challenge there was some evidence that the Menz may be somewhat more resistant than Horro lambs (Aynalem Haile *et al.,* 2002). Rege *et al.* (2002) reported a dramatic and economically important breed effect in their study that compared Menz and Horro breeds of sheep at Debre Berhan Research Station for mortality rate for which the overall cumulative mortality from birth to 12 months of age was 37.3% for the Menz and 67.6% for the Horro lambs. Mukasa-Mugerwa *et al.* (2000) investigated the causes of lamb mortality and found that the most important cause of death for lambs was pneumonia, which accounted for 54% of all deaths. Endoparasite infections as a cause of mortality were of limited importance in both breeds (accounting for about 10% of deaths). With regard to reproductive performance of the ewes and overall flock productivity, Menz sheep had a significantly higher weaning rate (lambs weaned per ewe mated) than the Horro ewes (0.73 *vs.* 0.57) and ewes which lambed in the wet season had a significantly higher ($P<0.001$) weaning rate than those that lambed in the dry season (0.76 *vs.* 0.53). Menz ewes showed their superiority in weaning rate over the Horro ewes more clearly when lambing in the wet season (0.85 *vs.* 0.67) than when lambing in the dry season (0.59 *vs.* 0.47). The

authors expressed overall flock productivity in terms of potential off-take (number of sheep sold) of yearling sheep from flocks of Menz or Horro ewes lambing in either the wet or dry seasons. Both as number of yearling sheep and total live weight for sale, the off-take of a flock of Menz sheep in this environment was about three times greater than a flock of Horro sheep when they lambed in the wet season, and about twice greater when they lambed in the dry. These results clearly demonstrate that, at least in this high altitude environment in Ethiopia, Menz sheep are better adapted than Horro sheep. However, the biological determinants of this adaptation are still unclear. Moreover, the study was conducted in an environment close to the home tract of Menz and yet attempted to compare Horro breed originating from a sub-humid warm environment with Menz adapted to cool temperate climate. Similar comparisons of performance should have been carried out in the home tract of Horro so that G × E interaction could be explored well and also be able to state indisputable conclusions. Thus, it is difficult to conclude that Menz breed is superior to Horro for the traits considered in the study. Besides, this study, and many others were carried out on a research station, which may not necessarily reflect the situation that applies on smallholder farms. Gebrekiros Asegede (1990) compared 4 breeds of Ethiopian sheep (Afar and Blackhead Somali native to semi-arid lowlands, Horro and Arsi from humid highlands) for their resistance to endoparasites, mainly *H. contortus,* at Awassa in southern Ethiopia and found that the Blackhead Somali were the most susceptible while the Arsi were the most resistant.

The evidence for genetic variation for resistance to endoparasites among goat breeds is limited. As for sheep, it is usually the indigenous goat breeds (e.g. the Alpine goats in France and the Small East African (SEA) in Kenya) that are more resistant (Baker and Gray, 2004). The SEA kids were more resistant than the Borana1 kids as evidenced by their lower FEC post-weaning but they found no breed difference for PCV (Baker et al., 1994, 1998). It is possible that the mechanisms or level of resistance may be different in sheep and goats, since goats are predominantly browsers they are likely to have been under less intense natural selection for resistance (Baker et al., 2001).

Many studies have quantified within-breed heritabilities, usually using FEC as the indicator of relative nematode resistance. Once appropriately transformed, FEC is a moderately heritable trait in lambs, and one which responds to selection (McEwan et al., 1992, 1995; Woolaston and Piper, 1996; Woolaston and Windon, 2001; Morris et al., 1997a, 2000; Bishop et al., 1996, 2004; Gruner et al., 2004; Eady et al., 1996). FEC tends to be less heritable in kids and does (Woolaston et al., 1992; Morris et al., 1997b; Mandonnet et al., 2001; Vagenas et al., 2002). However, Vagenas et al. (2002) showed that responses to selection for decreased FEC can be achieved over a short time period. In the periparturient ewe, FEC is also a moderately heritable trait (Woolaston, 1992; Morris et al., 1998; Bishop and Stear, 2001) as well as being genetically correlated with resistance in the lamb (Morris et al., 1998). Resistance to different species of nematodes tends to be related, with genetic correlations between the FEC values arising from different species or genera of parasites generally being close to 0.5 (e.g. Bishop et al., 2004) or higher in some cases (e.g. Gruner et al., 2004). Douch et al. (1995), working with Romney ewes in New Zealand, studied the antibody levels against antigens from infective larvae of C. curtecei, H. contortus, O. circumcincta, or T. colubriformis and immunoglobulin G1 (IgG1) specific to C. curtecei or T. colubriformis and reported heritability values for antibody and IgG1 ranging from 0.18 to 0.37 with average of 0.26 (for details, refer to the article). Heritabilities of loge (FEC + 100) and dag score (measure of breach soiling) were 0.28 and 0.13, respectively. Phenotypic correlations among the 6 antibody and IgG1 traits averaged 0.55, whilst the genetic correlations among them were even higher, averaging 0.83. Phenotypic and genetic correlations between antibody or IgG1 and loge (FEC+100) were all negative and generally small, with genetic correlations averaging -0.15. Antibody and IgG1 were positively correlated genetically with dag score (average value 0.35).

1 This nomenclature has been used in this article (the breed is so named in its home tract of Southern Ethiopia) instead of the offensive term used by the authors of the quoted article.

Studies in sheep to detect quantitative trait loci (QTL) for nematode resistance or detect associations with candidate genes are now well advanced in New Zealand, Australia, Kenya, US and Europe (UK, France, Italy and Spain) although results are not readily available in the public domain (Bishop and Morris, 2007). Several studies have also looked at associations between specific genes or markers and FEC. Coltman et al. (2001) found significant associations with a microsatellite within the interferon gamma gene in feral sheep, and various associations with microsatellites in or near the MHC have been observed (Schwaiger et al., 1995; Janssen et al., 2002).

To summarize, genetic variation in many aspects of host resistance to nematodes is well documented. There has been some success in QTL detection, but generally the number of significant QTL reported is probably less than expected given the input into this area. The current trends are to attempt to fine map QTL, for example using dense single nucleotide polymorphism (SNP) markers, and to study the functional significance of genes that may underlie host responses to infection (Bishop and Morris, 2007). Early results suggest that microarray studies do have the ability to detect genes differentially expressed between 'resistant' and 'susceptible' animal, with pathways implicated in these differences including the development of acquired resistance and the structure of the intestinal smooth muscle (Diez-Tascon et al., 2005).

Bacterial diseases: Mastitis is an inflammation of the mammary gland resulting from bacterial infections particularly staphylococci. Subclinical mastitis is generally diagnosed by an increase in somatic cell counts (SCC) in the milk of cows and ewes, although in goats the predictive value of SCC is less established (Bergonier et al., 2003). SCC may also be used to help select for increased resistance to mastitis though recent estimates of heritability for SCC are generally low ranging between 0.10 to 0.20 (Mrode and Swanson, 1996; El-Saied et al., 1999; Barillet et al., 2001; Rupp et al., 2003; Serrano et al., 2003; Gonzalo et al., 2003; Legarra and Ugarte, 2005; Bishop and Morris, 2007). The review by Mrode and Swanson (1996) summarized many genetic estimates, concluding that the heritability of mastitis incidence in dairy cattle is low (~0.04), as also is the heritability of SCC (0.11 ± 0.04), but the genetic correlation between the two is high at ~0.70. Attention is now turning to the mapping of QTL for SCC in dairy ewes, in both experimental crosses and commercial breeding programs, as described by Barillet et al. (2005).

In spite of the low heritabilities, numbers of daughters per young sire are generally large enough that breeding values for SCC can be determined accurately for dairy sires, and effective selection against SCC can then be applied. In many dairy countries today, a selection index approach is used, combining various production and disease traits, including milk yield and SCC (Sölkner *et al.,* 1999; Willam *et al.,* 2002). Analyses of large data sets have shown that there is a small unfavorable genetic correlation between SCC and first-lactation milk yield (the weighted estimate from Mrode and Swanson (1996) being 0.14 ± 0.04, as indicated above), but this correlation can be broken by appropriate genetic selection. Heringstad *et al.* (2003) reported a 0.19 percentage point annual decrease in cases of clinical mastitis in Norway since the 1990 calf crop, from using index selection, whereas clinical mastitis would otherwise increase with positive selection for milk yield alone. There have been questions about the ability of the immune system to function effectively against mastitic pathogens if SCC is selected downwards genetically. Philipsson *et al.* (1995) used extensive Swedish industry data to investigate this subject, testing for non-linearity in the relationship between clinical mastitis values and SCC for sires. From the size and linearity of the genetic relationship between clinical mastitis and SCC, they concluded that cell counts reflected levels of infection, and that lower cell counts did not indicate any lowered ability to fight infection.

Footrot, a bacterial disease caused by Dichelobacter (Bacteroides) nodosus (D. nodosus), is a common cause of lameness in both lambs and mature sheep, and it is considered to be one of the major welfare problems in sheep; it is also a major cause of economic loss. Currently it is estimated to have economic costs to the UK industry of £31M per annum (Nieuwhof and Bishop, 2005; Bishop

and Morris, 2007). Assessing the genetic control of footrot and subsequently breeding for resistance is simple due to the fact that footrot severity is relatively easily scored under field conditions. As reviewed by Bishop and Morris (2007), Egerton and Roberts (1971) developed a footrot lesion scoring method using Australian Merino sheep which was later refined by Raadsma (2000a) into a system that separated clinical signs into 8 categories. Using this system, Raadsma et al. (1994) demonstrated substantial genetic variation in resistance both to challenge with virulent isolates of D. nodosus, and also to natural challenge. Heritabilities of individual assessments of severity of the disease were low to moderate; however, genetic correlations between indicators were high, approaching unity, and heritability estimates from repeated measurements approached 0.30. A practical application of this approach has been described by Patterson and Patterson (1989) who successfully bred for enhanced footrot resistance in Merinos. Additional evidence of the feasibility of selecting sheep for footrot resistance using phenotypic observations is given by Skerman and Moorhouse (1987), who report an evaluation of lines of New Zealand Corriedale ewes selected for enhanced footrot resistance. Therefore, breeding for enhanced footrot resistance using phenotypic assessment alone is possible and feasible, provided that footrot is present in the flock (Bishop and Morris, 2007). Less work has been done on QTL or genetic marker tests for footrot resistance than on phenotypic assessment of resistance; however, associations between resistance and MHC markers, particularly within the MHC class II region, have been published (Litchfield et al., 1993; Escayg et al., 1997). A specific association with the DQA2 gene has been used in New Zealand as a marker for footrot resistance (Hickford et al., 2004). This test is now commercially available (Hickford, 2000) as a tool to select more tolerant or resistant animals, without having to expose the animals to infection.

Resource allocation theory (production vs. fitness traits)

Under selection within a particular environment the resources used by the animal are optimally distributed between the important traits for breeding and production within that environment (Beilharz *et al.*, 1993) implying that any additional selection mediated increase in performance of a production-related trait, without a concurrent increase in resources, must lead to declines in other traits, due to reallocation of resources (Mignon-Grasteau *et al.,* 2005). The decrease in these traits is proportional to the heritability of the "*resource allocation factor*", defined by the proportion of resources devoted to production vs. fitness (van der Waaij, 2004; Mignon-Grasteau *et al.,* 2005). In animal production, negative correlations are observed between production and fitness-related traits, such as fertility and health (Rauw *et al.,* 1998). In lactating animals, poor BCS during the period of negative energy balance results in decreased fertility (Pryce *et al.,* 2000). It seems that energy allocated to production cannot be applied to other body functions, resulting in increased health and fertility problems (Collard *et al.,* 2000). Apart from the balance between production and health and fertility, the selection environment influences animal performance. For example, the effect of the negative energy balance has been partly compensated for by improving the environment. However, despite these actions, negatively correlated responses to increased production are becoming stronger: environmental sensitivity increases and is especially expressed in decreased fertility. Animals tend to adapt to the environment they are selected in, which may result in the development of a genotype × environment (G × E) interaction. It is clear that selection for production may lead to problems in health and fertility, and that under some circumstances, G × E may develop.

According to van der Waaij (2004), production gets first priority in contrast to what happens under natural selection in resource allocation; when selection is on observed production and resource intake is limited, selection pressure is consequently shifted toward resource intake and allocation of proportionally more resources for production and away from fitness. An insufficient proportion of resources allocated to fitness may result in decreased health, fertility, and energy available for maintenance, with consequences for reproduction rate and probability of survival. Beilharz *et al.* (1993) and Knap and Bishop (2000) argue that when resources become limiting, a negative corre-

lation between production traits and fitness-related traits will result. Results of a modeling study by van der Waaij (2004) indicate that environmental sensitivity, indicated by the negative correlation between observed production and survival probability, develops as soon as there is metabolic stress. Kolmodin *et al.* (2002) also found a similar trend in environmental sensitivity in Scandinavian dairy cattle. Apparently, the animals with the highest observed production (trait under selection) tend to be the animals with poorer values for the *"resource allocation factor"*, and thus are those with increased environmental sensitivity. Under artificial selection, when the weighting given to production is increased, highly specialized animals will have difficulty in adapting to changes in their breeding conditions, as no buffer is left to respond to unexpected changes (and hence care must be taken in introducing highly specialized breeds in to the tropical environment) as equilibrium is expected to be reached within a given environment. If the weighting given to production is disproportionate, resources are diverted from other traits such as health or reproduction (e.g. high-producing dairy cows often have reproduction or health problems).

Conclusion

Livestock productivity remains relatively low in the tropics particularly in sub-Saharan African countries despite the crucial role of livestock in the economies of many countries in the region. Breed improvement programs serve as natural entry points for productivity increases. However, the tendency for genetic improvement programs to concentrate on one aspect, such as meat or milk, in isolation from broader livelihood system needs often results in the substitution of exotic cattle for indigenous breeds (Tano et al., 2003). This emanates from the commonly held view that most indigenous livestock breeds are 'unproductive' (when traits like milk and beef are considered in isolation) because of, for example, small size and high mortality rates despite the well documented evidences that they are well adapted to their stressful environments. This has resulted in many misguided livestock improvement programs importing exotic breeds which are assumed to be more productive based on their performances in their conducive environments of origin (Baker and Gray, 2004; Abdulai and Huffman 2005). Ouma et al. (2007) carried out a choice experiment in Kenya and Ethiopia to examine farmers' preferences for cattle traits and indicated that good traction potential, fertility, and trypanotolerance were found to be the most preferred traits in the model of bull preferences while the most valued traits in the cow preference models were trypanotolerance and reproductive performance. In their study, quite significant and interesting was the finding that traits related to beef and milk yield were ranked below the adaptive traits mentioned above. These findings are particularly interesting because traditional economic analyses on livestock and cattle breeding programs often focus on raising milk and meat productivity, with little emphasis on the non-income traits such as traction and disease resistance. For example, the National Sahiwal Stud of Kenya, which was established with the objective of improving the breed for milk and meat production in marginal areas, focuses its selection criteria for the breeding stock on traits associated with meat and milk production such as lactation milk yield, age at first calving, calving interval, and growth rate without consideration of adaptation traits, which may be useful for marginal areas (Mpofu and Rege, 2002).

Genetic parameters and variance components are useful for making sound selection decisions and implementing successful breeding programs (Prayaga and Henshall, 2005). It is important to recognize the potential importance of G × E interactions issue when assessing individual animal/herd/flock productivity. It is also important to have a good understanding of the production systems and the relative importance of the different constraints to production in these systems before initiating any livestock improvement program. The three broad categories of constraints are ecological, biological (low quantity and quality of feed, lack of water, high disease prevalence, and perceived poor genetic potential) and socioeconomic (Fitzhugh and Bradford 1983). Most production systems are affected by several of these and often there are important interactions among them. It is commonly observed that traditional livestock management practices in the tropics, developed by trial

and error through generations of experience, often make efficient use of available resources with minimal external inputs or risk to producers. Sölkner et al. (1998) argue strongly that the decisive but most frequently missing step in the design of village breeding programs is the definition of a breeding objective. The authors also suggest that breeding objectives must be formulated in close collaboration with smallholder farmers with particular attention to the importance of risk avoidance, particularly in marginal environments. There are three pathways of genetic improvement (Sölkner et al., 1998): improvement of local breeds through purebred selection, breed substitution (by other local breeds or, more frequently, by exotic breeds), and systems of crossbreeding (terminal crosses, rotations, formation of synthetic lines). Whichever pathway to follow, choice of the most appropriate breed or breeds to use in a given environment or production system should be the logical first step when initiating a breeding program and due attention must be given to the adaptive performance. However, selection of purebred local breeds is often deemed as a method that will produce genetic gains too slowly to meet the increasing demand of a growing population and superiority of exotic breeds is taken for granted given that these animals produce so much more (e.g., milk yield) under temperate conditions than local breeds; unfortunately, importing live animals and placing them into village conditions has almost invariably produced devastating results (Hodges, 1990, cited by Sölkner et al., 1998). Therefore, the importance of identifying the most adapted genotype capable of coping with the environmental challenges posed by any particular production system has been indicated.

References

Abdulai, A., Huffman, W.E., 2005. The diffusion of new agricultural technologies: the case of crossbred-cow technology in Tanzania. Am. J. Agri. Econ., 87:645-59.

Albers, G.A.A., Gray, G.D., Piper, L.R., Barker, J.S., Le Jambre, L.F., Barger, I.A., 1987. The genetics of resistance and resilience to *H. contortus* in young Merino sheep. Int. J. Parasitol. 17, 1355-1363.

Aynalem Haile, Tembely, S., Anindo, D.O., Mukasa-Mugerwa, E., Rege, J.E.O., Alemu Yami, Baker, R.L., 2002. Effects of breed and dietary protein supplementation on the responses to gastro-intestinal nematode infections in Ethiopian sheep. Small Rumin. Res. 44, 247-261.

Aziz, N.N., Murray, D.M., Ball, R.O., 1992. The effect of live weight gain and live weight loss on body composition of Merino wethers: chemical composition of the dissected components. J. Anim. Sci. (70), 3412-3420.

Baker, R.L., Rege, J.E.O. 1994. Genetic resistance to diseases and other stresses in improvement of ruminant livestock in the tropics. Proc. 5th WCGALP, 20, 405-412.

Baker, R.L., Mwamachi D.M., Audho, J.O., Aduda, E.O., Thorpe, W., 1994. Genetic resistance to gastrointestinal nematode parasites in Red Maasai sheep in Kenya. Proc. 5th WCGALP, 20, 277-280.

Baker, R.L., 1995. Genetics of disease resistance in small ruminants in Africa. In: Gray, G. D., Woolaston, R. R., Eaton, B. T., (eds.), Breeding for resistance to infectious diseases of small ruminants. Canberra, ACIAR Monograph No. 34, pp. 120-138.

Baker, R.L., Mwamachi, D.M., Audhoa, J.O., Aduda, E.O., Thorpe, W., 1998. Resistance of Borana and Small East African goats in the sub-humid tropics to gastrointestinal nematode infections and the peri-parturient rise in fecal egg counts. Vet. Parasitol., 79, 53-64.

Baker, R.L., Mwamachi D.M., Audho, J.O., Aduda, E.O., Thorpe, W., 1999. Genetic resistance to gastro-intestinal nematode parasites in Red Maasai, Dorper and Maasai x Dorper ewes in the sub-humid tropics. Anim. Sci. 69, 335-344.

Baker, R.L., Audho, J.O., Aduda, E.O., Thorpe, W., 2001 Genetic resistance to gastro-intestinal nematode parasites in Borana and Small East African goats in the sub-humid tropics. Anim. Sci. 73, 61–70.

Baker, R.L., Mugambi, J.M., Audho, J.O., Carles A.B., Thorpe, W., 2002. Comparison of Red Maasai and Dorper sheep for resistance to gastro-intestinal nematode parasites, productivity and efficiency in a humid and a semi-arid environment in Kenya. Proc. 7th WCGALP, 31, 639-642.

Baker, R.L., Rodriguez-Zas, S.L., Southey, B.R., Audho, J.O., Aduda, E.O., Thorpe, W., 2003. Resistance and resilience to gastro-intestinal nematode parasites and relationships with productivity of Red Maasai, Dorper and Red Maasai x Dorper crossbred lambs in the sub-humid tropics. Anim. Sci. 76, 119-136.

Baker, R.L., Gray, G.D., 2004. Appropriate breeds and breeding schemes for sheep and goats in the tropics. In: Sani, R. A., Gray, G. D., Baker, R. L. (eds.). Worm Control for Small Ruminants in Tropical Asia, Canberra, ACIAR Monograph No. 113, 63-96.

Ball, A.J., Thompson, J.M., Pleasants, A.B., 1996. Seasonal changes in body composition of growing Merino sheep. Livest. Prod. Sci. 46, 173-180.

Barillet, F., Rupp, R., Mignon-Grasteau, S., Astruc, J.M., Jacquin, M., 2001. Genetic analysis for mastitis resistance and milk somatic cell score in French Lacaune dairy sheep. Genet. Sel. Evol. 33, 397-415.

Barillet, F., Arranz, J.J., Carta, A., 2005. Mapping quantitative trait loci for milk production and genetic polymorphisms of milk proteins in dairy sheep. Genet. Sel. Evol. 37, S109-S123.

Bayer, W., Feldmann, A., 2003. Diversity of animals adapted to smallholder system. In: Conservation and sustainable use of agricultural biodiversity. http://www.eseap.cipotato.org/UPWARD/Agrobio-sourcebook.htm

Beilharz, R.G., Luxford, B.G., Wilkinson, J.L., 1993. Quantitative genetics and evolution: Is our understanding of genetics sufficient to explain evolution? J. Anim. Br. Gen. 110:161-170.

Berejikian, B.A., 1995. The effects of hatchery and wild ancestry and experience on the relative ability of steelhead trout fry (Oncorhyncus mykiss) to avoid a benthic predator. Can. J. Fish. Aquat. Sci. 52, 2476-2482.

Bergonier, D., De Cremoux, R., Rupp, R., Lagriffoul, G., Berthelot, X., 2003. Mastitis of dairy small ruminants. Vet. Res. 34, 689-716.

Bhat, P.N., 1999. Sheep. In: Payne, W.J.A.; Wilson, T. (eds), An Introduction to Animal Husbandry in the Tropics, 5th Edn. Blackwell Science Ltd, UK.

Bishop, S.C., Bairden, K., McKellar, Q.A., Stear, M.J., 1996. Genetic parameters for faecal egg count following mixed, natural predominantly *Ostertagia circumcincta* infection and relationships with live weight in young lambs. Anim. Sci. 63, 423-428.

Bishop, S.C., Stear, M.J., 2001. Inheritance of, and factors affecting, egg counts during early lactation in Scottish Blackface ewes facing mixed, natural nematode infections. Anim. Sci. 73, 389–395.

Bishop, S.C., Jackson, F., Coop, R.L., Stear, M.J., 2004. Genetic parameters for resistance to nematode infections in Texel lambs. Anim. Sci. 78, 185-194.

Bishop, S.C., Morris, C.A., 2007. Genetics of disease resistance in sheep and goats. Small Rumin. Res., (70), 48-59.

Bisset, S.A., Morris, C.A., 1996. Feasibility and implications of breeding sheep for resilience tonematode challenge. Int. J. Parasitol. 26, 857-868.

Boissy, A., Fisher, A.D., Bouix, J., Hinch, G.N., Neindre, P.L., 2005. Genetics of fear in ruminant livestock. Livest. Prod. Sci., 93, 23-32.

Bosman, H.G., Moll, H.A.J., Udo, H.M.J., 1997. Measuring and interpreting the benefits of goat keeping in tropical farm systems. Agricultural Systems, 53, 349-372.

Boyce, W.M., Courtney, C.H. Loggins, P.E., 1987. Resistance to experimental infection with Fasciola hepatica in exotic and domestic breeds of sheep. Int. J Parasitol., 17, 1233-1237.

Brosh, A., Choshniak, I., Tadmor, A., Shkolnik, A., 1986a. Infrequent drinking, digestive efficiency, digestive efficiency and particle size of digesta in black Bedouin goats. J. Agric. Sci. (Camb.) 106, 575-579.

Brosh, A., Shkolnik, A., Choshniak, I., 1986b. Metabolic effects of infrequent drinking and low-quality feed on Bedouin goats. Ecology 67, 1086-1090.

Brosh, A., Aharoni, Y., Degen, A.A., Wright, D., Young, B., 1988. Estimation of energy expenditure from heart rate measurements in cattle maintained under different conditions. J. Anim. Sci., (76), 3054-3064.

Cardoso, S.J.M., Gomes, da S.R., Mario, C.M., Carneiro, B.C.S.S., Paranhos, da C.M.J.R., 2002. Analysis of some physiological variables for the evaluation of the degree of adaptation in sheep submitted to heat stress. Revi. Brasileira Zootec. 31 (5), 2070-2077.

Collard, B.L., Boettcher, P.J., Dekkers, J.C.M., Petitclerc, D., Schaeffer, L.R., 2000. Relationships between energy balance and health traits of dairy cattle in early lactation. J. Dairy Sci. 83:2683-2690.

Coltman, W., Pilkington, J., Krunk, L.E.B., Wilson, K., Pemiberton J.M., 2001. Positive genetic correlation between parasite resistance and body size in a free-living ungulate population. Evolution, 55(10), 2116-2125.

Dauncey, M.J., Ingrain, D.L., 1986. Acclimatization to warm or cold temperatures and the role of food intake. J. Therm. Biol. 11:89.

Demment, M.W., Van Soest, P.J., 1985. A nutritional explanation for body size patterns of ruminant and non-ruminant herbivores. Am. Naturalist 125, 640-671.

Devendra, C., 1987. Goats. In: Johnson, H.D., (ed.), World Animal Science B5. Disciplinary approach, bioclimatology and adaptation of livestock, Amsterdam, Elsevier, pp. 157-168.

Devendra, C., 1990. Comparative aspects of digestive physiology and nutrition in goats and sheep. In: Devendra, C., Imazumi, E. (Ed.), Ruminant Nutrition and Physiology in Asia, pp. 45-60.

Diez-Tascon, C., Keane, O.M., Wilson, T., Zadissa, A., Hyndman, D.L., Baird, D.B., McEwan, J.C., Crawford, A.M., 2005. Microarray analysis of selection lines from outbred populations to identify genes involved with nematode parasite resistance in sheep. Phys. Genom. 21, 59-69.

Douch, P.G.C., Green, R.S., Morris, C.A., Hickey, S.M., 1995. Genetic factors affecting antibody responses to four species of nematode parasite in Romney ewe lambs. Int. J. Parasitol., 25, 823-828.

Eady, S.J., Woolaston, R.R., Mortimer, S.I., Lewer, R.P., Raadsma, H.W., Swan, A.A., Ponzoni, R.W., 1996. Resistance to nematode parasites in merino sheep: sources of genetic variation. Aust. J. Agric. Res. 47, 895-915.

Egerton, J.R., Roberts, D.S., 1971. Vaccination against ovine footrot. J. Comp. Pathol. 81, 179-370.

El-Saied, U.M., Carriedo, J.A., De la Fuente, L.F., San Primitivo, F., 1999. Genetic parameters of lactation cell counts and milk and protein yields in dairy ewes. J. Dairy Sci. 82, 639-644.

Eniyew Nigussie, Rottmann O.J., Pirchner F., Rege J.E.O., 2000. Allometric growth coefficients and partitioning of fat deposits in indigenous Ethiopian Menz and Horro sheep breeds. In: R.C. Merkel, G. Abebe and A.L. Goetsch (eds.). The opportunities and challenges of enhancing goat production in East Africa. Proc. of a conference held at Debub University, Awassa, Ethiopia from November 10-12, 2000. E (Kika) de la Garza Institute for Goat Research, Langston University, Langston, OK, pp. 151-163.

Escayg, A.P., Hickford, J.G.H., Bullock, D.W., 1997. Association between alleles of the ovine major histocompatibility complex and resistance to footrot. Res. Vet. Sci. 63, 283-287.

Ewnetu Ermias, Alemu Yami, Rege, J.E.O., 2002. Fat deposition in tropical sheep as adaptive attribute to periodic feed fluctuation. J. Anim. Breed. Genet. 119, 235-246

Farid, A., 1991. Slaughter and carcass characteristics of three fat-tailed sheep breeds and their crosses with Corriedale and Targhee rams. Small Rumin. Res. (5) 55-271.

Finocchiaro, R., van Kaam, J.B.C.H.M., Portolano, B., Misztal, I., 2005. Effect of heat stress on production of Mediterranean dairy sheep. J. Dairy Sci. 88 (5), 1855-1864.

Fitzhugh, H.A., Bradford, G.E., 1983. Productivity of hair sheep and opportunities for improvement. In: Fitzhugh, H.A., Bradford, G.E. (ed.), Hair Sheep of Western Africa and the Americas - a genetic resource for the tropics. Boulder, Colorado, Westview Press, pp. 23-52.

Geay, Y., 1984. Energy and protein utilisation in growing cattle. J. Anim. Sci. (58), 766-778.

Gebrekiros Asegede, 1990. Studies on the ecology of helminth parasites in naturally infected indigenous sheep in Awassa, southern Ethiopia. Giesen University, Germany, Centre of Tropical Sciences and Parasitology, PhD Thesis.

Ghalsasi, P.M., Nimbkar, C., Gray, G.D., 1994. Garole-prolific micro sheep of West Bengal, India. Proc. 5th WCGALP, 20, 456-459.

Ghosh, P.K., Khan, M.S., Abichandani, R.K., 1976. Effect of short-term water deprivation in summer on Marwari sheep. J. Agric. Sci. (Camb.) 87, 121-123.

Gillespie, J.R., 1997. Modern Livestock and Poultry Production. 5th ed. Delmar Publisher, USA

Gonzalo, C., Ariznabarreta, A., Othmane, M.H., Carriedo, J.A., De la Fuente, L.F., San Primitivo, F., 2003. Genetic parameters of somatic cell count in dairy sheep considering the type of mammary pathogen effect. J. Anim. Breed. Genet. 120, 282-287.

Gruner, L., Bouix, J., Brunel, J.C., 2004. High genetic correlation between resistance to Haemonchus contortus and to richostrongylus,colubriformis in INRA 401 sheep. Vet. Parasitol., 119, 51-58

Habeeb, A.A., Marai, I.F.M., Kamal, T.H., 1992. Heat stress. In: Philips, C., Piggens, D. (Eds.), Farm Animals and the Environment. C.A.B. International, pp. 27-47.

Hale, E.B., 1969. Domestication and the evolution of behaviour. In: Hafez, E.S.E. (Ed.), The Behaviour of Domestic Animals. Bailliere, Tindall and Cassell, London, pp. 22-42.

Harvey, G.R., Tobin, G., 1982. The part played by variation of energy expenditure in the regulation of energy balance. Proc. Nutr. Soc. 41, 137-142.

Heringstad, B., Klemetsdal, G., Steine, T., 2003. Selection responses for clinical mastitis and protein yield in two Norwegian dairy cattle selection experiments. J. Dairy Sci. 86, 2990-2999.

Hickford, J., 2000. Development of a sustainable method of natural footrot control. Report to the NZ Meat Research and Development Council, Lincoln University.

Hickford, J.G.H., Zhou, H., Slow, S., Fang, Q., 2004. Diversity of the ovine DQA2 gene. J. Anim. Sci. 82, 1553-1563.

Hill, D., Robertson, P., 1988. Breeding success of wild and handreared ring-necked pheasants. J. Wildl. Manage. 52, 446-450.

Hofmann, R.R., 1989. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. Oecologia 78, 443-457.

Hossaini-Hilali, J., Benlamlih, S., Dahlborn, K., 1993. Fluid balance and milk secretion in the fed and food deprived black Moroccan goat. Small Rumin. Res. 12, 271-285.

ILCA, 1991. Proceedings of the Research Planning Workshop on Resistance to Endoparasites in Small Ruminants, 5-7 February 1991, Addis Ababa, Ethiopia, 78 pp.

Janssen, M.,Weimann, C., Gauly, M., Erhardt, G., 2002. Associations between infections with Haemonchus contortus and genetic markers on ovine chromosome 20. In: Proc. 7th WCGALP, Comm. No. 13-11.

Johnsson, J.I., Abrahams, M.V., 1991. Interbreeding with domestic strain increases foraging under threat of predation in juvenile steelhead trout (Oncorhynchus mykiss): an experimental study. Aquaculture 121, 73-77.

Kay, R.N.B., Maloiy, G.M.O., 1989. Digestive secretions in the camel. Options Me'diterrane'ennes, Ser. A 2, 83-87.

Kempester, A.J., 1980. Fat partition and distribution in the carcasses of cattle, sheep and pigs. A review. Meat Sci. 24: 83-98.

Khan, M.S., Sasidharan, T.U., Ghosh, P.K., 1979a. Water economy of the Barmer goat of the Rajasthan desert. J. Arid Environ. 1, 351-355.

Khan, M.S., Sasidharan, T.U., Ghosh, P.K., 1979b. Water regulation in the Barmer goat of the Rajasthan desert. Experientia 3, 1185.

Khan, M.S., Sasidharan, T.U., Ghosh, P.K., 1979c. Glomerular filtration rate and blood and urinary urea concentrations in Barmers goats of the Rajasthan desert. J. Agric. Sci. (Camb.) 93, 247-248.

Knap, P.W., Bishop, S.C., 2000. Relations between genetic change and infectious disease in domestic livestock. Pages 65–80 in Occas. Pub. Br. Soc. Anim. Sci. No. 27. BSAS, Edinburgh, Scotland.

Knights, M., Garcia, G.W., 1997. The status and characteristics of the goat (Capva hircus) and its potential role as a significant milk producer in the tropics: A Review. Small Rumin. Res. (26), 203-215.

Kolmodin, R., Strandberg, E., Madsen, E., Jensen, J., Jorjani, H., 2002. Genotype by environment interaction in Nordic dairy cattle studied using reaction norms. Acta Agric. Scand. 52:11-24.

Lankin, V., 1997. Factors of diversity of domestic behavior in sheep. Gen. Sel. Evol. 29, 73-92

Legarra, A., Ugarte, E., 2005. Genetic parameters of udder traits, somatic cell score, and milk yield in Latxa sheep. J. Dairy Sci. 88, 2238-2245.

Litchfield, A.M., Raadsma, H.W., Hulme, D.J., Brown, S.C., Nicholas, F.W., Egerton, J.R., 1993. Disease resistance in Merino sheep. II. RFLPs in Class 2 MHC and their association with footrot. J. Anim. Breed. Genet. 110, 321-334.

Macfarlane, W.V., Morris, R.J.H., Howard, B., 1963. Turn-over and distribution of water in desert camels, sheep cattle and kangaroos. Nature 791, 270-271.

Maltz, E., Silanikove, N., Shkolnik, A., 1982. Energy cost and water requirements of black Bedouin goats at different level of production. J. Agric. Sci. (Camb.) 98, 499-504.

Maltz, E., Shkolnik, A., 1984b. Milk composition and yield of black Bedouin goat during dehydration and rehydration. J. Dairy Res. 51, 23-27.

Mandonnet, N., Aumont, G., Fleury, J., Arquet, R., Varo, H., Gruner, L., Bouix, J., Vu Tien Khang, J., 2001. Assessment of genetic variability of resistance to gastrointestinal nematode parasites in Creole goats in the humid tropics. J. Anim. Sci. 79, 1706-1712.

Marai, I.F.M., Bahgat, L.B., Shalaby, T.H., Abdel-Hafez, M.A., 2000. Fattening performance, some behavioural traits and physiological reactions of male lambs fed concentrate mixture alone with or without natural clay, under hot summer of Egypt. Ann. Arid Zone, 39(4), 449-460.

Marai, I.F.M., El-Darawany, A.A., Abou-Fandoud, E.M., Abdel-Hafez, M.A.M., 2003. Alleviation of heat stressed Egyptian Suffolk rams by treatment with selenium, melatonin or prostaglandin F2α during hot summer of Egypt. J. Anim. Vet. Adv. 2 (4), 215-220.

Marai, I.F.M., El- Darawany, A.A., Abou-Fandoud, E.I., Abdel-Hafez, M.A.M., 2006a. Serun blood components during pre-oestrus, oestru and pregnancy phases in Egyptian Suffolk as affected by heat stress, under the conditions of Egypt. Egypt. J. Sheep Goats Desert Anim. Sci. 1(1), 47-62.

Marai, I.F.M., El-Darawany, A.A., Fadiel, A., Abdel-Hafez M.A.M., 2007. Physiological traits as affected by heat stress in sheep: a review. Small Rumin. Res., (71), 1-12

McEwan, J.C., Mason, P., Baker, R.L., Clarke, J.N., Hickey, S.M., Turner, K., 1992. Effect of selection for productive traits on internal parasite resistance in sheep. Proc. N. Z. Soc. Anim. Prod. 52, 53-56.

McEwan, J.C., Dodds, K.G., Greer, G.J., Bain, W.E., Duncan, S.J., Wheeler, R., Knowler, K.J., Reid, P.J., Green, R.S., Douch, P.G.C., 1995. Genetic estimates for parasite resistance traits in sheep and their correlations with production traits. N. Z. J. Zool. 22, 177.

MacHugh, D. E., Shriver, M. D., Loftus, R. T., Cunningham, P., Bradley, D. G., 1997. Microsatellite DNA variation and the evolution, domestication and phylogeography of taurine and zebu cattle (Bos taurus and Bos indicus). Genetics, 146, 1071-1086.

McManus, C., Paludo, G.R., Louvandini, H., Gugel, R., Sasaki, L.C.B., Paiva, S.R., 2008. Heat tolerance in Brazilian sheep: Physiological and blood parameters. Tropical Animal Health and Production. doi: 10.1007/s11250-008-9162-1

Mignon-Grasteaua, S., Boissy, A., Bouix, J., Faurea, J., Fisherd, A.D., Hinche, G.N., Jensen, P., Neindre, P.L., Mormedeg, P., Pruneth, P., Vandeputtei, M., Beaumonta, C., 2005. Genetics of adaptation and domestication in livestock. Livest. Prod. Sci., 93, 3-14.

Morris, C.A., Vlassoff, A., Bisset, S.A., Baker, R.L., West, C.J., Hurford, A.P., 1997a. Responses of Romney sheep to selection for resistance or susceptibility to nematode infection. Anim. Sci. 64, 319-329.

Morris, C.A., Wheeler, M., Hosking, B.C., Watson, T.G., Hurford, A.P., Foote, B.J., Foote, J.F., 1997b. Genetic parameters for milk yield and faecal nematode egg count in Saanen does. N. Z. J. Agric. Res. 40, 523-528.

Morris, C.A., Bisset, S.A., Vlassoff, A., West, C.J., Wheeler, M., 1998. Faecal nematode egg counts in lactating ewes from Romney flocks selectively bred for divergence in lamb faecal egg count. Anim. Sci. 67, 283-288.

Morris, C.A., Vlassoff, A., Bisset, S.A., Baker, R.L., Watson, T.G., West, C.J., Wheeler, M., 2000. Continued selection of Romney sheep for resistance or susceptibility to nematode infection: estimates of direct and correlated responses. Anim. Sci. 70, 17-27.

Mpofu, N., Rege, J.E.O., 2002. Monitoring of Sahiwal and Friesian Cattle Genetic Improvement Programs in Kenya. In: Ojango, J.M., Malmfors, B., Okeyo, A.M. (eds.) Animal Genetics Training Resource, Version 2, 2006. Nairobi, Kenya: International Livestock Research Institute; Uppsala, Sweden: Swedish University of Agricultural Sciences, pp. 35-44.

Mrode, R.A., Swanson, G.J.T., 1996. Genetic and statistical properties of somatic cell count and its suitability as an indirect means of reducing the incidence of mastitis in dairy cattle. Animal Breeding Abstracts 64, 847-857.

Mukasa-Mugerwa, E., Lahlou-Kassi, A., Anindo, D., Rege, J.E.O., Tembely, S., Markos, T., Baker, R.L., 2000. Between and within breed variation in lamb survival and the risk factors associated with major causes of mortality in indigenous Horro and Menz sheep in Ethiopia. Small Rumin. Res. 37, 1-12.

National Research Council (NRC), 1993. Managing Global Genetic Resources: Livestock. Washington, D.C.: National Academy Press.

Nieuwhof, G.J., Bishop, S.C., 2005. Costs of the major endemic diseases of sheep in Great Britain and the potential benefits of reduction in disease impact. Anim. Sci. 81, 23-29.

Nimbkar, C., Ghalsasi, P.M., Swan, A.A., Walkden-Brown, S.W. and Kahn, L.P., 2003. Evaluation of growth rates and resistance to nematodes of Deccani and Bannur lambs and their crosses with Garole. Anim. Sci. 76, 503-515.

Ørskov, E.R., 1998. Feed evaluation with emphasis on fibrous roughages and fluctuating supply of nutrients. A review. Small Rumin. Res. (28), 1-8.

Osaer, S., Goosens, B., Kora, S., Gaye, M., Darboe, L., 1999. Health and productivity of traditionally managed Djallonke sheep and West African Dwarf goats under high and moderate trypanosomiasis risk. Vet. Parasitol. 82, 101-119.

Ouma E., Abdulai, A., Drucker, A., 2007. Measuring heterogeneous preferences for cattle traits among cattle-keeping households in East Africa. Amer. J. Agr. Econ. 89(4), 1005-1019.

Patterson, R.G., Patterson, H.M., 1989. A practical approach to breeding for footrot resistant Merinos. J. N. Z. Mount. Lands Inst. 46, 64-75.

Philipsson, J., Ral, G., Berglund, B., 1995. Somatic cell count as a selection criterion for mastitis resistance in dairy cattle. Livest. Prod. Sci. 41, 195-200.

Philipsson, J., Lindhe, B., 2003. Experiences of including reproduction and health traits in Scandinavian dairy cattle breeding programs Livest. Prod. Sci. 83, 99-112

Pielberg, G.R., Golovko, A., Sundström, E., Curik, I., Lennartsson, J., Seltenhammer, M.H, Druml, T., Binns, M., Fitzsimmons, C., Lindgren, G., Sandberg, K., Baumung, R., Vetterlein, M., Strömberg, S., Grabherr, M., Wade, C., Lindblad-Toh, K., Pontén, F., Heldin, C., Sölkner, J., Andersson, L., 2008. A cis-acting regulatory mutation causes premature hair graying and susceptibility to melanoma in the horse. Nature Genetics, 40(8), 1004-1009.

Prayaga, K.C., Henshall, J.M., 2005. Adaptability in tropical beef cattle: genetic parameters of growth, adaptive and temperament traits in a crossbred population. Aust. J Exp. Agri., 45, 971-983.

Preston, J.M., Allonby, E.W. 1978. The influence of breed on the susceptibility of sheep and goats to a single experimental infection with *H. contortus*. Vet. Record, 103, 509-512.

Preston, J.M. and Allonby, E.W. 1979. The influence of breed on the susceptibility of sheep to H. contortus. Am. J. Vet. Res., 33, 817-823.

Price, E.O., 1984. Behavioral aspects of animal domestication. Q. Rev. Biol. 59, 1-32.

Price, E.O., 1999. Behavioral development in animals undergoing domestication. Appl. Anim. Behav. Sci. 65, 245-271.

Pryce, J.E., Coffey, M.P., Brotherstone, S., 2000. The genetic relationship between calving interval, body condition score and linear type and management traits in registered Holsteins. J. Dairy Sci. 83:2664-2671.

Pryce, J.E., Royal, M.D., Garnsworthy, P.C., Mao, P.L., 2004. Fertility in the high-producing dairy cow. Livest. Prod. Sci., 86, 125-136.

Purohit, G.R., Ghosh, P.K., Taneja, G.C., 1972. Water metabolism in desert sheep: effects of various degrees of water restriction on the distribution of body water in Marwari sheep. Aust. J. Agric. Res. 23, 685-691.

Raadsma, H.W., Egerton, J.R., Wood, D., Kristo, C., Nicholas, F.W., 1994. Disease resistance in Merino sheep. III. Genetic variation in resistance following challenge and subsequent vaccination with a homologous rDNA pilus vaccine. J. Anim. Breed. Genet. 111, 367-390.

Raadsma, H.W., 2000a. Genetic aspects of resistance to ovine footrot. In: Axford, R.F.E., Bishop, S.C., Nicholas, F.W., Owen, J.B. (Eds.), Breeding for Disease Resistance in Farm Animals, second ed. CABI Publishing, Wallingford, UK, pp. 214-219.

Rauw, W.M., Kanis, E., Noordhuizen-Stassen, E.N., Grommers F.J., 1998. Undesirable side effects of selection for high production efficiency in farm animals: a review. Livest. Prod. Sci., 56, 15-33.

Rege, J.E.O., Tembely, S., Mukasa-Mugerwa, E., Sovani, S., Anindo, D., Lahlou-Kassi, A., Nagda, S., Baker R.L., 2002. Effect of breed and season on production and response to infections with gastro-intestinal nematode parasites in sheep in the highlands of Ethiopia. Livest. Prod. Sci., 78, 159-174.

Rischkowsky, B., Iñiguez, L. and Tibbo, M. 2008. Management practices for adapting sheep production systems in the WANA region to climate change. Proceedings of a Conference on Livestock & Global Climate Change held from 17–20 May 2008, Hammamet, Tunisia. Supported by BSAS, ICARDA, IRESA, OEP, EAAP, INRA, ILRI, ESF, RIU and the Scottish Government.

Roberts, J.A., Estuninngsih, E., Widjayanti, S., Wiedosari, E., Partoutomo, S., Spithill, T.W., 1997a. Evidence for a major gene determining the resistance of Indonesian Thin Tail sheep against Fasciola gigantica. Vet. Parasitol. 68, 69-78.

Roberts, J.A., Widjayanti, S., Estuninngsih, E., Hetzel, D.J., 1997b. Evidence for a major gene determining the resistance of Indonesian Thin Tail sheep against Fasciola gigantica. Vet. Parasitol. 68, 69-78

Rupp, R., Lagriffoul, G., Astruc, J.M., Barillet, F., 2003. Genetic parameters for milk somatic cell scores and relationships with production traits in French Lacaune dairy sheep. J. Dairy Sci. 86, 1476-1481.

Samore, A.B., Schneider, M.del P., Canavesi, F., Bagnato, A., Groen, A.F. 2003. Relationship between somatic cell count and functional longevity assessed using survival analysis in Italian Holstein Friesian cows. Livest. Prod. Sci. 80, 211-220

Schwaiger, F.W., Gostomski, D., Stear, M.J., Duncan, J.L., McKellar, Q.A., Epplen, J.T., Buitkamp, J., 1995. An ovine MHC DRB1 allele is associated with low faecal egg counts following natural, predominantly O. circumcincta infection. Int. J. Parasitol. 25, 815-822.

Serrano, M., Perez-Guzman, M.D., Montoro, V., Jurado, J.J., 2003. Genetic analysis of somatic cell count and milk traits in Manchega ewes-mean lactation and test-day approaches. Livest. Prod. Sci. 84, 1-10.

Silanikove, N., 1986a. Interrelationships between feed quality, digestibility, feed consumption, and energy requirements in desert (Bedouin), and energy requirements in desert (Bedouin) and non-desert (Saanen) goats. J. Dairy Sci. 69, 2157-2162.

Silanikove, N., 1986b. Feed utilization, energy, energy and nitrogen balance in desert black Bedouin goats. Wld Rev. Anim. Prod. 22, 93-96.

Silanikove, N., 1987. Effect of imposed reduction in energy intake on resting and fasting heat production in the black Bedouin Goat. Nutr. Report International 35, 725-731.

Silanikove, N., Tagari, H., Shkolnik, A., 1980. Gross energy digestion and urea recycling in the desert black Bedouin goats. Comp. Biochem. Physiol. 67A, 215-218.

Silanikove, N., Brosh, A., 1989. Lignocellulose degradation and subsequent metabolism of lignin fermentation products by the desert black Bedouin goat fed on wheat straw as a single component diet. Br. J. Nutr. 62, 509-520.

Silanikove, N., Tagari, H., Shkolnik, A., 1993. Comparison of rate passage fermentation rate and efficiency of digestion of high fiber diet in desert black Bedouin goats as compared to Swiss Saanen goats. Small Rumin. Res. 12, 45-60.

Silanikove, N., 1994. The struggle to maintain hydration and osmoregulation in animals experiencing severe dehydration and rapid rehydration: the story of ruminants. Exper. Physiol. 79, 281-300.

Silanikove, N., Gilboa, N., Nitsan, Z., Perevolotsky, A., 1996a. Effect of daily supplementation of polyethylene glycol on intake and digestion of tannin-containing leaves (Quercus calliprinos, pistacia lentiscus and Ceratonia siliqua) by goats. J. Agric. Food Chem. 44, 199-205.

Silanikove, N., Gilboa, N., Perevolotsky, A., Nitsan, Z., 1996b. Goats fed tannin-containing leaves do not exhibit toxic syndrome. Small Rumin. Res. 21, 195-201.

Silanikove, N., 2000. The physiological basis of adaptation in goats to harsh environments: a review. Small Rumin. Res., (35), 181-193.

Skerman, T.M., Moorhouse, S.R., 1987. Broomfield Corriedales: a strain of sheep selectively bred for resistance to footrot. N. Z. Vet. J. 35, 101-106.

Sölkner, J., Nakimbugwe, H., Valle Zarate, A., 1998. Analysis of determinants of the success and failure of village breeding programs. Proc. 6th WCGALP, 25, 273-280.

Sölkner, J., Miesenberger, J., Willam, A., Fürst, Ch., Baumung, R., 1999. Total merit indices in dual purpose cattle. Proceedings of the 50th Annual Meeting of the European Association for Animal Production (EAAP), August 23-26, Zürich, Switzerland.

Tano, K., Kamuanga, M., Faminow, M., Swallow, B., 2003. Using Conjoint Analysis to Estimate Farmer's Preferences for Cattle Traits in West Africa. Ecological Economics 45:393-407.

Tembely, S., Lahlou-Kassi, A., Rege, J.E.O., Mukasa-Mugerwa, E., Anindo, D., Sovani, S., Baker, R.L. 1998. Breed and season effects on the peri-parturient rise in nematode egg output in indigenous ewes in a cool tropical environment. Vet. Parasitol., 77, 123-132.

Tibbo, M., Rischkowsky, B. and Iñiguez, L. 2008a. Livestock research helps producers cope with climate change. CARAVAN Issue 25. In press.

Tibbo, M., Rischkowsky, B. and Iñiguez, L. 2008b. Local Breeds to Cope with Climate Change. CARAVAN Issue 25. In press.

Tisserand, J.L., Hadjipanayiotou, M., Gihad, E.A., 1991. Digestion in goats, Chapter 5, in: Morand-Fehr, P. (Ed.), Goat Nutrition, Pudoc Wageningen.

Trail, J.C.M., Feron, A., Pelo, M., Colardelle, C., Ordner, G., d'Ieteren, G., Durkin, J., Maehl, H., Thorpe, W., 1998. Election in trypanotolerant cattle breeds in Africa. Proc. 3rd World Congress on Sheep and Beef Cattle Breeding, Paris 1, 613-624.

Turner, J.W., 1980. Genetic and biological aspects of Zebu adaptability. J. Anim. Sci., 50(6), 1201-1205.

Vagenas, D., Jackson, F., Russel, A.J.F., Merchant, M., Wright, I.A., Bishop, S.C., 2002. Genetic control of resistance to gastrointestinal parasites in crossbred cashmere producing goats: responses to selection, genetic parameters and relationships with production traits. Anim. Sci. 74, 199-208.

van der Waaij, E.H., 2004. A resource allocation model describing consequences of artificial selection under metabolic stress. J. Anim. Sci., (82), 973-981.

Van Soest, P. J., 1982. Nutritional Ecology of Ruminant. Corvallis, Or: O & B Books Inc.

Veerkamp, R.F., Dillon, P., Kelly, E., Cromie, A.R., Groen, A.F., 2002. Dairy cattle breeding objectives combining yield, survival and calving interval for pasture-based systems in Ireland under different milk quota scenarios. Livest. Prod. Sci. 76, 137-151

Webster, A.J.F. 1974. Adaptation to cold. In: D. Robertshaw (Ed.) Environmental Physiology. Physiology Series I, 7. University Park Press, Baltimore.

Weigel, K.A. 2006. Prospects for improving reproductive performance through genetic selection. Anim. Reprod. Sci. 96, 323-330

Wiedosari, E., Copeman, D.B., 1990. High resistance to experimental infection with Fasciola gigantica in Javanese thin-tailed sheep. Vet. Parasitol., 37, 101-111.

Willam A., Egger-Danner, Ch., Sölkner, J., Gierzinger, E., 2002. Optimization of progeny testing schemes when functional traits play an important role in the total merit index. Livest. Prod. Sci. 77, 217-225.

Woolaston, R.R., Singh, R., Tabunakawai, N., Le Jambre, L.F., Banks, D.J.D., Barger, I.A., 1992. Genetic and environmental influences on worm egg counts of goats in the humid tropics. Proc. Aust. Assoc. Anim. Breed. Genet. 10, 147-150.

Woolaston, R.R., Baker, R.L., 1996. Prospects of breeding small ruminants for resistance to internal parasites. Int. J Parasitol., 26(8/9), 845-855.

Woolaston, R.R., Piper, L.R., 1996. Selection of merino sheep for resistance to Haemonchus contortus: genetic variation. Anim. Sci. 62, 451-460.

Woolaston, R.R.,Windon, R.G., 2001. Selection of sheep for response to Trichostrongylus colubriformis larvae: genetic parameters. Anim. Sci. 73, 41-48.

Workneh Ayalew, Rischkowsky, B., King, J.M., Bruns, E., 2003. Crossbreds did not create more net benefits than indigenous goats in Ethiopian smallholdings. Agric. Sys., 76, 1137-1156.

Young, B.A., Walker, B., Dixon, A.E., Walker, V.A., 1989. Physiological adaptation to the environment. J. Anim. Sci., (67), 2426-2432.