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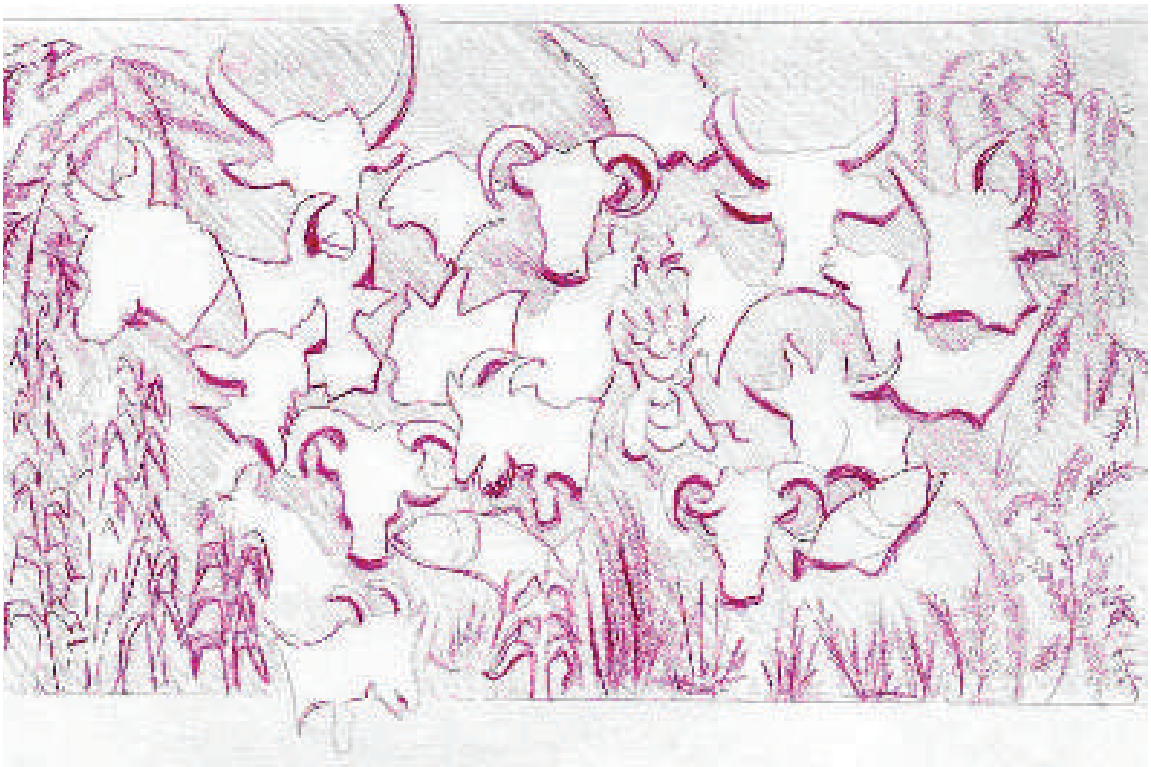

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An Official Journal of the Ethiopian Society of Animal Production (ESAP)

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Contents

Prevalence and distribution of camel trypanosomosis in the semi-arid and arid Awash Valley of Ethiopia

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Abstract

A three-year study (from December 1998 to September 2001) was conducted on 1013 camels (Camelus dromedarius) for the prevalence and distribution of potential camel trypanosomosis and its vectors in two districts of the Awash valley, i.e., Fantalle in Oromia and Gowani in Afar Regional National States. Standard parasitological detection techniques (SPDT) and conventional entomological collection and identification procedures were applied in this investigation. Only *Trypanosoma evansi* was detected in this study with an overall mean prevalence rate of 5.20%. The two localities did not have significant difference in mean prevalence of surra (5.60% in Gowani, n=376 and 5.20% in Fantalle, n=637). Young stock (1-3 years of age) and males were found to be infected at higher rate than adults and females in the Gowani area ($p<0.05$), but there were no age and sex related differences in camels of the Fantalle area ($p>0.05$). Prevalence varied much between herds than within herds indicative, most likely, of ephemeral nature of disease transmission by mechanical vectors such as tabanids. Although not strong, prevalence appeared to be higher after rains (August to October) and at peak of the dry season (December to March) where the camel herds from different places congregate at watering points along permanent surface water bodies or bore holes. It is obvious that surra causes considerable socio-economic losses although it is difficult to make exact estimation. However, if Food and Agriculture Organization of the United Nations' static herd model estimate of annual losses from trypanosomiasis of US$10-20 per animal for cattle is also valid for camels it will be plausible to estimate annual losses of US$20-40 million from the population of about two million in Ethiopia. It is, therefore, recommended that management and appropriate treatment interventions could substantially reduce losses from surra in Ethiopia and elsewhere, where similar conditions prevail.

Keywords: Camel, prevalence, surra, vectors

Introduction

Camel (*Camelus dromedarius*) plays an important socio-economic role in the arid and semi-arid lowlands of eastern and southeastern Ethiopia, where nomadic and semi-nomadic pastoral and agro-pastoral production systems predominate. Camel is the major source of the highly valued milk supply and of transport energy in addition to its considerable contribution to meat supply for the human population in

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and out of their area of production. Moreover, the role of camel as cash income generator at producer as well at national levels is highly esteemed. Camel serves as an indicator of wealth and high social status, particularly in the society of pastoralists and agro-pastoralists of eastern and southeastern Ethiopia (Getahun and Belay, 2002). Camel is considered as the champion of domestic herbivores and conqueror of deserts, arid and semi-arid agro-ecological zones of Africa and Asia where it turns the scrub vegetation into valuable and useful products and byproducts for human consumption.

Despite all the above mentioned contribution and potential of camels to the betterment of human life, proportional respect and care are not given to these loyal and friendly animals considering animal husbandry and health care. Camels also have not attracted much attention from researchers and research organizations in view to improving their genetic potential and heath conditions for greater production and productivity.

In Ethiopia, human neglect and environmental vagaries, particularly of frequent recurrent droughts and feed shortages have aggravated the condition leading to unforgettable consequences of heavy mortalities on several occasions in recent past. Although camels are hardy animals to tolerate feed shortages and different infections than most other domestic animals in general, they do suffer from different parasites and diseases the severity of which usually depends on the animal's nutritional status as poorly nourished individuals suffer the most. The few reports on camel's health indicate that haemo-parasites, particularly surra, stands as the most important health problem of camels in many countries including Ethiopia (Richard, 1975; Olaho-Mukani *et al.*, 1992).

This study is attempting to fill the gap in knowledge in camel's trypanosomosis prevalence and distribution in the well-known camel rearing area of the Awash Valley. Hence, a three-year epidemiological study (December, 1998 - September, 2001) was conducted on camels/dromedaries using conventional parasitological and entomological techniques.

The main objectives of this study were to determine the etiology, prevalence and distribution of *T. evansi* infection in arid and semi-arid Awash Valley of Ethiopia with the view of assessing the economic impact and devising appropriate intervention strategy to alleviate the problem.

Materials and Methods

Study area

The study was conducted in Fantalle and Gowan districts, in Oromia and Afar regional states respectively, located in semi-arid and arid agro-ecological zones in the Awash Valley (Figure 1). The reason for the selection of the two sites was, the

little information available from these two sites than other camel rearing areas, but these areas are known for camel rearing in the eastern part of Ethiopia.

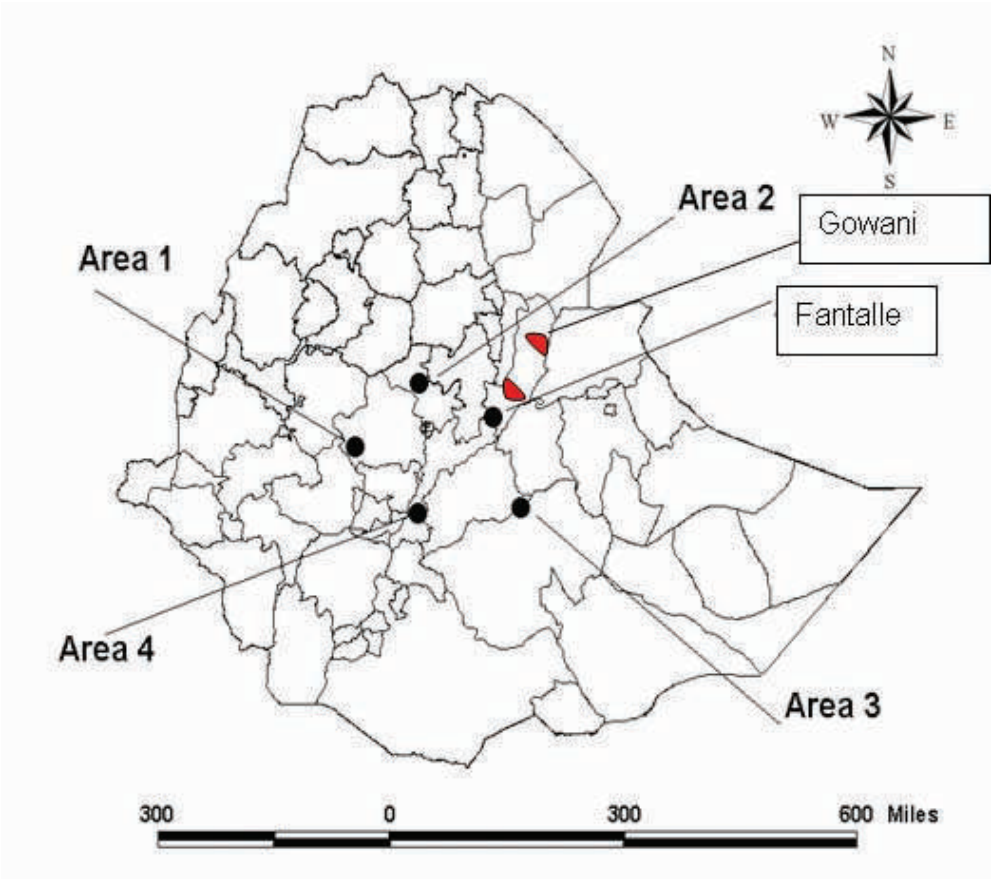

Figure 1. Surra study sites in Gowani and Fantalle areas. Area 1-4 not included for this study.

Sampling methods

Blood sampling: In each site, 50 animals of all age groups i.e. calf (6 to 12 months old), young (12 months to 3 years older), and adult (3 years and above) were randomly selected on each visit. Males and calves were generally fewer in number. It was tried to sample what was available and the analysis made into different age groups and sex was only to extract more information about the distribution of surra with what was made available.

Thick and thin blood smears were prepared from ear tip of each animal on clean and grease-free slides by deep puncture with sterile needle and allowed to dry thoroughly and then kept in dust-free slide boxes. Thin smears were fixed for three minutes with

absolute methyl alcohol on the same day they were prepared. Both thick and thin smears were stained with 10% Giemsa solution pH 7.2, for 35-40 minutes in the laboratory. Slides were then thoroughly washed of excess stain with tap water and allowed to drip-dry in an upright position before microscopic examination. Smears were examined under x40 and x100 oil immersion objectives and at least, 100 fields were scrutinized before a slide was considered negative. Identification of trypanosome parasites were based on morphology and measurement using standard identification keys (Soulsby, 1982; Morel, 1989). Blood samples were taken seasonally in heparinized micro-haematocrit capillary tubes from same animals that were subjected to blood smear sampling for packed cell volume (PCV) determination. PCV was determined within two hours after taking the blood samples. Buffy coat technique (BCT) could have been one of the sensitive methods to test surra, however, it was not employed because of the reason that the technique does not detect other haemo-parasites, such as Babesia, Theileria etc.

Vector sampling: Potential vectors were captured on and off the host using fine forceps and hand nets depending on feeding behavior of each vector. Traps were used to catch flies. Fine forceps were used in collecting ticks from their attachment sites on the host. Ticks were collected to identify them in order to determine their vector role for haemo-parasites which prefer their vector. Vector samples were collected in properly labeled specimen bottles, half-filled with 70% ethyl alcohol. Identification was carried out in the laboratory under stereomicroscope using standard identification keys (Soulsby, 1982; Morel, 1989). Data were analyzed using both descriptive statistics and the General Linear Model Procedures of SAS (SAS, 2002)

Results

A total of 1013 blood samples were collected from juvenile, young and adult camels of both sex groups in the two project areas of Fantalle and Gowani. A total of 637 animals were from Fantalle and 376 from Gowani. Only T. evansi was detected in herds of both areas with similar prevalence when animals of all age and sex groups were considered together. The mean prevalence in Fantalle was found to be 5% while that of Gowani was 5.6% indicating no significant differences ($P>0.05$). Animals of different age and sex groups in Gowani area manifested significantly different prevalence rates ($P<0.01$) by a Chi-square test, but 33% of the cells had expected values less than five. In Fantalle area no such difference was apparent (Table 1 and Figure 2). In Gowani area, the young stock, particularly the males appeared to be more frequently infected than the adults and the females, respectively. A study in Kenya (Olaho-Mukani et al., 1992) showed a high prevalence (85%, n=55) in males while all females were parasitologically negative (0%, n=83). The overall mean prevalence of the two areas was calculated at 5.2%, of which 32 out of 637 (5%) was from Fantalle and 21 out of 376 (5.6%) from Gowani.

Table 1.The prevalence rate (%) of surra in different age and sex groups of camels in the middle and lower Awash Valleys

Study area	AEC	Age group									Sex					
		Calf (1-12 months)			Young (12-36months)			Adult (> 36 months)			Male			Female		
		n	Inf	%	n	Inf	%	n	Inf	%	n	Inf	%	n	Inf	%
Gowani	Arid	50	8	16	78	5	6.4	248	8	3.2	58	6	10.3	318	15	4.7
Fantalle	Semi-arid	57	3	5.3	211	11	5.2	369	19	5.2	136	6	4.4	501	26	5.2
Total		107	11	10.28	289	16	5.54	617	27	4.38	194	12	6.19	819	41	5

n=number of camels examined, Inf = number of camels infected with surra

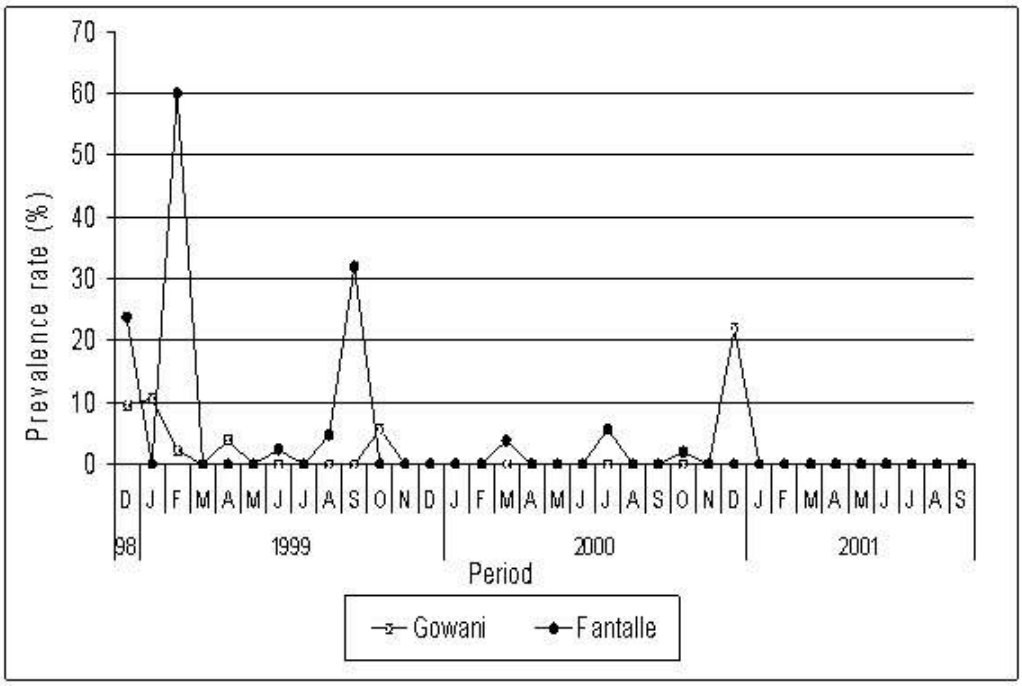

Figure 2. Prevalence of sura during the period Dec 1998-Sep 2001

Infection rates varied from place to place and from time to time and ranged from 0 to 60% (Figure 2). Although not consistent, infections appeared more common after rainy season between August and October, and during dry season between December and March when camel herds from different villages (encampments) meet at watering points far away from their camp-stead (Figure 2). Potential vectors identified in the study areas are depicted in Table 2 where *Tabanus* spp, *Stomoxys* spp *Lyperosia* spp and *Hippobosca* spp were dominant. *Tabanusspp* and *Stomoxys spp* were probably the chief culprits for surra transmission in the study area, although neither transmission trials nor dissections for infection rate analysis of the potential vectors were carried out in this study.

Table 2. Potential vectors identified in camels in the study areas

Study area	Agro-ecological climate	Animal species	Acarines	Insects
Gowani and Fantalle localities	Arid climate	Cameline*	Amblyomma cohaerens	Hippobosca spp
			Amblyomma gemma	Lucilia spp
			Amblyomma lepidum	Lyperosia spp
			Amblyomma variegatum	Musca spp
			Boophilus decoloratus	Stomoxys spp
			Hyalomma dromedarii	Tabanus spp
			Hyalomma marginatum rufipes	
			Hyalomma truncatum	
			Rhipicephalus evertsi evertsi	
			Rhipicephalus pulchellus	
			Rhipicephalus simus	

* the breeds are consisted of the Afar and Ogaden camels' breed and their crosses

Trypanocidal drugs were infrequently applied to camels for surra treatment according to the informal interviews made to selected elders from among camel breeders and veterinary personnel in the study area probably due to misdiagnosis or inability of diagnosis of the disease.

Affected herds showed high prevalence rates while there were many instances in same localities where camel herds not involved by the incident were encountered. This is believed to be due to ephemeral nature of surra mechanical transmission by biting flies in animals living in close contact. This phenomenon has produced an apparently low surra overall prevalence rate in the area of study. Although overall mean prevalence rate in Gowani was slightly higher than that of Fantalle, the highest prevalence rate in one visit was recorded in the latter in February 1999 (Figure 2).

The investigation team encountered three active cases, *i.e.*, two in Fantalle and one in Gowani localities, during the study period. In the one case of Fantalle area three adult female camels were found prostrate with typical symptoms of surra such as fever, debility, wasting, anaemia and lachrymation. The other two incidents, one around Gowani town and the other at Matahara veterinary clinic, involved mainly growing stock (1-3 years of age), which showed major symptoms of fever, coughing and lachrymation. Microscopic examination of blood smears taken from these animals revealed high parasitaemia of *T. evansi*. The PCV results were omitted because it did not give any additional information to separate infected and uninfected.

Discussion and Conclusion

This study has indicated that surra is a common disease of camels in the project area, although actual prevalence could have been higher had more sensitive techniques been employed in the study. Scott (1974) found a surra prevalence of 19% in camels in Negele area of southern Ethiopia through thin and thick blood smear examination whereas he obtained a prevalence of 37% from same animals by mouse inoculation test. The

overall 5.2% prevalence rate, which we obtained in camels of Gowani and Fantalle area would have provided a prevalence of not less than 10% had mouse inoculation technique been utilized in the study in analogy to the study conducted in Negele area (Pegram and Scott, 1976). Dirie *et al*. (1989) found similar results of 5.33% from 3000 blood samples analyzed in Somalia. Njiru *et al*. (2004) in Kenya also obtained similar results of 5.3% by microhaematocrit centrifugation technique (MHCT). However, they reported higher prevalence rates utilizing polymerase chain reaction-PCR (26.6%) and card agglutination test-CATT/*T.evansi* (45.9%) from randomly sampled 549 camels. Some other reports in southern Ethiopia (Scott, 1974; Pegram and Scott, 1976) put surra prevalence in camels at 15-19% by thin and thick smear method, 37% by mouse inoculation and 53% and 66% by mercuric chloride and formol gel test, respectively. Shank (2005) reports the prevalence of 15% in Shinile zone of Somali Regional National State of eastern Ethiopia.

The higher surra prevalence recorded in our study in growing stock and particularly in calves contradicts with some previous work elsewhere (Jaiquiet *et al.,* 1994) where it was stated that young calves below one year old seem to be free of *T. evansi* infection. Njiru *et al.,* (2004) also declared that an adult camel was 2.2 times more likely to be infected when compared to calves or young. However, our study has indicated, on several occasions, that infections are detected more frequently in growing stock than in adults. This is assumed to be due to newer infections in the young age that does not give much time for the parasite to go into chronicity where parasite detection becomes difficult through microscopic examination. Management differences amongst camel breeders could also be the factor responsible for the variation of surra prevalence in different age groups. Some breeders keep the calves around camp-stead while others allow the calves to follow the adults in most of the cases. Such practices will obviously produce variable levels or degrees of exposure to surra infection in the concerned stocks. Calves, which roam with the adults, will have greater risk of acquiring the infection than those kept most of the time around camp-stead/homestead.

As to camel surra prevalence variation in different herds, it appears that the suitability of the environment for multiplication of biting flies plays major role. Camels, which graze or stay for longer time along river courses with ample woody vegetation, would have more chances of being bitten by haematophagous flies (Table 2) than those grazing far away from river courses. The latter would be at risk only during watering times where they could meet other infected herds at the watering points. The risk could significantly be reduced, if mingling of uninfected with infected herds is avoided.

The assessment of the impact of surra in camels in the study area or in the whole country is not an easy task to undertake considering, *inter alia*, the lack of necessary information on camel production and productivity, on the one hand, and the actual number of animals affected by the disease at any one time on the other. However, there

should not be any doubt that surra in the affected animals produces morbidity and mortality losses of variable degrees depending on the challenge level, parasite strain, physical condition (plain of nutrition) of affected herds, environmental and man-made stresses to which the animals are subjected and a host of other circumstances that may prevail in the host or in the environment. All the camels in the area are at risk of acquiring surra infection at any one time as the parasite and its vectors are present in the area at variable frequency. If the Food and Agriculture Organization of the United Nations-FAO/UN (1991) static herd model estimate of annual loss from trypanosomiasis of US$10-20 per animal per year from cattle is applicable also to camels, the camel population in the study area could be multiplied by the annual loss per animal (US$10-20) to obtain annual loss from the population each year. Ethiopia with nearly two million camels all of which are at risk of acquiring surra could potentially lose US$20-40 million per annum according to the abovementioned estimate.

Losses from camel surra could be greatly reduced if appropriate intervention that is based on vector distribution and abundance and on camel management system is correctly applied. Strategic application of effective trypanocides (antrycide sulphate, cymelarsan, etc.) at the right dose rates during or just after rainy seasons, preferably to all animals in the affected herd, would effectively control the disease. Separation of different camel herds at watering points could assist in stopping transmission of the infections between herds. A tactical block application of trypanocides could also be given at any one time when more that 5% of the herd is found parasitologically positive to further enhance the reduction of losses. The control of biting flies such as *Tabanus, Stomoxys, Lyperosia* and *Hippobosca* species during peak fly seasons using appropriate insecticide formulations, preferably synthetic pyrethroid 'pour-ons', could significantly reduce surra prevalence and associated losses.

The standard parasitological detection technique (SPDT) employed in this study was not sensitive enough to capture all infected cases, and certainly, might have underestimated the magnitude of the problem. It is recommended that future studies need to employ more sensitive and specific techniques including animal inoculation, monoclonal antibody-based techniques such as the enzyme-linked immuno-sorbent assay (ELISA), card agglutination trypanosomiasis test (CATT) and recombinant DNA-based techniques in order to come up with reliable qualitative and quantitative analysis of surra and its impacts.

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Current Uses of Cactus Pear (*Opuntia ficus-indica*) as Forage in Northern Ethiopia and Farmers' Indigenous Knowledge on its Utilisation

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Abstract

This study was initiated to assess the overall contribution of cactus pear under the prevailing harsh conditions in northern Ethiopia with particular emphasis on its current production and utilisation as an animal feed. The survey was conducted in two zones of Tigray region that are known for their cactus production and utilisation. Two hundred thirty (230) randomly selected smallholder farmers were interviewed using semi-structured questionnaires. This was supplemented by information obtained from key-informants. The adaptation of cactus to the region was evaluated using observation of its stands (vegetative measurement and density) and by comparing the ecological and/or bio-climatic requirements of the plant vis-à-vis agro-climatic data of the region. To assess the current status and prospect of cactus pear in the region policy related documents and plans and actions of institutions were reviewed. The multipurpose cactus pear fits well into the farming system and contributes significantly to combating food and feed insecurity. The main current uses of cactus are food (fruit), feed (cladode), live fence, source of income, soil and water conservation and land rehabilitation, with varying order of importance between the study areas. Cactus pear is used as forage by all farmers over 9-12 months a year. The main problems associated with feeding cactus include bloat, diarrhoea, coiling of fibre in the rumen, sore mouth and dropping and wear of teeth. Agro-climatic and edaphic conditions in the region and similar arid and semiarid areas of the country are most ideally suited to cactus pear production. The potential of cactus as source of food, feed and income seems to expand and even extend to the food, drink, dye, cosmetic and medicinal industries.

Key words: Cactus pear, *Opuntia*, forage use, indigenous knowledge, survey, arid

Introduction

The increasing requirement for human food in Ethiopia is progressively forcing farmers of the highland and mid-altitude areas to cultivate more land at the expense of grazing pasture and browses. Consequently, the contribution of natural pasture and range resources, which used to account for about 78% of the feed supply in

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the country (Alemayehu, 2006), have been seriously reduced and livestock depend increasingly upon crop by-products. For instance, in some areas such as Tigray, there are times when 65% of the total feed supply may come from crop residues and stubble grazing, which unless supplemented, are seldom adequate for livestock maintenance let alone for production. However, only one percent of the farmers in Tigray use forage crop during the dry season (WBISPPO, 2003). These common feed resources are dry, contain a high proportion of cell wall and are deficient, among others, in water-soluble carbohydrates.

There has been a growing interest in the utilisation of locally available non-conventional feed resources to improve forage supply in smallholder livestock farms. Experts recommended planting trees and shrubs to provide feed resources so that herds and flocks are able to survive critical periods of shortfall and prolonged droughts (Le Houérou, 1996). Thus, screening of drought tolerant species should be taken as one of the research priorities in Ethiopia (Alemayehu, 2006) and elsewhere. In screening plants for animal nutrition in drought prone regions, drought tolerance and palatability for animals are the two most important criteria. Dry matter yield, digestibility, nitrogen/crude protein contents, adaptability of forage to marginal lands, ease of propagation and persistency are also of importance.

After its introduction in the mid-19th century to Ethiopia, cactus pear (*Opuntia ficus-indica*) has become one of the most common plants in northern Ethiopia particularly in Tigray, where it is integrated into the farming systems. Apart from Tigray, cactus is present predominantly also in other arid and semi-arid areas of Ethiopia. But, as can be seen in Debre Zeit and Bale, it also thrives in higher-rainfall highland areas. It grows in a variety of soil types, but does best in well-drained sandy loam soils (Le Houérou, 1996; De Kock, 2001). So far, there have been no formal studies on the distribution and use of cactus in Ethiopia. However, a general survey in Tigray showed that cactus is used for a range of purposes, mainly as food and forage (SAERT, 1994). The first step in evaluating a new or unconventional feed resource is to gather information from farmers in the area where the plant is grown (Preston, 1995). Though surveys on the traditional production and utilisation of cactus as animal feed were done in Tigray, they were conducted during the dry season only and with limited area coverage; in one district of the eastern zone (Hailu, 1998) and in one peasant association per zone (Mengistu and Udén, 2003); sample size (100 and 56 farmers, respectively) and different methodology (peasant associations selected randomly). In this study, data were collected during the rainy season, with more area coverage and sample size (230 interviewees selected from 32 villages, 3 districts and 2 zones), and for two consecutive years so that inter-year and inter-survey area comparisons could easily be made. This study was initiated to generate baseline information about the overall contribution of cactus pear for forage under the

prevailing harsh conditions in northern Ethiopia, the problems associated with feeding cactus, traditional prevention and treatment practices, farmers' indigenous knowledge in its utilisation and to assess the current status and prospects of cactus pear.

Materials and methods

Study Area

Though cactus pear is found widely distributed in the arid and semi-arid areas of Ethiopia, it was realised at the outset that a country-wide survey would only produce superficial information. Attention was, therefore, directed to detailed surveying of contrasting, but representative areas (Raya Azebo and Irob and Ganta-Afeshum districts) in the southern and eastern zones, respectively, of Tigray, northern Ethiopia, which are known for their cactus pear production and utilisation. The survey areas generally represent different agro-ecologies and soil types. The altitude and annual average rainfall of the study areas in the two zones range from 1300-3250 m above see level and 300-600 mm, respectively. Average minimum and maximum temperatures were 5 and 28 ^{o}C, respectively. The dominant soil types are sandy silt, red clay loam, fluvisol and litosol. The survey areas in the eastern zone have inherently low soil fertility, while rainfall is the most limiting factor for plant growth in Raya Azebo district. There is also variation in arable land availability; the average land holding in Raya Azebo district was four times greater than Irob district (BoANR, 2002, unpublished). Cattle are the dominant livestock type in Irob and Ganta-Afeshum districts, followed by sheep and goats in that order while in Raya Azebo district the proportion of sheep and goat is almost equal and camels account for 5% (BoANR, 2002, unpublished). The dominant crop types in Irob and Ganta-Afeshum are barely and wheat, while sorghum and maize are dominating in Raya Azebo. Consequently, there are variations in cropping pattern, relative land productivity and food and feed security status in the study areas.

Sample Stratification, Data Collection and Statistical Analysis

The survey was undertaken at three levels, namely *Tabia* (peasant association), *Kushet* (village), and household (HH) levels. Purposive sampling technique was used to select three *Woredas* (districts) from the southern and eastern zones of Tigray. Similarly, 14 peasant associations were selected from the three districts. A total of 32 villages and 230 HHs were randomly selected. Data were collected in single visit interviews using semi-structured questionnaires. The questionnaires covered issues related to farmers' current practices and indigenous knowledge on the production and utilisation of cactus. The questions focused on: whether or not farmers own cactus, type of cactus ownership, variety, production practices, current uses, practices of feeding cactus to animals (when, how, to which livestock type, in what frequency), farmers'

perception (opinions and views) on its quality, problems in processing and after feeding cactus and traditional prevention and treatment practices for its safe use. Data collected by using questionnaires were supplemented by information obtained from key-informants and substantiated by cross-questioning, making field checks at the time of survey and secondary data derived largely from the Bureau of Agriculture and Natural Resources (BoANR) at district levels. Cactus fruit market survey was done in four locations (Maychew, Mehoni, Mekelle and Adigrat) of the two zones. Data on fruit quality, amount transacted, prices and number of people involved were collected. Cactus pear's adaptability to the region was evaluated using observation of its stands (vegetative measurement and density) and by comparing the ecological and/or bioclimatic requirements of the plant (Inglese, 1995; Nobel, 2001) vis-à-vis agro-climatic data of the region (WBISPPO, 2003). Policy related documents, plans and actions of institutions were reviewed in order to assess the current status and prospect of cactus. The collected raw data were systematically coded and analysed using descriptive statistics.

Results and discussion

Cactus Pear Production System

Cactus pear ownership in the study areas is either communal or private (Table 1). On average, about 63% of the respondents have cactus pear in their backyard or homestead. However, there were clear differences between study areas. All farmers in Irob district of eastern zone have both communal and private cactus pear to produce fruits and forage while those in Ganta-Afeshum district of the same zone have private type of ownership. In contrast, relatively more farmers in Raya Azebo district of the southern zone, where about 64% of cactus plant is found (SAERT, 1994), do not have cactus in their backyard. If farmers of Raya Azebo district have cactus in homesteads, it is mainly for live fence, which is also used for fruit production and livestock feed.

Table 1: Type of cactus pear ownership in the study districts (%)

Zone	District	Private	Communal	Both
Southern	Raya Azebo	18.4	34.2	47.4
Eastern	Ganta-Afeshum	100.0	0.0	0.0
Eastern	Irob	69.1	10.2	20.7
	Average	62.5	14.8	22.7

All farmers have both spiny and spineless cactus; the spiny variety is dominant even in Ganta-Afeshum district. It is also surprising to note that more farmers (55%) in Irob district prefer spiny to spineless cactus pear because, they believe, feeding spiny cactus after burning decreases the water content of cladodes and consequently bloat and diarrhoea. This may show the importance the farmers give to the above disorders.

Farmers in Irob district, where cactus pear is believed to be introduced first, have a longer familiarization with the plant than others. They named more than 60 local 'varieties'; while those in the other two districts named only 14 'varieties'. The criteria for traditional classification were mainly based on fruit characteristics that include taste, colour, size and shape, which are basic fruit quality parameters (Mondragón, 2002). Farmers also use internal quality parameters such as total seed and water content. Presence or absence of spines, amount of spine per fruit and cladode, height of the plant and size and shape of cladode are some of the additional criteria used. These criteria clearly show that the forage aspect is considered during variety selection though it may be secondary. Some farmers mentioned the presence of poisonous 'varieties'. The available farmer-identified 'varieties' deserve further characterisation and identification.

About 80% of the farmers in Irob plant cactus pear during the long dry season (September-June). The remaining (20%) plant before the rain starts or stops. Farmers are aware of poor establishment during the rainy season due to decaying of cactus plant by excess moisture. None of the farmers treat planting materials with pesticides. Farmers usually use selected 'varieties' for planting material. In agreement with scientific recommendations (Mondragón, 2002), farmers in Ganta-Afeshum district cut the material to be planted from young plants, usually below six years. In the same district farmers carefully cut cactus cladodes below the joints and wilt. While 95% of the farmers in Irob district plant cactus in a pit, most respondents in Raya Azebo do not do so. In agreement with SAERT's (1994) report, the land that was selected for planting is not suitable for conventional crops (cereals and pulses). Assuming land is equitably distributed; this may imply that farmers who plant cactus might have more land and therefore produce more food and feed than their counterparts. Manure application to cactus pear plant was common in Ganta-Afeshum district (72%), while in the other districts negligible number of farmers apply manure (e.g., 5% in Irob).

General Current Uses of Cactus Pear

Cactus is used for a range of functions with varying order of importance between zones and between districts within the eastern zone (Table 2). The primary current use is that cactus fruit is the main source of food, especially during the rainy season (June-September), when food scarcity is at its worst. In some areas consumption of cactus fruit for food extends up to December.

Cactus is an income source for resource poor people (mainly school children and women). During the peak cactus fruit selling month (early August) more than 3350 street vendors were involved in selling cactus fruit in four locations only and they were able to double their income. Any attempt to improve harvesting practices and thereby fruit quality could increase the income vendors are getting.

Table 2: General current uses of cactus pear as first-ranked function by interviewed farmers

Use	Study districts (number of respondents = 227)							
	Raya Azebo		Ganta-Afeshum		Irob		Overall	
	Rank	%	Rank	%	Rank	%	Rank	%
Food (fruit)	3rd	24.2	1st	37.5	1st	37.5	1st	31.7
Forage	1st	29.3	2nd	30.7	2nd	25.0	2nd	29.1
Income	4th	16.2	3rd	14.8	5th	7.5	4th	14.1
Fence	2nd	26.3	4th	10.2	3rd	17.5	3rd	18.5
Others	5th	4.0	5th	6.8	4th	12.5	5th	6.6

As a living fence around houses and crop lands, spiny cactus saves other thorny plants that are usually cut for fencing and reduces deforestation of the already sparse vegetation. It serves as fuel source as well. Cactus is also planted on hilly and degraded lands to reclaim land, as a biological control and to strengthen physical structures built against soil erosion. However, its impact on soil quantity and quality is not yet studied. Cactus pear flowers during the dry months (January to March) when most other plants are not flowering and serves as a vital source of bee forage.

Cactus Pear as Forage

According to 93% of the respondents, livestock population size per HH has declined mainly due to drought and the consequent feed and water shortages (81%). Feed shortage is severe, especially in the study zones of Tigray region (WBISPPO, 2003). Recurrent drought and consequently feed and water scarcity have increased the demand for cactus as forage. A parallel account has been reported by López *et al*. (2001) in Mexico. Especially since the 1960s, as elders recalled, cactus pear has become a fodder crop of prime importance. It is palatable, a vital source of water (cactus fed cattle stay two to three days without water) and easily available during dry seasons and drought periods, when other forages are not.

All farmers use cactus as forage during much of the feeding calendar (9-12 months a year) depending on drought occurrence or rain availability (Fig. 1). While cactus feeding extends to June, farmers in Irob district start using it earlier than those in Ganta-Afeshum, mainly related to availability of crop residues and aftermath. Around Atsbi, eastern zone, the importance of cactus is reported to be crucial during the peak rainy season (June to August) (Assefa, 2005). Animals may also graze on the communal or wild cactus through out the year, whether there is drought or not.

All livestock types (cattle, sheep, goats, camels and equines) are reported to consume cactus pear. Cutting the cladodes and superficial burning to eliminate spines and chopping are the dominant form of processing cactus pear (85%). Few use scraping or rubbing to eliminate spines. Farmers burn both sides of the cladodes by putting straw or firewood on the cactus. To save firewood some households prepare traditional oven and add small amount of fuel on it. Traditional sharp materials like knife and sickle are

used to cut and chop the cladodes; none of the respondents were using specially designed tools. In order of importance, cattle and sheep are fed with processed cactus, either because they are preferred or their inability to graze *in situ*; only 15% of the farmers prepare cactus for equine while camels and goats do not face problems to browse even the spiny cactus.

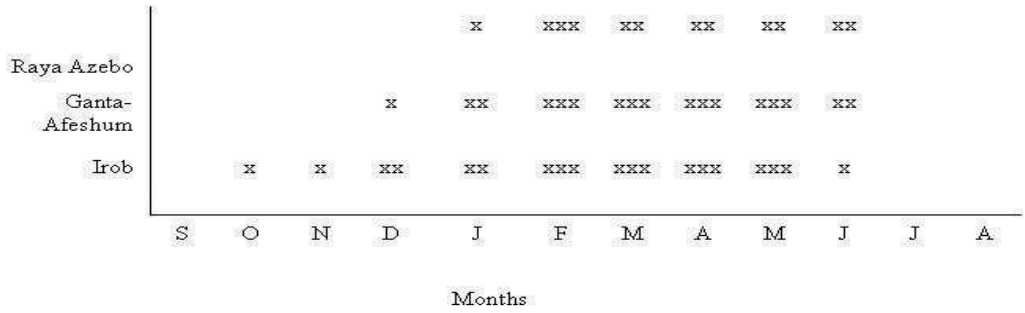

Fig.1. Feeding calendar of cactus pear in the three districts during 'normal' years

About 86% of the respondents feed prepared cactus to their animals once daily, either in the morning or evening. Draught oxen and lactating cows, however, are fed more frequently. Some 45% of the respondents (Table 3) feed cactus alone; not because they do not know the consequences, but rather due to either feed shortage or farmers believe that the animals may consume what is available in the wild.

Table 3: Response of farmers to the different methods of feeding cactus pear to animals

Ways of feeding	Number of respondents	%
Alone	96	44.7
With crop residues	93	43.3
Either alone or with crop residues	26	12.0
Total	215	100

About 63% of the farmers feed their animals with young cladodes, if available, because it was preferable in terms of quality (palatability, and ability to walk long distance and body condition of cactus fed animals), while about 90% use young and moderate age cladodes. Moderately young cladodes are fed when there is scarcity of young cladodes and lack of labour. Farmers believe there are fewer side effects (bloating and diarrhoea) in feeding moderately young cladodes. In Ganta-Afeshum district, however, moderately young or old cladodes are used because there is no communal cactus and cactus holding is small that there is conflict of interest between fruit and forage uses.

According to 65% of the respondents, cactus supplementation increases milk production, but they believe that water content of the milk increases with level of feeding. About 35% reported that cactus supplementation does not bring visible change. In contrast, farmers characterised the meat of cactus fed animals as 'clean' and 'fatty/soft' and therefore

more preferred to lean meat. Farmers associated feeding young cladodes with improved body condition and shiny coat hair of animals, which are vital in price negotiations in selling live animals in Ethiopia.

Cactus pears' high productivity, adaptation and easy establishment were appreciated by farmers who favour the plant. Based on indigenous quality criteria, cactus has been preferred to, for example *Acacia etbaica*, which is also important in the study areas. Cactus is one of the preferred fodder species in Hawsi Dogu'u and Dogu'u villages of Tembien, central Tigray (Kindeya and Yemane, 1997). In Raya Azebo district, however, cactus was ranked at the bottom probably a protest against the fact that cultivable land is being infested with the plant and its invasion is on the increase, according to 82% of the respondents. This is clearly the result of mismanagement of the plant in the southern zone and should not overshadow its strategic importance. On average, 53% of the farmers believe that one of the mechanisms of controlling cactus invasion is using it as feed resource, which is the most economical and environmentally friendly way of controlling it from becoming weed.

Problems in Using Cactus Pear as Forage

Processing difficulties

Spiny cactus being the dominant variety, fuel shortage to burn the spines, labour, time, physical injury by spines and flames and discomfort related to heat and smoke are the major problems associated with processing cactus pear. Burning the spines is causing deforestation and environmental degradation. After cutting the cladodes and burning the spines farmers have to transport the bulky cladodes to their animals, which is a tiresome job. In addition, farmers in Raya Azebo district mentioned sunstroke while burning spines as a problem, which may be related to the prevailing high day-time environmental temperature.

Problems Associated with Feeding Cactus Pear

All farmers reported that the main problems associated with feeding of cactus are bloat and diarrhoea. Coiling of fibre in the rumen, sore mouth and dropping and wear of teeth are also identified as problems. Coiling of fibre might be due to feeding of unchopped old cladodes whose digestibility is very low (Le Houérou, 1996). Bloat and diarrhoea commonly occur in oxen and lactating cows that consume excess amount of cactus. In agreement with the finding of Mengistu and Udén (2003), bloat was reported to be more severe when animals are fed on cactus for the first time.

As indicated by 70% of the respondents, lack of proper feeding management and high water content of cactus are the major causes for bloat and diarrhoea (Table 4). In addition, farmers (100%) in Irob associated severity of bloat with feeding of cactus pear

and *Acacia etbaica* together, especially from April to September. Farmers also associated bloat with feeding cactus infested with insects locally known as "*Chanchu*" which belong to the family of ants. Though Mengistu and Udén (2003) reported that stock death due to bloat is common, only 20% of the farmers claimed that *ad libitum* feeding of cactus pear alone might result in death of animals.

Table 4: Main causes of bloat and diarrhoea which are associated with feeding of cactus to animals

Causes	Number of respondents	%
Improper feeding practice*	156	70.1
High water content	67	29.9
Total	223	100

*Overfeeding and feeding alone

Traditional Practices for Safe Use of Cactus as Forage

Traditionally, farmers developed their own prevention practices against problems that occur due to cactus feeding. Farmers (60%) are well aware that the best way of preventing bloat and diarrhoea is feeding cactus with dry feeds. When available, almost all farmers (97%) feed dry roughage before cactus. However, the optimum inclusion level that prevents bloat and diarrhoea is not known. Restricting cactus consumption by animals when fed alone is also practiced, which seems impractical as these are the times when nothing else may be available. Allowing the burnt cladodes to cool, mixing the cactus with salt, supplementing cactus with local beer residue and chopping the cladodes are also practiced.

Drenching the animals with diluted detergent is the most common treatment practice against bloat, followed by drenching with oil (Table 5). The use of detergents is seemingly related to proximity to towns. Drenching with mixture of flour of barely malt (fermented solution), dung, egg, pepper and soil with water is practiced by some farmers. Farmers smash a local plant called "Amamgmel", mix with water and drench to animals suffering from bloat. Allowing the animal to run, pulling its tongue by hand and inserting a smooth stick in to the oesophagus of the victim are also practiced. At extreme cases farmers pierce the left abdomen between ribs. The scientific merit of some of the traditional treatment practices should be investigated.

Table 5: Traditional bloat and diarrhoea treatment methods practiced by farmers

Traditional treatment method	Number of respondents	%
Drenching with detergents	136	62.2
Drenching with oil	54	24.4
Drenching with local plant species	11	5.0
Others	18	8.4
Total	219	100

Current Status and Prospects of Cactus Pear

The observation of good cactus plantations in Tigray and comparison of the agro-climatic and edaphic requirements of the plant (Inglese, 1995; Nobel, 2001) with the agro-climatic data of the region (WBISPPO, 2003) showed that cactus could be grown in all areas of Tigray. Cladodes of the southern zone were significantly (P<0.05) wider, longer and heavier than those from the eastern zone (Table 6), which could be related to the agro-climatic and edaphic differences (WBISPPO, 2003). In southern Tigray, cactus has colonized open cultivated farmlands. Though cactus could be an important forage source for any area that suffers from feed and water shortages in dry seasons and drought periods, relatively little attention has been given to its potential in other areas than Tigray.

Table 6: Cladode size of spiny wild cactus pear collected from the southern (Raya Azebo district) and eastern (Irob district) zones of Tigray region

Zone	Width, cm	Length, cm	Wet weight, g
Southern	19.7a	36.7a	733.3a
Eastern	15.0b	29.3b	428.4a
Mean	17.3	33.0	580.9
±S.E.	2.03	3.47	94.26
P value	*	*	**

Different superscripts in a column show presence of statistical differences

*P<0.05; **P<0.01

In Tigray the interest in cactus has remarkably increased and led to the identification of cactus pear as one of the food security crops. The BoANR is using cactus pear for its extensive rehabilitation of degraded lands (Gebreyohannes, 2004; personal communication). Mekelle University considered the potential of the plant and was involved in organising an international workshop (Mintesinot and Firew, 1997), which sparked interest in cactus. This has resulted into a FAO funded project (TCP/ETH/2901(A)) which mainly focused on screening the applicability of technologies developed elsewhere for the full exploitation of the plant in Tigray.

Conclusions and recommendations

Being a multipurpose plant, cactus fits well into the farming system. Farmers of the eastern zone have rich traditional experience in its production and utilisation compared to their counterparts in the southern zone of Tigray. Production and utilisation practices in Tigray are based on empirical knowledge and could be advanced through additional scientific information and modern technologies. Cactus is primarily used as source of food. Recurrent droughts and the consequent scarcity of feeds and water have increased the demand for cactus forage. Farmers use cactus pear as forage over 9-12 months a year and have rich indigenous knowledge on how to process and feed cactus and treat problems associated with its feeding. This should be

supported by scientific investigation. The main problems associated with feeding of cactus to animals are identified to be bloat and diarrhoea. Since all of cactus processing difficulties are related to the presence of spines, the spineless variety has to be promoted. Conditions in Tigray and similar arid and semiarid areas of the country are most ideally suited to cactus pear's production. The interest in cactus especially in arid and semi-arid areas has remarkably increased and the plant could be an important forage source for any area that suffers from feed and water shortages. It has tremendous potential in food, natural dye, medicinal and cosmetic industries (Barbera, 1995). Determining the optimal supplementation level of cactus, its role as a source of water and complementarity with locally available feeds are believed to be priority research areas. Though there are farmer identified 'varieties' no characterisation and selection have been done to improve cactus pear's potential as forage. Differences in drought resistance, palatability, crude protein content, plant habit, etc. among varieties need investigation.

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On-farm Phenotypic Characterization of Cattle Genetic Resources in South and North Wollo Zones of Amhara Region, North Eastern Ethiopia

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Abstract

This study was conducted to identify and describe the cattle genetic resources in South and North Wollo zones of Amhara Region, North Eastern Ethiopia based on their descriptive morphological characteristics. A total of seven sampling sites were selected based on the information obtained about the distributions of cattle types in the area. Quantitative and qualitative characters were taken from 1,321 mature animals and subjected to multivariate analysis of variance. The results showed significant ($p<0.0001$) differences in quantitative traits between sites for both female and male populations. Chi-square tests also showed very strong ($p<0.0001$) associations between qualitative variables and sites. Horn length and navel flap were the best discriminating variables from quantitative and qualitative variables, respectively. The canonical discriminant analysis applied to calculate the Mahalanobis' distances between sites using quantitative variables showed significant ($p<0.0001$) distances between the sites. The maximum and minimum distances were obtained between Were-Ilu and Afar sites (46.96) and Gimba and Kutaber sites (0.49) for female populations. The validity of discriminant analysis was assessed by reclassification statistics putting equal a priori probability levels for all sample populations and the results showed the overall classification rate (hit rate) was 55.2% and 60.1% for female and male populations, respectively. Sample populations from Kobo and Afar were highly divergent from other cattle populations in the other sites. Based on results of cluster analysis, it is concluded that, morphologically, at least three distinct cattle types are found in the area, namely the Wollo Highland Zebu (comprising of cattle from Gimba, Were-Ilu and Kutaber sites), the Raya Sanga (Raya/Kobo site) and the Afar Sanga (Afar site). The fourth cluster is considered as intermediate cattle that are found in the adjacent areas of Sanga and highland zebu cattle types. The Wollo highland zebu cattle type comprises compact animals with short legs, ears and horns with coat color being dominantly black. On the other hand, the Raya and Afar Sanga cattle types found in lower altitude areas have longer legs, ears and horns reaching to maximum measurements for the Afar cattle.

Keywords: indigenous breeds, phenotypic characterization, Wollo Highland Zebu, Raya Sanga, Afar Sanga, cattle, Ethiopia.

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Introduction

Given its diversified topographic and climatic conditions, and its strategic location along the known routes of cattle introduction from Asia into Africa, and from northern Africa to southern and western Africa, Ethiopia has become a major centre of cattle genetic diversity in Africa (Epstein, 1971; Rege, 1999). To date, at least 27 recognized indigenous cattle breeds are known to exist in Ethiopia, dispersed over a diverse range of ecological zones (DAGRIS, 2007). The current cattle population of Ethiopia is estimated at 40 million of which the indigenous breeds constitute over 99% (CSA, 2003).

Despite the long evolutionary history and vital livelihood services that cattle provide to their keepers in the country, very little effort has been made to comprehensively describe the indigenous cattle genetic diversity in Ethiopia. The first comprehensive attempt was made by Alberro and Haile-Mariam (1982a; b), who tried to identify and classify the common Ethiopian cattle breed types based on published literature. Only six of the breed types were fairly described in terms of their physical appearance; only seven of the breeds have at least one estimate of their population and even these were either outdated or based on crude assessments (Workneh Ayalew *et al.,* 2004).

Except the Sheko breed, none of the major cattle breeds of Ethiopia are said to be in serious danger of disappearance (DAGRIS, 2007). However, some of the indigenous cattle are threatened with genetic dilution from a number of factors, including market related cattle movements, restocking following recurrent droughts, cattle keepers' choices for more adapted and preferred breeding animals and neglect. For instance, the Ethiopian Borana cattle are gradually disappearing from their natural habitat (Workneh Ayalew, 1992; Nigatu Alemayehu *et al.*, 2003). Rapid survey reports made by Workneh Ayalew *et al*. (2002) also indicated that the Fogera cattle are undergoing serious genetic erosion. The situation of other cattle types of Ethiopia is not known at this time due to lack of information, but it is believed that genetic erosion may be in motion in other breeds too.

There is an increasing awareness of the need for genetic conservation of indigenous livestock genetic resources all over the world (Cunningham, 1992). In a workshop held in 1992 at the International Livestock Centre for Africa (ILCA) in Addis Ababa on characterization, conservation and utilization of African animal genetic resources, it was recommended that macro-level exploratory surveys for identification of indigenous breed types be carried out in countries like Ethiopia where there is a clear lack of information on indigenous livestock genetic resources. Breed identification, estimation of their population size, documentation of their common uses and description of the management systems in which they are maintained are needed before improvement and conservation measures can be planned (Rege and Lippner, 1992).

This paper reports the results of a cattle breed survey initiated to characterize and document cattle genetic resources in the Amhara Region of Ethiopia, and is part of an earlier work (Dereje Tadesse, 2005). The specific objective was to identify and phenotypically characterize indigenous cattle genetic resources in the North and South Wollo Administrative Zones of the Amhara Region, northeastern Ethiopia.

Materials and methods

Study Area

The survey was carried out in the North and South Wollo Administrative Zones of Amhara Regional State from October 2003 to January 2004. The area is situated approximately between 10º 10' N and 12º 25' N latitude and 38º 28' E and 40º 5' E longitude. The two zones have a total surface area of about 30,908 square kilometers, comprising the highland masses in the west and the lowlands in the east (SIDA, 1996).

The topography of the area is characterized by flat to undulating and hilly landscapes, with contrasting tropical, sub-tropical and temperate climates. The minimum and maximum average annual temperatures of the zones are about 15 and 20 ºC, respectively, and average annual rainfall is between 300 and 1200 mm, with 70% of the rains falling during the main rainy season between July and September (SIDA, 1996).

Livestock production in these areas is characterized by minimal management input in terms of feeding, breeding and disease control, and is mainly traditional and subsistence-oriented. Cattle are principally kept to provide draught power, cash and milk for subsistence. Oxen are the main source of traction in the area but in major barely growing highlands of Wollo, equines are also used for traction. Poor nutrition and diseases are major challenges to livestock production in the area. Natural pasture is the source of feed throughout the year. Grazing lands especially in South Wollo Zone are limited and even certain areas with potential for grazing cannot be utilized due to seasonal water logging. Mating is natural and uncontrolled.

Sampling and data collection

The survey purposively included the main indigenous cattle types identified locally by the farmers, with the view to ascertain whether this local classification is in line with the phenotypic classification results. For this reason a rapid appraisal was conducted before the main survey in order to identify and sketch the distribution of main cattle types in the area and to establish sampling framework. Discussions were held with zonal and Wereda agricultural experts and farmers about the distribution of cattle genotypes. Out of 15 Weredas explored, 7 Weredas representing all the three agro-climatic zones were selected based on locally identified cattle types

and from these 7 Weredas, again a total of 18 peasant associations used as sampling units were selected based on their accessibility and proximity to each other. The survey included only one visit to the sampling units at which whole herds of cattle were sampled until enough qualitative and quantitative measurements were taken from a minimum of 100 mature females along with about 20 males. However, for site 7 (Afar), only 23 female animals were sampled due to aggressive behavior of the cattle and unwillingness of cattle owners fearing that their cows will develop vice against milking.

Linear measurements were taken using plastic tape and age of animals was estimated from dentition, as demonstrated by Workneh Ayalew (1992) and later applied by Zewdu Wuletaw (2004), to compare with the age information given by the farmers. Morphological variables recorded in this study were adopted from the standard breed descriptor lists developed by the Food and Agricultural Organization of the United Nations (FAO, 1986). Each animal was enumerated by sex, dentition and the location. A total of 21 characters (15 qualitative and 6 quantitative) were recorded from all adult animals.

Linear measurements were taken from 1,315 animals as well as notes on their color and body conformation. Only mature animals were sampled to minimize the effect of age on the classification. Analysis was done separately for female (680) and male (129) sample populations to see whether the results are consistent for the sex categories.

Data analysis

The General Linear Model (GLM) procedures of the SAS (Statistical Analysis Systems) software (SAS, 1999) were employed to analyze the quantitative data and to detect statistically significant quantitative variation in body size between the sample cattle populations. The analysis was done separately for the female and male populations as the breed characterization needs to be sex specific. Taking site and dentition class as main fixed effects, the following model was used to analyze the data. Since none of the interaction components was significant, they were dropped from the final model. The model used was $Y_{ijk} = \mu + S_i + B_j + e_{ijk}$, where; Y_{ijk} is the observed value of trait of interest, μ is the overall mean, S_i is the effect of ith site (i= 1,2, 3…7), B_j is the effect of jth dentition class (j=1,2,3,….14), and e_{ijk} is the residual random error. The Frequency procedure of SAS (1999) was also employed to evaluate categorical variables for both sexes.

The quantitative variables taken from female and male animals were separately subjected to discriminant analysis procedures (SAS, 1999) to ascertain the existence of population level phenotypic differences among the sample cattle populations. The analysis was done taking the individual animal as the unit of classification. Discriminant analysis was also used to build a predictive model of group membership based on observed

discriminant scores of each case that have the general form of $Y = A_i + \beta_i x_1 + \beta_i x_2 + \ldots + \beta_i x_p$, where: Y is the classification score (i.e. linear combination of a set of variables), A is the constant for i^{th} group, β is the weights of corresponding variable for i^{th} group, x is the discriminator variable score, and p is the number of discriminator variables.

Pair-wise distance between sample populations and spatial distribution of cattle population on plot of the first two canonical variates (CAN1 and CAN2) were obtained by running canonical discriminant analysis. The stepwise discriminant analysis procedure (SAS, 1999) was run to rank the variables by their discriminating power.

Results and Discussions

Quantitative variation for the female population

Least squares means of all the six variables were significantly different (P<0.0001) between sites (Table 1). Between dentition categories, significant differences (P<0.05) were also detected for all the traits except for two variables - height at withers and ear length.

The respective R^2 values and coefficients of variation (CV) ranged from 13.5 for heart girth to 78.6 for horn length and from 4.6 for height at withers to 23.9 for horn length, respectively. The coefficient of variation for horn length was the highest followed by ear length and pelvic width, indicating the existence of high variations in the populations for these traits. The highly significant (P<0.0001) differences between the sites indicated that these variables are important in explaining variations between sample populations.

Table 1. Level of significance of each quantitative variable for the female sample populations (n = 680)

Variables	P-value for site	P-value for dentition	R2	C.V.
Body length	< 0.0001	0.0095	13.8	5.8
Height at withers	< 0.0001	0.8095	16.4	4.6
Heart girth	< 0.0001	0.0076	13.5	4.9
Pelvic width	< 0.0001	0.0018	17.4	7.2
Ear length	< 0.0001	0.8831	10.9	11.0
Horn length	< 0.0001	0.0361	78.6	23.9

Pair-wise comparisons of least squares means of variables between sites also showed significant differences (P<0.05). In all the six linear measurements, the female population sampled from site 7 (Afar type) had significantly largest value when compared to other populations (Table 2), and those from site 6 (Raya type) had the second larger value in all variables though no significant differences were observed for two of the measurements (heart girth and ear length). This indicates that the two sample populations are more distinct or divergent than the other populations (Table 2).

Body length, height at withers, heart girth and pelvic width measurements of female sample populations from the three sites (Kutaber, Tehuledere and Habru) were not significantly different from each other and had generally smaller measurements when compared to the other sites. Sample populations of sites 1 (Gimba) and 2 (Were-Ilu) had intermediate values for these variables. The female population of site 3 (Kutaber) had body length, height at withers and heart girth measurements with intermediate values between Gimba and Were-Ilu sites and Tehuledere and Habru sites. Measurements of ear length and horn length for the Kutaber population were found to be similar with those of sample populations from Gimba and Were-Ilu sites whereas in heart girth it was closer to Tehuledere and Habru sites.

Table 2. Least squares means of quantitative variables by study site for the female sample populations (n = 680)

Variables* (n)	Gimba (100)	Were-Ilu (105)	Kutaber (114)	Tehuledere (115)	Habru (116)	Raya (107)	Afar (23)
Body length	115.26bc	115.92c	113.59ab	112.91a	112.74a	117.76d	124.64e
Height at withers	108.98b	106.23a	107.24a	106.52a	106.55a	111.02c	115.53d
Heart girth	139.95b	140.42b	135.47a	136.49a	135.52a	136.86a	146.44c
Pelvic width	33.29b	33.23ab	32.59a	32.14a	32.99a	34.61c	38.09d
Ear length	17.78a	17.74a	17.90a	19.30b	18.88b	18.94b	20.31c
Horn length	17.41a	16.55a	16.40a	24.12b	31.13c	47.66d	60.83e

* Least Squares means with different superscripts in a row are statistically significant at P<0.05.

Quantitative variation for the male population

As with the female population, the quantitative data from the male sample populations was analysed by considering site and dentition as fixed effects. However, the number of sites in this model was six instead of seven considered for female populations, because no male animals were sampled from site 7 (Afar). The analysis of variance showed significant differences ($P<0.05$) between sites for all variables (Table 3).

A significant (at least $P<0.05$) difference was also noted between dentition categories for half of the variables. Height at withers, ear length and horn length did not vary significantly ($P>0.05$) between dentition categories, indicating that these variables are less affected by age of animals. This pattern is similar to the observation by Hall (1991) who pointed out that height at withers, which is related to inherent size of animals, is little affected by environmental factors when compared to other measurements such as heart girth and body length.

Horn length and height at withers had respectively the maximum and minimum R^2 value and CV, respectively. Horn length had the highest variability between sites (Table 3). Similar to the female population, horn length had the highest coefficient of

variation followed by pelvic width and ear length. Generally the coefficients of variation of all variables on male animals were higher than those of females partly due to small sample sizes.

Table 3. Level of significance of main effects for the quantitative variables and their associated R^2 and CV for male sample populations (n = 129)

Variables	P-value for site	P-value for dentition	R2 (%)	C.V.(%)
Body length	= 0.0005	= 0.0033	20.25	6.52
Height at withers	= 0.0248	= 0.1355	11.29	4.61
Heart girth	< 0.0001	= 0.0019	29.83	7.17
Pelvic width	< 0.0001	= 0.0088	22.94	10.67
Ear length	< 0.0001	= 0.7129	25.87	9.66
Horn length	< 0.0001	= 0.1324	64.07	33.42

Pair-wise comparisons of the least squares means of body linear measurements of male populations between sites (Table 4) revealed that those from Were-Ilu (site 2) have the highest measurement values for three variables namely body length, heart girth and pelvic width, indicating that they have the largest body frame. But they have shorter ear and horn length, similar to those from sites 1 (Gimba) and site 3 (Kutaber). Similarly, males from site 6 (Raya/Kobo) have the longest horn and ear measurements. Males from Tehuledere and Habru sites tend to maintain intermediate values for these variables (Table 4). This may be explained by their adjacent location and likely continual interbreeding (admixture) with cattle populations from lowland (Afar, Raya) and highland (Were-Ilu, Gimba) cattle. This hypothesis is also strengthened by the observation that both highland and lowland type cattle are found in these mid-altitude areas.

Table 4. Least squares means of quantitative variables and pair-wise comparisons by study sites for male sample populations (n =129)

Variables* (n)	Gimba (23)	Were-Ilu (21)	Kutaber (22)	Tehuledere (20)	Habru (20)	Raya (23)
Body length	121.62a	129.70b	120.51 a	121.03a	119.38a	120.57a
Height at withers	116.12b	115.89b	112.28a	113.33ab	112.04a	115.44b
Heart girth	145.78b	156.45c	142.89ab	147.27b	139.46a	137.34a
Pelvic width	33.00a	37.51b	33.51a	33.54a	32.22a	32.34a
Ear length	16.69a	17.64ab	18.09bc	18.89cd	19.85d	19.02cd
Horn length	16.13a	18.95a	20.93a	30.29b	36.34c	49.31d

* Means with different superscripts in a row are statistically significant at P <0.05

In general, within site adult males have larger measurements than females for body length, height at withers and heart girth, but shorter horn and ear lengths, which is generally expected for the species. This is consistent with what has been reported before for growth related traits in cattle (Saeed *et al*., 1987; Mwandotto, 1985). However, this difference was more conspicuous at Were-Ilu site (e.g. 156.4 vs. 140.4cm for heart girth) due to the better management practice of farmers for males as they prepare them for a lucrative beef animal market in Addis Ababa.

Qualitative variation

The chi-square test results showed highly significant differences (P<0.0001) between sample populations in all categorical variables (Table 5). Generally, most of the variables had medium to high association values with the study sites. Navel flap size and facial profile had respectively the maximum and minimum phi and contingency coefficient values. Among the lowland cattle owners, size of navel flap is considered as good selection criterion for breeding females. Naval flap had the highest association value or discriminating power in the present study. The importance of this trait as selection criteria of breeding females was also documented by Zewdu Wuletaw (2004) from the adjacent North and South Gonder Zones of the Amhara Region.

Table 5. Chi-square tests and level of association between sites and categorical variables for both female and male sample populations (n = 809)

Variables	P-value	Phi-coefficients	Contingency coefficients	Cramer's V
Coat pattern	< 0.0001	0.33	0.31	0.23
Body score	< 0.0001	0.28	0.26	0.16
Hump size	< 0.0001	0.29	0.29	0.17
Hair type	< 0.0001	0.66	0.55	0.66
Dewlap size	< 0.0001	0.74	0.59	0.52
Horn shape	< 0.0001	0.68	0.56	0.30
Face profile	< 0.0001	0.26	0.25	0.19
Size of navel flap	< 0.0001	0.84	0.64	0.48
Size of sheath	< 0.0001	0.32	0.30	0.18

Discriminant analysis

Putting equal a priori probability levels for all sample populations, the known sample cases were subjected to reclassification using discriminant analysis separately for female and male sample populations to determine the matching hit rate. The overall classification rates (hit rate) of female and male sample populations were 55.2 and 60.1 per cent, respectively (Tables 6 and 7).

The overall hit rate was not very high as the hit rates observed for some sites or sample populations were small. This is due to phenotypic similarities observed between some sites (for example the first three sites) in their cattle populations. For female populations, the highest hit rate of 73.9 per cent was obtained for Afar site, followed by 69.2 per cent for Raya site (Table 6), indicating that the female cattle of these sites are relatively more homogenous and distinct from such populations of other sites, suggesting that cattle keepers may be exerting directional selection pressure on the female population, for instance for traits perceived to be related to dairy production. In case of male populations, where the Afar sample population was missing, the highest hit

rate was 91 per cent for site 6 followed by the Were-Ilu site with 66.7 per cent (Table 7). Unlike female sample populations, the male sample population from Were Ilu site had a relatively high hit rate, apparently due to the special selective management practices of the farmers in their desire to participate in the lucrative Addis Ababa beef market.

Table 6. Per cent classified into each site for female sample populations using discriminant analysis (n=680)

From site	Gimba	Were-Ilu	Kutaber	Tehuledere	Habru	Raya	Afar
Gimba	41.0	23.0	20.0	14.0	2.0	0.0	0.0
Were-Ilu	21.9	52.4	10.5	15.2	0.0	0.0	0.0
Kutaber	18.4	23.7	45.6	12.3	0.0	0.0	0.0
Tehuledere	6.9	13.0	7.8	45.2	26.9	0.0	0.0
Habru	4.3	0.9	0.9	24.1	59.5	9.5	0.9
Raya	0.0	0.0	0.9	0.0	14.0	69.2	15.9
Afar	0.0	0.0	0.0	0.0	13.0	13.0	73.9

Table 7. Per cent classified into each site for male populations using discriminant analysis (n = 129)

From site	Gimba	Were-Ilu	Kutaber	Tehuledere	Habru	Raya
Gimba	56.5	30.4	8.7	4.4	0.0	0.0
Were-Ilu	14.3	66.7	19.1	0.0	0.0	0.0
Kutaber	27.3	13.6	40.9	9.1	9.1	0.0
Tehuledere	5.0	5.0	10.0	50.0	15.0	15.0
Habru	0.0	0.0	10.0	5.0	55.0	30.0
Raya	0.0	0.0	0.0	0.0	8.7	91.0

Stepwise discriminant analysis

The stepwise discriminant analysis procedure revealed that in both sexes all the variables had good discriminating power between sites or sample populations. This was confirmed by a high significant value ($P<0.0001$) associated for each variable against Wilk's Lambda. For both female and male sample populations, horn length was found to have the highest discriminating power. This can be explained by the sexual dimorphism in this trait and the strong variations between breed populations.

In all variables, the standard deviations for female populations were lesser than those of the male populations, partly due to the small sample size of males. The difference in standard deviation particularly for heart girth measurement was very high: 7.3 for females and 11.6 for males. The discriminating importance of horn length was also confirmed by the large pooled-within class standardized class mean value obtained from stepwise discriminant analysis of female and male sample populations.

Canonical discriminant analysis

All squared Mahalanobis' distances obtained between sites or sample populations for females were significant ($P<0.0001$), indicating the existence of measurable

differences between female sample populations or sites (Table 8). The smallest (0.49) and largest (46.9) distances were observed between Gimba and Kutaber, and Were-Ilu and Afar, respectively.

All multivariate tests (i.e. Wilk's Lambda, Pillia's Trace, Hotelling-Lawley Trace and Ray's Greatest Root) obtained from canonical discriminant analysis showed significant differences (P<0.0001) between sites or sample populations. This result is consistent with that of the univariate analysis that tests the hypothesis that class means are equal. In this test, values of all quantitative variables considered (i.e. class means) were highly significantly different (P<0.0001) between sites or sample populations.

Table 8. Squared Mahalanobis' distances between sites or sample populations for female sample populations

Sites	Gimba	Were-Ilu	Kutaber	Tehuledere	Habru	Raya	Afar
Gimba	***						
Were-Ilu	0.5106	***					
Kutaber	0.4991	0.9363	***				
Tehuledere	2.2939	2.8604	1.8441	***			
Habru	5.7897	6.7963	5.4181	1.3518	***		
Raya	22.5274	25.0677	22.9129	13.8558	6.9531	***	
Afar	43.9221	46.9647	46.2479	32.6251	22.4665	5.5646	***

The procedure of canonical discriminant analysis extracted six canonical variates of which the first two canonical variates (CAN1 and CAN2) accounted for about 97 per cent of the total variation. Therefore the rest four canonical variates that accounted for about 3 per cent of the variance were dropped as these were less important in separating sample populations.

The plot of the first two canonical variates (CAN1 and CAN2) showed that CAN1 best separated sample populations of the Raya and Afar sites, which have mainly Sanga characteristics, from those of the first three sites (Gimba, Were-Ilu and Kutaber), which have more of zebu type characters. Sample population from Tehuledere and Habru were positioned in between these two groups. The second canonical variate further separated sample populations of Were-Ilu and Afar from those of Habru, with the other sample populations positioned more or less in between (plot not shown).

In case of the male sample populations, the squared Mahalanobis' distances between sites or sample populations were slightly higher than it was for female populations (Table 9). The nearest distance (2.19) was observed between populations of Tehuledere and Habru and the largest distance between populations of Were-Ilu and Raya with value of 25.98 standard units (Table 9). The distance observed between sample populations is due to distinct phenotypic differences observed between them in quantitative traits. Both univariate and multivariate tests generated from canonical discriminant analysis once again confirmed the existence of highly significant differences (P<0.0001) between male sample populations sampled from different sites.

Table 9. Squared Mahalanobis' distance between sites or sample populations for male sample populations

Sites	Gimba	Were-Ilu	Kutaber	Tehuledere	Habru	Raya
Gimba	***					
Were-Ilu	2.87269	***				
Kutaber	2.71533	3.19062	***			
Tehuledere	7.15578	7.23198	2.21367	***		
Habru	15.20410	15.70844	6.47770	2.19370	***	
Raya	23.33843	25.97509	14.45410	7.54204	2.94131	***

A total of five canonical variates were extracted from canonical discriminant analysis using male sample populations. The first two canonical variates (CAN1 and CAN2) altogether explained about 94.3 per cent of the total variation, with the remaining three variates accounting for only about 5 per cent of the total variation. The plot of the first two canonical variates showed to some extent similar pattern with that of female populations. As with the female populations, the first canonical variate (CAN1) separated sample population of the first three sites (Gimba, Were-Ilu and Kutaber) from that of Habru and Raya, with Tehuledere site positioned in between. The second canonical variate (CAN2) further differentiated sample populations of Gimba and Raya from those of Were-Ilu and Habru (plot not shown).

Cluster analysis

Results of cluster analysis using Unweighted Pair-Group Method (UPGM) (Sneath and Sokal, 1973) revealed the existence of four different clusters for female as well as male populations, but the length of the branch in the dendogram formed was different for the two sexes. In case of female populations (Figure 1), the first cluster consisted of sample population of three sites (Gimba, Were-Ilu and Kutaber) whereas in males (Figure 2), it consisted of two sites (Gimba and Kutaber), perhaps due to the preferential management of males in Were-Ilu area. The second and third clusters consisted of sample populations of two sites (Tehuledere and Habru), and one site (Raya/Kobo), respectively, for both female and male sample populations. The fourth cluster consisted of the Afar sample in case of females and Were-Ilu sample in case of males.

In the male sample population, where the Afar sample was missing, the Were-Ilu site came out separately forming one cluster but it was clustered with Gimba and Kutaber sites in the female classification tree. This is due to the fact that males of this site appear to be selected for larger body size (body length, heart girth and pelvic width) than males of other sites. It was also noted that the standard deviation of heart girth (7.3) for females of this site was by far less than that of males (11.6). The reason for this divergence of the male population at Were-Ilu is that farmers in this area have got special treatment for males and therefore they tend to have bigger body size and better body condition when compared to other areas.

According to Nei *et al*. (1983), error in topology and branch length is expected from the sample populations due to differences in branching pattern and deviations of branch length. For this case, the difference between classification trees constructed for female and male populations could be attributed to differences in sample size, and other sex-linked characters such as heart girth and pelvic width.

Generally it is believed that phenogram tends to reflect the evolutionary process of population development though it may not represent the true genetic relationships among the populations. It may therefore be difficult to verify the relative merit of classification trees. However; classification tree constructed from females seems to represent the true difference between sample populations because on one hand the formation of clusters go with the geographical proximity of the populations and on the other hand the sample size of female population is larger than males making it more likely to reflect real differences.

Though no classification method is yet available for testing significant differences between clusters, the clusters formed in this study can be taken as true and natural differences between sample populations because in most cases the results are in line with the outcome of group discussions conducted in the area. The other is that the quantitative variables used in this study have been proven to be cattle breed descriptors (FAO, 1986) that could make the results even more realistic and acceptable.

Finally, combining the results of both female and male sample populations with the outcome of group discussions, the following three clusters can be considered as the most meaningful clusters to biologically explain and tentatively classify cattle genetic resources of the area into three breed types but the fourth cluster is considered as intermediate type and hence not taken as breed type.

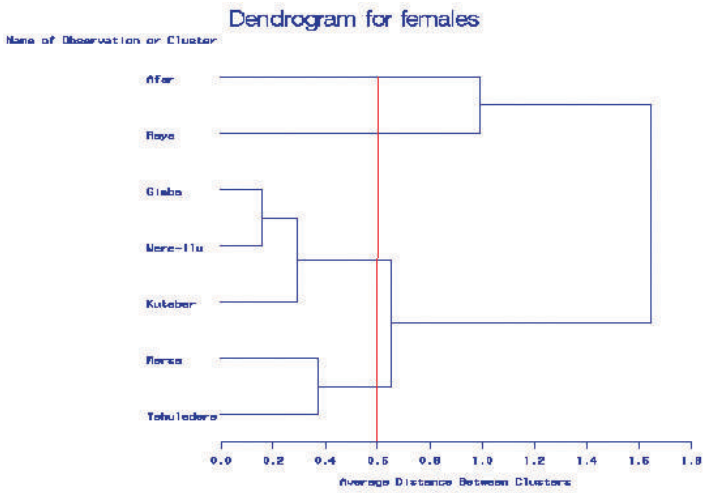

Figure 1. Dendrogram for female sample population by sites

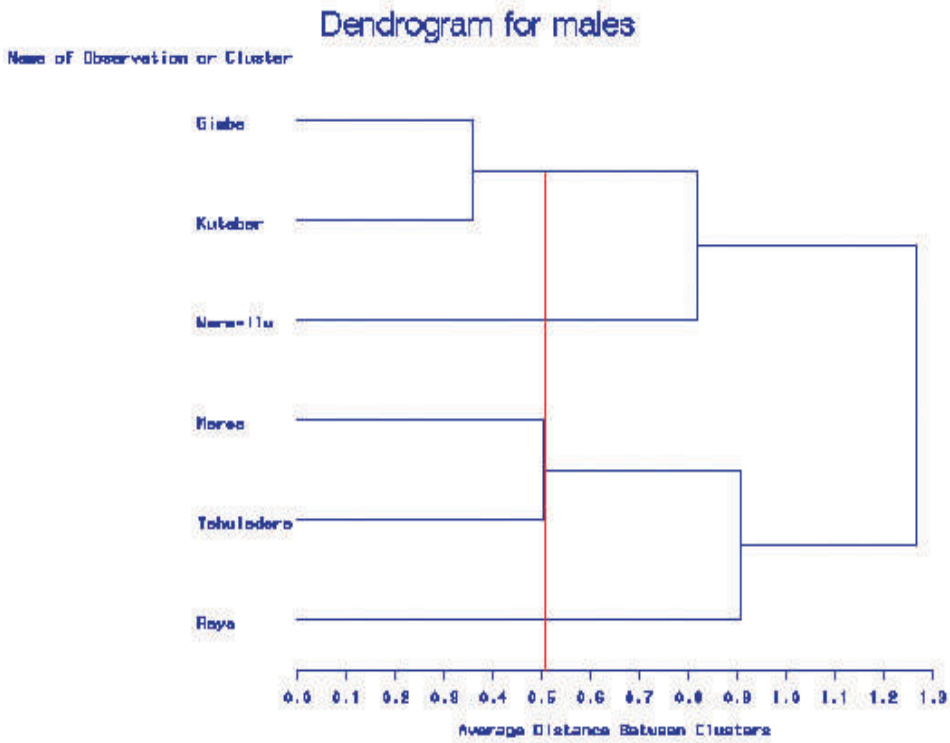

Figure 2. Dendrogram for male sample population by sites

Cluster 1: Wollo Highland Zebu

This cluster consists of the cattle populations from Gimba, Were-Ilu and Kutaber sites. This cluster appears to reflect more zebu-like characteristics. This cattle type is not known before in the literature. This cattle type is found in the highlands of Wollo, well adapted to cold climatic conditions. The main production functions of these cattle are traction, reproduction, milk and meat. Based on the information of cattle population size of each Wereda and the percentage distribution of the main agro-ecologies of the two zones, the population size of this breed type is estimated to be about 450,000.

They are short and compact animals with short legs and predominantly black coat color. They are characterized by having short ears (17.7± 0.14cm) and horns (18.0± 0.49cm). Mature females measure 116.8 (± 0.47cm) for body length, 107.5 (± 0.35cm) for height at withers and 33.8 (± 0.17) cm for pelvic width, which are smaller than those of the Raya and Afar Sanga breed types. Their heart girth measurement (141.5± 0.48 cm) is smaller than that of Afar Sanga type. Owner-recalled estimates of daily milk yield, calving intervals and lactation length of this breed type is about 2.3 liters, 16 months and 8.6 months, respectively (Figure 3).

Cluster 2: Raya Sanga

This cluster consists of the Raya cattle of site 6. They stood alone separately from others in both female and male classification trees. They are known by the name Raya cattle and already known in literature but not well described in terms of population size and reproductive performances in the study area. They are found in North Wello Zone particularly in Kobo Wereda with the Raya people. The main functions of this cattle breed type are traction, milk, meat and reproduction. The population size of this cattle type in this area is estimated to be around 120,000.

They have big body frame and long horns (48.7± 0.67 cm), which are thick at the base with an upward and slightly forward orientation to 50% of the length and then turning inward, and continue to grow upward. In some animals, the tip of the horn turns backwards. Predominantly, they have light red coat color. Their ear is longer (18.9± 0.19 cm) than that of the Wollo Highland Zebu but smaller than the Afar Sanga. Mature females measure 119.0 (±1.65) cm for body length, 110.9 (± 0.49) cm for height at withers, 138.2 (± 0.66) cm for heart girth and 35.2 (± 0.24) cm for pelvic width. Estimated daily milk yield, calving intervals and lactation length of these cattle is about 1.8 liters, 19 months and 11 months, respectively (Figure 4).

Cluster 3: Afar Sanga

This cluster consists of the Afar cattle of site 7 that came out separately from other populations in the classification tree. The name Afar is already known in the literature. Apart from their existence in the study area, their distribution and population size are not well described in earlier reports. The Afar people keep these cattle for reproduction and milk production, which is the main staple food for the pastoralists. Their number is very limited within the South and North Wollo Zones and is estimated to be not more than 4,500 based on the information obtained from Wereda Agricultural Offices where the Afar breed type is believed to exist and based on the frequency of their existence within the herds of the two zones during the survey.

They are long framed but look thinner when compared to Raya cattle. Many animals have a combination of black and white spots being distributed over the body giving them ashy or grey or light chestnut colors. They have straight facial profile and the longest horns (61.9± 1.45 cm) of all cattle types in the area, with an upward and outward orientation at the base and slightly inward orientation around the tips. In most animals the tip of the horn turns backward after forming a spiral-twisting curve. The horns appear thinner at the base than they are for the Raya breed type. They have also the longest ear (20.3 ± 0.42 cm). Mature females are 126.0 (± 1.39) cm long and 115.4 (± 1.05) cm high. They also measure 147.9 (± 1.42) cm for heart girth and 38.7 (± 0.51) cm for pelvic width (Figure 5).

Figure 3. Picture of Wollo highland zebu

Figure 4. Picture of Raya Sanga

Figure 5. Picture of Afar Sanga

Conclusion

The present study confirmed the existence of three cattle breed types in the North and South Wollo Zones of Amhara Region: the Wollo Highland Zebu, the Raya Sanga and the Afar Sanga. Results of both quantitative and qualitative analyses clearly showed population level differentiation into distinct breed types.

All the study sites covered differed in climatic conditions, vegetation cover, topography, and to some extent cattle husbandry practices. The existence of interbreeding at least between sites that are proximal to each other is highly likely as a result of exchange of breeding males and females through livestock markets, social transactions, and occasional matings at times of transhumant cattle movements. Cyclical famines that have been occurring for the past several decades in these areas and the subsequent restocking activities are believed to cause large scale movement of breeding cattle from place to place which could lead to population admixtures; however, this cannot be

substantiated based on the data generated in this study. Traditional selection practices of breeding animals within and between populations are also one potential external force that could lead to gradual genetic differentiation and breed divergence. Adaptation of animals to specific environmental stresses is another force responsible for genetic variations between cattle populations.

Nevertheless the results of these morphological classifications need to be verified through genetic characterization to substantiate genetic breed differences.

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The Mahibere-Silassie composite: a new cattle breed type in north-western Ethiopia

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Abstract

Despite the significant contribution of cattle to the country, little attention has been given to identify, characterize and conserve the diversity of cattle breeds. This paper presents a unique cattle population found in a monastery in the northwest of Ethiopia referred to as Mahibere–Silassie composite breed. With the view to investigate to what extent the breed in question is different from the rest of the cattle population of the study area a survey work that included focus group discussions, administration of semi-structured and measurement of variations using quantitative and qualitative traits was conducted in 2003. Findings of the study showed that the breed is reported as closed and geographically isolated within the territories of the Mahibere-Silassie Monastery. Also some descriptive data on general husbandry practices, population size, and phenotypic features categorized as primary and secondary features were documented and which further confirmed that the Mahibere-Slassie herd is distinct. Series of different but interlinked statistical tests have confirmed that the breed is basically different from the rest of cattle population of the study area. Particularly, the generated Mahalanobis' distance matrix of the canonical discriminate analysis from twelve quantitative variables which was used to construct the phenograms or classification trees for the female and male populations, singled out the monastery cattle population far from the rest of the group. Apart from its distinct breed characteristics, the fact that the population has been maintained within the territories of the Monastery in isolation for over three centuries may have particular relevance in the study of evolutionary relationships of cattle breed types in this part of eastern Africa. Therefore, without doubt, the Mahibere-Silasie herd is a unique cattle breed type. However, the effective population size (Ne) of the herd was calculated to be around 94; this low value can cause inbreeding at a rate of about 0.5% per generation. Thus, this herd is vulnerable to sudden or persisting threats that cause loss of genetic diversity and lead to gradual extinction unless urgent genetic conservation measures are taken.

Key words: Mahibere-Slassie cattle, characterization, phenotypic distance

Introduction

The ideal procedure in genetic improvement of livestock involves identification of the breeds and their environment, characterization of their adaptive as well as productive capabilities, and determination of the extent to which variations in performance are due to additive and non-additive genetic effects. Based on these appropriate strategies can be outlined for combining the superior traits of different breeds, or possibly for exploiting outstanding abilities in the purebred (ILCA, 1992; Falconer and Mackay, 1996). The initial step for long-term genetic improvement of indigenous livestock is, therefore, identification of the breed types, estimation of their population size, and documentation of their common uses and description of the management system in which they are maintained (Hall, 1992). Traditional animal breeding efforts and techniques are important for any breed improvement work, but more information is needed regarding the breeding population that exists in the system. This background information should precede any major interventions. Indigenous genotypes may well be adequate and able to respond sufficiently to reasonable economic improvements in the system (Workneh et al., 2003). Over many generations they have evolved to perform various functions under local conditions. Unfortunately, inadequate attention has been given to evaluating these resources or to setting up realistic and optimum breeding goals for their improvement. As a result some of the animal genetic resources of Africa are endangered and, unless urgent concerted efforts are made to characterize and conserve, these may be lost even before they are described and documented. The classical description of breeds is based upon phenotype on the basis that an organism's phenotype is principally a manifestation of its genotype, and that it lends itself to direct measurement on the organism. As such, phenotypic characterization is therefore complementary to the powerful biotechnological techniques for measuring genetic diversity on the genome. Given its diversified ecology, its huge livestock size and cattle types which have evolved over time in the various production systems, and its geographic location on the route to major livestock migrations across Africa, Ethiopia can be considered a centre of diversity for animal genetic resources. It is also home to most important cattle breeds for eastern and southern Africa (Beyene and Bruke, 1992; Workneh *et al.*, 2004). The indigenous breeds as explained by Epstein (1957, 1971) and Hanotte et al. (2002) originated from the migration of Hamitic Longhorn and Shorthorn from Egypt along the Nile Valley and the humped Zebu from India through the horn of Africa.

The present day Ethiopian cattle are classified into four main breed groups: the Humpless, Zebu, Sanga and Zebu-Sanga (intermediate) (Beyene and Bruke, 1992; Workneh et al., 2004). Besides, the Red Bororo or Fellata are also confirmed for their presence (Zewdu, 2004). Sometimes the Humpless cattle are divided into Shorthorn Humpless and

Longhorn Humpless (Alberro and Hailemariam 1982a, b; Beyene and Bruke, 1992). With similar classification, 17 Ethiopian cattle breeds are registered in Mason's (1988) dictionary of livestock breeds of the World. Rege et al. (2001) identified two more breeds, the Simada and Adwa. The Domestic Animal Genetic Resources Information System (DAGRIS) being developed by ILRI shows a total of 23 Ethiopian indigenous cattle breed types (DAGRIS, 2004). Generally other than such broad classifications, very little effort has been made to describe each of the indigenous cattle populations of the nation. Alberro and Hailemariam (1982a; b) attempted to identify and classify some of the cattle types by compiling available literature and gathering information from field reports of the Ministry of Agriculture (MOA) provincial offices, and in so doing they have contributed an eye-opener work for this field. Later, Sisay (1996) had also worked on characterization of some of the most known cattle types using protein polymorphism. Recent study made by Zewdu (2004) on characterization of indigenous cattle genetic resources in North-western Ethiopia identified a new cattle breed located in Metema district. The breed is owned by an Orthodox Church Monastery and is referred to as "Mahibere-Silassie composite" (Zewdu, 2004).

The objective of this paper is to confirm how the breed type in question is different from the rest of the indigenous cattle breeds found in the area.

Materials and methods

The study area

The study area, North Gondar and some part of South Gondar, is located in northwestern part of Ethiopia. It has 2.654 million cattle, 1.12 million sheep, 0.657 million goats, 0.312 million equines and 2.445 million poultry (DOA, 2003). The altitude ranges from 4620 meters in the Semein Mountain in the North to 550 meters in the western parts of the study area and rainfall varies from 880 mm to 1772 mm from a monomodal distribution with the maximum temperature of 44.5^{o}C in the West and minimum temperature of –10°C in the highland. The area is also characterized by two seasons, the wet season, from June to September and the dry season from October to May. The farming system of the study area is largely characterized by crop-livestock production system, which in turn grossly divides into two: the crop-livestock production system in the lowland and crop-livestock production system in the highland. So, the term mixed crop-livestock farming is preferred to denote farming system that exists in the high and mid highland areas. Trans-humance, from the highlands to western lowlands, is practiced as one of the most important strategies to secure grazing resources for the highland livestock during lean seasons of the year.

Sampling frame work and data collection procedures

The study covered the majority of North Gondar Zone and partly South Gondar. Initially rapid field survey was conducted with the specific objective of exploring available knowledge on the type, distribution, movement and utility of cattle genotypes in North Gonder and parts of South Gondar on the eastern flanks of Lake Tana. Based on the outcomes of this survey, six study sites were selected representing home areas of the six cattle types identified. These were;

Semein (1) = site representing cattle population found >3200 m.a.s.l
Wegera (2) = site representing cattle population found at 2200 -3200 m.a.s.l
Dembia (3) = site representing cattle population found at 1500 – 2200 m.a.s.l
Fogera (4) = site representing Fogera cattle breed found at 1700 – 1800 m.a.s.l
Lowland (5) = site representing cattle population found at 500 - 1500 m.a.s.l
Monastery(6) = site representing cattle population found at 500 – 700 m.a.s.l

The actual survey work consisted of linear body measurements on adult male and female animals, administration of semi-structured questionnaires on husbandry practices and farmer perceptions on cattle breed types and breeding preferences, and focus group discussions on the identity, origin and characteristics of the local cattle types of the area.

Table 1. Details of data sources and sites.

Sites	Sample size	Measured for quantitative traits			Individual interviews	Focus group discussions
		Male	Female	Total		
1	301	24	122	146	29	2
2	347	23	134	137	29	2
3	329	47	144	191	22	2
4	283	19	129	148	24	2
5	172	27	118	145	35	2
6	184	6	61	67	1	1
Total	1616	146	708	854	140	11

Data management and statistical technique

The importance of each quantitative variable in explaining phenotypic differences between sample cattle populations of the six sites was examined using the Generalized Linear Model (GLM) procedures of SAS (1999). When the analysis showed significant differences between sites (all the 12 quantitative variables were found significant), the generated **site** least squares means of each of the variable were then compared using Tukey's test of multiple comparison (Klockars *et al*., 1995). Because of known biological differences between males and females in the measured quantitative variables, and hence to avoid confounding effects of sex, data for the male and female populations were analysed separately. The following model was used for the female sample by taking site and birth class as fixed main effects:

$Y_{ijk} = \mu + S_i + B_j + e_{ij}$ where: Y_{ij}= observed value of the trait of interest, μ = overall mean S_i = fixed effect of site i, (I= 1.....6); B_j= fixed effect of birth class j, (j = 0.....6); e_{ij}= residual random error

The interaction of site and birth class was not found significant, and hence it was dropped from the model. Similarly, taking site and age class as fixed main effects, the following model was fit for males, after eliminating non-significant interaction effects:

$Y_{ij} = \mu + S_i + A_j + e_{ij,}$ where: Y_{ijk}= observed value of the trait of interest, S_i = fixed effect of site i, (i= 1.....6); A_j= fixed effect of age class j,(j = 1…3); where age was categorized as 3-5, 5-7 and >7 years, e_{ij}= residual random error.

For the categorical variables, chi-square tests were employed to test for the independence between the two factors of interest (Petrie and Watson, 1999; SAS, 1999). In this case unlike the quantitative variables, both male and female populations of each sample site were treated as one population. Since the statistics produced by the chi square tests for most of the variables are highly significant ($p<.0001$), other statistics derived from the Pearson chi square were used to measure the levels of association. Furthermore, multiple mean comparisons were also made for categorical variables using Bonferroni's correction (Petrie and Watson, 1999).

Furthermore, to evaluate differences between the Monastery populations with that of other breed groups on multivariate basis, taking into account quantitative traits, canonical discriminant analysis was conducted for males and females separately.

Results

Description of the breed

Results from the questionnaires and group discussions indicated that Mahibere-Silassie composite is a hitherto undocumented indigenous breed type that has been maintained within the territories of the Monastery in isolation for over three centuries. The Monastery rests on a mountainous landscape in the middle of a large lowland area with altitudes as low as 550 m.a.s.l. near the border with the Sudan. Inhabitants of the Monastery raise them with very little or no technical support from the extension services and that is limited to veterinary services. For quite a long time, no breeding animals were introduced into the herd, but culled and other animals have been disposed via local cattle markets. At present the herd is estimated to be as large as 3000 heads. Based on the information of age and sex structure of the population, effective population size (Ne) of the herd was calculated to be around 94; this low value can cause inbreeding at a rate of about 0.5% per generation. Thus, this herd is vulnerable to sudden or persisting threats that cause loss of genetic diversity and lead to gradual extinction unless urgent genetic conservation measures are taken. Information gathered from key informants

both from within and outside the Monastery, confirmed that the herd was established at the initiation of the Monastery in the middle of the 17th century (about 1630), from religious donations of breeding cattle from the area as well as far off places. According to the key informants it is believed that at least three breed types from the vicinity were involved in the creation of this herd: the Dembia, the Barca (Rutana) and the Felata (Red Bororo). The resultant breeding population interbred since then without additional introduction of breeding stock. It can therefore be considered a composite breed type.

The major characteristic features of this cattle type are larger frame of body and more aggressive temperament than all breed types in the area, loose drooping horns and sometimes polledness, light coat colour ranging from white to brown and dairy type body conformation, including wide hind quarters, large udder and teats. This cattle type is different in many respects from the rest of other cattle populations of the vicinity. Their coat colour pattern is predominately plain. Most common coat colour types are white, brown, and red. Patchy and spotted coat colour patterns account for less than 10%. The hair is always shiny. The facial profile is always concave. The majorities have droopy rumps. Hump size is moderate and purely cervico-thoracic in its position.. Ear is big in size. Cows have the largest naval lengths (an average width of 10.08 cm) of all the breed types in the north-western Ethiopia. The majority have medium to large teat and udder size, but they are not used mainly for milk as income generation and traction appear to be more important functions of the herd. The surrounding communities also consider this herd distinctly different from other breed types in the area

There has never been systematic recording of pedigree or performance, but dedicated herdsmen have been in charge of the day-to-day management of the herd. Cows are closely monitored for good milking ability, regular calving and cool temperament. The herd size is steadily declining due to shrinking land holdings of the Monastery under pressure from expanding cultivation in the lowlands. The herdsmen from the Monastery reported that contagious diseases transmitted from trans-humant cattle herds that often trespass grazing territories of the Monastery have been increasingly affecting the herd. Breeding of this herd has been closed for a long time, and mating is normally random. Breeding bulls are kept separately as are breeding females and young stock, and the herdsmen say there is no shortage of bulls. Because there is no pedigree recording, it is possible that closely related animals can be mated. Breeding animals are selected by way of selection for good phenotypic performance as well as culling of undesirable animals. Breeding males are selected based on body size (height and body length) and family performance mainly on milk yield, whereas breeding females are selected mainly based on good milk yield and mothering ability. In both cases large sized animals are preferred. Culling is also practiced occasionally against cows that are poor in milk yield and for undesirable temperament. Culled animals, often oxen and old cows, are sold

in a livestock market in Metema. Essentially this composite cattle type is maintained very much like an extensive ranching system (Jahnke, 1982), but without systematic recording of performance and genetic selection.

Quantitative variation

Female populations:

The analysis of variance showed that in all cases site, which represents cattle population types, and birth class, a proxy variable for age, were highly significant (p<.0001) in the model for all the twelve quantitative variables. Table 2 shows the level of significance of main effects. The respective R^2 value ranged from 34.7% in the case of horn length to 56.1% for mouth circumference. Subsequent pair-wise means comparisons also showed highly significant (P<0.0001) or significant (p<0.01) differences between the sites for all twelve measured quantitative traits (Table 17).

Table 2. Level of significance of main effects for each of the variables and their associated R2 values for the female sample population.

Variable	Site	Birth class	R2
Body length	p<.0001	p<.0001	42.8
Cannon bone circumference	p<.0001	0.0028	56.0
Chest depth	p<.0001	p<.0001	45.2
Dewlap width	p<.0001	p<.0001	42.2
Ear length	p<.0001	Excluded	47.5
Heart girth	p<.0001	p<.0001	52.5
Horn length	p<.0001	p<.0001	34.7
Hump length	p<.0001	0.0019	34.9
Mouth circumference	p<.0001	p<.0001	56.1
Naval length	p<.0001	excluded	55.7
Pelvic width	p<.0001	p<.0001	37.9
Wither height	p<.0001	p<.0001	55.0

Considering only the four important linear measurements, namely body length, chest depth, pelvic width and height at wither, the sample cattle population in the monastery have the largest of the measurements and those of the Semien mountains have the smallest of the measurements of all sites (Table 3).

Pair wise comparison of least squares means of these variables between sites shows significant differences for many of the traits (Table 3). In many instances Semein stands alone, where as monastery are highly significantly different from other study sites.

Table 3. Least squares means and pair wise comparisons of body measurements for females by site (cm)

Traits	Semien	Wegera	Dembia	Fogera	lowland	Monastery	RMSE
Body length	111.49a	115.60b	117.35bc	119.77c	114.72b	127.33d	5.61
Wither height	102.39a	109.37b	108.57b	111.78c	109.69b	120.82d	4.66
Pelvic width	35.81a	37.60b	37.28b	37.77b	38.37b	41.07c	2.39
Chest depth	53.59a	56.13b	55.98b	56.81b	56.73b	60.77c	2.74
Heart girth	129.15a	139.88b	132.76a	143.59c	147.95d	146.93cd	8.06
Dewlap width	16.79a	18.06ab	18.77b	20.58c	21.84c	24.08d	3.19
3Cannon bone circumference	12.39a	13.73b	12.98c	13.91b	15.04d	14.86d	0.89
Mouth circumference	33.41a	36.80b	32.64a	34.95c	37.73d	33.80a	1.97
Hump length	18.17a	22.27b	17.83a	20.55c	-	17.70a	3.61
Horn length	21.08ab	20.96ac	15.6d	16.98d	21.24a	17.95bcd	6.13
Ear length	17.73a	20.29b	18.41a	20.68bc	22.52d	21.68cd	2.02
Naval width	1.77a	3.94b	7.09c	8.30c	5.68d	10.08e	2.51

3 forelimb

a.b.c.d.e.f. means with different superscripts within the same row are significantly (p<0.01) different.

-- no data collected for that particular variable

Male populations:

Similar to the female sample populations, the overall F test was highly significant (P<.0001) for all dependent variables considered, indicating that the sample populations indeed differed between sites and age classes. Site was highly significant (p<.0001) for all traits, but age class was significant only for some of the traits. This might be due to the narrow age range (4-7 years) of the sample populations. However, in most cases the R^2 value of each of the dependent variable was slightly higher in the male than it was for the female population. Similar to those of the female population, population of cattle from Semien Mountains (site 1) is the shortest and narrowest, and the sample population from the monastery (site 6) is longest and widest.

Table 4. Least square means and pair wise comparisons of body measurements for males by site (cm)

Traits 2	Semien	Wegera	Dembia	Fogera	Lowland	Monastery	RMSE
body length	111.45e	119.15bd	119.23bc	124.39b	118.16cd	138.00a	6.80
wither height	102.43c	111.65b	110.77b	114.59b	113.62b	131.76a	5.39
pelvic width	34.11de	39.10ba	36.03ce	36.75bde	37.52bc	42.54a	3.30
chest depth	53.03d	59.13b	55.63c	57.47bc	58.19b	67.08a	3.41
heart girth	128.41c	146.90b	133.56c	148.21b	152.24b	170.48a	9.82
dewlap width	19.42a	22.69b	20.67ac	23.01cb	25.44b	25.50bc	3.87
3cannonbone circu	13.13e	15.61ac	13.77e	15.43bcd	16.11dba	17.11a	1.06
mouth circumference	34.18de	39.60ba	34.14e	37.60cb	40.28a	37.52acd	2.23
hump length	22.90a	35.71b	26.32a	32.18b	41.13c	34.70bcd	6.54
horn length	17.14a	19.84a	12.87b	13.10b	18.92a	17.30ab	5.16
ear length	17.50c	20.87b	17.75c	19.80b	23.06a	21.56ab	1.95
sheath width	8.86b	12.23a	13.70a	13.32a	13.60a	12.01ab	3.31

3 cannon bone circumference (forelimb)

a.b.c.d.ef. means with different superscripts within the same row are significantly (p<0.01) different.

Qualitative variation

The chi-square test was highly significant (P<.0001) for all variables with an association ranging from the lowest of 0.33 for coat pattern to the highest of 0.73 for horn orientation using phi coefficients, from 0.31 for coat pattern to 0.59 for horn shape using contingency coefficients and from 0.17 for coat pattern to 0.71 for hump position using Cramer's V. Generally, in all three measures of associations the level of correlation for most factors was medium, with a few exceptional cases of high levels. Pair wise comparisons between sites on categorical data was made after the general chi square test of independence was performed and found significant. Table 5 presents the pair-wise comparisons made for each of the categorical variables across sites based on p-value derived from Bonferroni's correction (Petrie and Watson, 1999).

Table 5. Pair wise comparisons using the Bonferroni's correction*

Trait/variable	Semien	Wegera	Dembia	Fogera	Lowland	Monastery
Coat color pattern	a	b	b	c	dc	e
Body score	a	b	c	d	e	f
Hair type	a	a	b	b	b	b
Facial profile	a	b	a	c	d	e
Rump slope	a	a	a	b	b	c
Hump position	a	b	b	c	b	d
Tail length	a	b	c	c	c	d
Horn shape	a	b	c	d	e	f
Horn orientation	a	b	c	d	e	f
Udder size	a	b	c	d	e	f
Teat size	a	b	c	d	e	f
Coat color	a	b	c	d	e	f
Birth class	a	b	a	ab	c	d

* sites with different letters in the same row are significantly different

The result based on pair-wise Mahalanobis' distances for females (Table 6) and males (Table 7) populations showed that the Monastery herd is distinctly different from all other sample populations.

Table 6. Mahalanobis distance between sites for the female sample populations

Sites	Semein	Wegera	Dembia	Fogera	lowland	Monastery
Semein	0	5.57	5.67	11.27	15.54	28.29
Wegera	5.57	0	6.80	5.38	4.57	18.88
Dembia	5.67	6.80	0	3.28	14.95	11.93
Fogera	11.27	5.38	3.28	0	7.64	7.38
Lowland	15.54	4.58	14.95	7.64	0	18.80
Monastery	28.30	18.88	11.93	7.38	18.80	0

Table 7. Mahalanobis distances between sites for the male sample populations

Sites	Semein	Wegera	Dembia	Fogera	Lowland	Monastery
Semein	0	12.97	5.90	13.57	24.73	48.83
Wegera	12.98	0	13.39	9.02	5.34	32.58
Dembia	5.90	13.39	0	5.92	21.47	32.58
Fogera	13.57	9.02	5.92	0	9.80	20.73
lowland	24.73	5.34	21.47	9.80	0	30.94
Momastery	48.83	32.58	32.58	20.73	30.94	0

Finally the phenograms or classification trees were constructed separately for the female and male populations, using only the twelve quantitative variables. The Mahalanobis' distance matrix was used to calculate arithmetic averages using the Unweighted Pair-Group Method (UPGMA) (Sneath and Sokal, 1973). The tree topology as well as the branch length differs between the sexes. However, in both cases the Monastery cattle type, cluster 1, came out distinctly singled out far from the rest of the group (Figures 1 and 2). Therefore, without doubt, the Mahibere-Silasie herd is a unique cattle breed type. Apart from its distinct breed characteristics, the fact that the population has been maintained within the territories of the Monastery in isolation for over three centuries may have particular relevance in the study of evolutionary relationships of cattle breed types in this part of eastern Africa.

```
            +----Wagara
     +-----925.0
     !      +----Matema
 +981.0
 !   !      +----Semien
 !   !   +605.0
 !   +584.0   +----Dembia
 !       !
 !       +---------Fogara
 !
 +------------------Monastry
```

Figure 1. Consensus tree: male population:*

*the numbers at the forks indicate the number of times the group consisting of the species which are to the right of that fork occurred among the trees, out of 1000.00 trees

```
+------------------Monastry
!
!          +----Dembia
!      +999.0
!   +384.0   +----Fogara
!   !   !
+908.0   +---------Semien
    !
    !       +----Matema
    +-----816.0
            +----Wagara
```

*Figure 2. Consensus tree: female population**

*the numbers at the forks indicate the number of times the group consisting of the species which are to the right of that fork occurred among the trees, out of 1000.00 trees

Conclusions and recommendations

The outcomes of key informant interviews, multivariate analysis of quantitative as well as categorical variables and the phenograms constructed from the Mahalanobis' distance matrix strongly supported the hypothesis that the Monastery cattle population is distinctly different from other cattle breed types in the area and has some unique phenotypic features. It can therefore be considered as a breed type in its own right. Because of its effective isolation from breeding with neighbouring cattle populations for over three centuries, this cattle population may have relevance in the study of evolution of cattle breed types in the eastern Africa in general.

The breed is referred to as Mahibere-Silassie Composite since it is constituted from different breeds that existed in the surrounding three centuries ago. Preliminary data on its performance showed that the breed is potentially rich in milk yield, reproductive performance and known to have good adaptation to the harsh environmental conditions of the area. Despite this, support from livestock extension services has been minimal. The Monastery particularly needs animal health service, and possibly advice on improved breeding, feeding and marketing of products. Furthermore, as the breed is closed and isolated for more than 300 years, it has a paramount importance for evolutionary studies. However, the effective population size of the breed in question is 94, which makes the population vulnerable to rapid build up of inbreeding at a rate of 0.5% per annum. Thus, unless urgent conservation measures are taken, the breed is feared to be in danger of genetic erosion and eventually gradual extinction. Unfavourable environmental effects

and cattle diseases could speed up the loss of genetic diversity. Mention should be made here that as the findings reported in this study are only preliminary, and detailed studies on selected key traits is urgently needed.

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Effects of Draught and Transport Animals on Rural Livelihoods and the Natural Environment in Tigray National Regional State, Ethiopia

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Abstract

Cattle, camels and equines are widely employed to provide energy for agricultural operations and for transport in the Ethiopian Highlands. Their use is promoted by many Government and non Government agencies. They are generally considered to be beneficial in reducing the drudgery of many agricultural and transport activities, in raising food output, and in contributing to household incomes and food security. Human welfare is thus considered to be enhanced. The negative effects of the need for and use of animals to provide energy and power are rarely considered. Such effects include reduced output from other livestock functions such as milk and meat. There is also a need for additional labour to support and care for work animals during prolonged periods when they are not producing any output. Work animals also exert negative effects on the environment. These include their contribution to the expansion of arable areas on to lands unsuitable for this type of production and over and excessive use of and competition for limited natural feed resources. They are directly responsible for a major part of erosion in general and the creation of gullies in particular along their tracks. This paper provides an overview of the benefits and costs of the use of domestic livestock as providers of rural and urban energy in Tigray.

Keywords: Livestock herd age and sex composition, household income, food security, degradation

Introduction

In much of the Developing World animal power on and off the farm is considered essential to people's survival. Livestock furnish energy for draught and transport, help relieve the drudgery of arduous and repetitive tasks and contribute to larger cultivated areas and higher crop yields. They may create additional income that can be used for a variety of purposes including contributing to food security and assisting in payment of taxes and other expenses. Draught and transport animals in Tigray National Regional State (TNRS) and in its neighbouring states are implicated in most if not all of these functions (Wilson, 1975; Wilson et al, 2002; Mengistu et al 2005). So what is the problem?

The problem is that positive effects must be balanced -- as in all nature -- against associated negative ones which are rarely considered by proponents of animal power. In livestock production *per se* negative effects include reduced output from other components of the enterprise and the need for extra labour to feed and care for work animals. In human well being the have nots (those without animal power or with only a limited amount) are generally exploited – often shamefully – by the haves (those who do have it or have a surplus of it). In the environment and in sustainable production draught and transport animals consume enormous amounts of feed and contribute to and cause sheet and gully erosion in much the same way as do other classes of large livestock. This paper first calculates the number of draught and transport animals in TNRS, presents some of the pros and cons of this class of animal and then looks at their effect on the environment.

Draught and transport animal numbers

Cattle, camel, donkey, horse and mule are draught and transport animals in TNRS. In 2004-2005 the region was home to more than 3 million of these species (Table 1, CSA, 2006). Some 32.6 per cent of cattle were under 3 years, 62.8 per cent were aged 3-10 years and 4.4 per cent were over 10 years of age. In the group 3-10 years, 46.6 per cent of cattle or 766 600 head were used for draught compared to 16.9 per cent (278 000 head) for milk with 33.2 per cent (546 146 head) described as "breeding" animals and only 0.8 per cent (13 160 head) were kept for beef production. The total of three-quarters of a million draught cattle (which are mainly oxen of 3-10 years) does not provide the true picture as these are animals actually in work but 50 per cent (426 985 head) of the under 3-year olds are also being reared for draught and most animals over 10 years (amounting to about 55 000 head) plus about 8500 adult cows are also used for draught. The total of "draught" cattle is therefore of the order of 1.2 million head. Not all of theses are native to Tigray as in order to meet the demand for power additional oxen have to be imported from the neighbouring lowland areas. This very high proportion of work animals has negative effects on other aspects of output including low herd reproductive performance and reduced outputs of meat and milk. This results from competition for grazing and for crop residues used as feed as well as from fewer young (especially cattle) being born due to the low percentage of breeding females in the total herd.

The CSA census indicated that 90.1 per cent of camels over four years old were used for transport and 3.5 per cent for draught purposes. For camels, therefore, and in contrast to cattle, females as well as males are used for work. The total number of work camels (including those of both sexes under four years old) is therefore about 37 500.

Equines are mainly used for transport and to a lesser extent for draught. For donkeys 69.8 per cent are used for transport and 27.2 per cent for draught purposes leading to a

total number of 391 410 working animals. Horses are mostly used for transport (85.3 per cent) and to a lesser extent (8.3 per cent) for draught to give a total of 7370 animals actually being used or reared for work. Similar proportions of mules, as for horses, are work animals with 89.6 per cent used for transport and 8.6 per cent for draught to give a total of 16 120 work animals across all age groups.

Table 1. Estimated number of livestock and numbers of draught and transport animals in Tigray National Regional State, 2004/2005

Livestock species	Whole population	Animals for draught and transport
Cattle	2 619 540	1 200 000
Camel	39 791	37 500
Donkey	403 517	391 410
Horse	7 598	7 370
Mule	16 418	16 120
Total	3 086 864	1 652 400

Source: adapted from CSA (2006)

Table 2. Biomass (kg live weight) of work and non work animals in Tigray National Regional State

Livestock species	Mean population weight (kg)	Working animals		Non working animals		All animals	
		Number	Total biomass (kg)	Number	Total biomass (kg)	Number	Total biomass (kg)
Cattle	220	1 200 000	264 000 000	1 420 000	312 400 000	2 620 000	576 400 000
Camel	300	37 500	11 250 000	2 300	690 000	39 500	11 940 000
Donkey	90	391 400	35 226 000	12 100	1 089 000	403 500	36 315 000
Horse	200	73 700	14 740 000	230	46 000	37 930	14 786 000
Mule	200	16 120	3 224 000	300	60 000	16 420	3 284 000
Sheep	18	0	0	687 200	12 369 600	687 200	12 369 000
Goat	18	0	0	1 760 000	31 680 000	1 760 000	31 680 000
Total			328 400 000		358 334 600		682 734 600

Source: Author's calculations

In sum 1.2 million cattle, 37 500 camels and 414 900 equines are work animals. The total of approximately 1.65 million work animals means that there is one of these beasts for every 2.5 people -- the human population of TNRS is put at just over 4.2 million (CSA, 2006). In addition to the larger species of domestic herbivores used for draught there are 687 212 sheep in Tigray as well as 1 759 126 goats. The total number of quadruped livestock is therefore 5.53 million of which work animals constitute 29.8 per cent. Numbers alone are not, however, very helpful in this context as it is the biomass of animals that is important in calculating the use they make of resources. Based on population structure and weight for age a rough assessment of the weight of the "average" bovine in the regional herd is 220 kg, of camel 300 kg, of donkey 90 kg, of horse and mule 200 kg and of sheep and goat 18 kg (calculated from author's personal observations and empirical data collected in Tigray and elsewhere). Calculated in this

way work animals constitute 48 per cent of the total biomass of domestic animals in TNRS (Table 2) and can be expected in general to consume that proportion of all the feed eaten.

Benefits

Using oxen for ploughing is often seen as implying "integration" of livestock and crops in a farming system (Goe, 1987). Others see the use of animal power as a means of "intensification" (Astatke and Mohamed-Saleem, 1996; Mohamed Saleem and Astatke, 1996). Both of these pathways lead -- at least in theory -- to increased crop output either by increasing the area cultivated or contributing to higher yields. In the latter case yields are lifted mainly because of the more timely cultivation and planting than can be achieved with animal draught than with human labour. In Ethiopia using oxen to construct broad raised beds intersected with drainage furrows on heavy black cotton soils led to increases in both grain and straw yields with yields of the former apparently being double after constructing beds than what they had been before (Astatke and Mohamed-Saleem, 1998).

Crop yields are also considered to be increased through the production of manure and nutrient recycling (de Leeuw et al., 1994; Powell et al., 2004). There is a further belief in some quarters that grazing is of importance in maintaining or even enhancing diversity by dispersion of seeds in time and in space via deposition of dung (Zerihun and Mohammed, 2000). If this is actually the case, work animals would be major contributors to biodiversity as they travel more widely than other types of livestock.

Another source of income from draught oxen as well as from transport animals is the possibility of hiring out. This is clearly beneficial for those with animals and may be so for those without if it enables them to plant a larger area and at an earlier date than would otherwise be possible. There do not appear to be any quantitative data on the percentage of owners that hire out animals of different types but several types of arrangements are known (Beck and van Waveren, 2002). These vary depending on draught need and the availability of feed and labour. Common arrangements include provision of all inputs by the animal owner in exchange for a proportion of the yield after threshing, payment by the land owner of part of the harvest or provision by the land owner to the draught owner of two days' labour for each day's draught use.

Disadvantages

A major negative effect of large numbers of work oxen is that of reduced production from other elements of the cattle herd. There is clearly competition for feed resources which results in reduced growth rates for young animals, lesser milk yields by lactating cows, lowered reproductive performance of breeding females and higher

morbidity and mortality in the herd as a whole. These simple and straightforward consequences are compounded by the effects on herd structure so there is a multiplier effect of poor overall performance by a smaller number of (non draught) animals. "Draught" herds evidently have a smaller percentage of females than non draught herds. In herds with mixed production objectives of meat and milk, as for example the Borana of southern Ethiopia, females constitute about 70 per cent of the herd, as indeed they do in many other parts of Africa (de Leeuw and Wilson 1987). In herds that make considerable use of draught, as in Tigray, the female portion is reduced to 50 per cent or less. In East Shewa in the early 1990s females were only 46 per cent of the herd and in Illubabor they were only 43 per cent (GRM, 1994). In Tigray in the mid 1970s male animals in some of the "Rural Development Units" of the time were 70 per cent of the herd because they were fed the few resources there were as a result of the drought to the detriment of females (Wilson, 1975). To use another livestock metaphor this is putting all your eggs in one basket because if crops fail there is no fall back position in the sale of other animals or animal products from which the cash can be used to procure food.

It is difficult to condemn a fair rent or a fair hire charge for provision of a fair service. In much of highland Ethiopia, however, it seems rare that the party without or with insufficient draught or transport animals gets a fair deal. In all three arrangements described as being profitable for animal owners an adjunct to the rent is that they also receive all or most of the straw from arable related activities. Indeed this may be a prime consideration in hiring out by owners. In contrast, it has a further strongly negative effect on the person hiring if he or she has other cattle or other species of livestock to feed. On fertile soils, where higher yields might be expected, half the grain (as well as up to all the straw) might be demanded of the person hiring by the owner of the draught animals. On less fertile soils two-thirds or even three-quarters may be demanded (SCF-UK, 2001). In these transactions there are net disadvantages to the land owner or land user that represent income foregone and decreased household food security.

Labour requirements are not always absolutely decreased as a result of the use of animal power. Unless all operations are mechanized – not only ploughing but sowing, weeding and harvesting among others – labour requirements may actually increase. It is possible, however, that there is an increase in the productivity of the labour associated with crop activities. Some or all of this productivity is nonetheless offset by the need for additional labour for herding and for feeding and watering the livestock although this labour is seldom if ever considered when calculating the benefits that accrue from the use of animal traction.

The use of draught and transport animals may not be and usually is not gender neutral. Women are almost always expected to do much of the work associated with planting, weeding and harvesting. Seldom, however, do they receive rewards commensurate with

the extra effort they put in due to larger crop areas and higher total output. In Ethiopia women can gain access to draught power whereby they exchange their labour for hire of animals but the "payment" they make may be more than the returns they receive (SCF-UK, 2001) with a resultant negative impact on their livlihoods.

In Ethiopia the possibility of increasing the size of the cattle herd is further proscribed by the large number of equines – most unusual in Africa – that are kept for transport and compete for use of the natural resource base. Concomitant with the need to keep oxen to advanced ages is reduced commercial offtake of animals for beef as is evident from the fact that only 0.8 per cent of cattle in Tigray are kept with this production objective. In Zimbabwe in production systems where draught is also a priority market offtake is 2-5 per cent compared to probably 8-10 per cent in other traditional systems of production and 15-20 per cent in larger scale commercial operations (Wilson, 2000). The negative effects on reduced offtake for beef are not only internal to the system but also external to it. Thus because the Tigray herds are not self sustaining they import younger males from the lowlands -- the Afar herds are only 11 per cent male in the 3-10 year age group (CSA, 2006) -- which otherwise would have been grown on for beef and probably made a higher price. Even imports of animals may not be sufficient to provide the required power and lead to unusual combinations of a draught pair such as a camel and a donkey or an ox and a mule (Figure 1).

Figure 1. Ox and mule as a plough pair in Tigray in 1970 (the long horns and small cervico-thoracic hump indicate this is an Afar animal imported into Tigray from the lowlands) (photograph by the author)

Environmental effects

Over several hundreds of years the natural vegetation of Tigray has been gradually transformed under anthropic influences by the direct and indirect actions of man and by those of his animals. In the early 21st century much of the area has been completely cleared of natural vegetation and put under cereal and other food crops. Pressure on the remaining areas mainly for fuel wood (Figure 2), building materials and animal feed has resulted in the extinction of much of the original vegetation although remnants do remain in usually small and isolated areas. Some major plant species have disappeared and many others are present only as stunted specimens. Other vegetative species have benefited from man's interference and expanded greatly in the area they cover. In general this latter group comprises noxious plants that are not useful to man and are not eaten by his animals. In short plant biodiversity has been compromised and probably greatly reduced. Animal biodiversity has also been affected in a negative manner with many species of mammals, birds, reptiles, arthropods and other taxa disappearing or now present in the area in very low numbers and in very circumscribed areas. Further negative effects result from exposure of the substrate to the direct action of wind and rain with attendant and continued erosion of the chemical and physical properties of the already depleted soil base.

Figure 2. Fuel wood brought to market by donkey pack and cart (photo by the author)

In more practical terms for the livestock subsector, however, the main result has been that the resources potentially available as animal feed are greatly reduced over most of the area for most of the time. In many places only sparse scrubby and

unpalatable vegetation remains. Fluctuations in available feed occur not only within years (production is highly seasonal in relation to the annual rainfall pattern) but also across years. Fluctuations across years are, however, only relative under the prevailing low if considerably variable rainfall regime. In this context it appears unfortunate that owners of livestock do not recognize the problem of feed supply and nutrition. In one study in which farmers were questioned about feed deficits (WBISPP, 2003) they considered that major deficits in feed availability occurred in only two or three months of the year from February to May. In fact the inverse is the case as feed is available in sufficient quantities to provide more than minimal maintenance for only two to three months in most years (WBISPP, 2003). The natural environment is so degraded that only 40-50 per cent of livestock feed is obtained from the rangelands with the remainder deriving from arable stubbles and crop residues (WBISPP, 2003).

Global warming is perceived as a major problem at the beginning of the 21st century. Annual global emissions of methane from agriculture were estimated at 165 million tonnes in the early 1990s (IPCC, 1992). Draught and beef cattle contribute 50 per cent of this amount (Leng, 1993). Animals on low quality feed -- as in Tigray -- consume 15-18 per cent of all livestock energy intake but produce 75 per cent of the methane. Draught animals are used very inefficiently throughout their lives. In Ethiopia they have a very long maturation period during which they consume feed and produce methane. Training does not start until they are well into the fifth year of life (NEDECO/DHV, 1998). Even when mature they are used very inefficiently working for about 120 days a year of which 93 are for ploughing, 21 threshing, 5 transport and 1 other work (Figure 3). A "day" is not very long although it may be exhausting for an undernourished ox in a debilitated condition. In Tigray in the 1970s at the height of the ploughing season and over an 11-day period oxen were in the field only 4.7 hours per day and there were 6 hours 46 minutes of rest in the 45 hours 7 minutes of working time (Wilson, 1975). An area of 19 990 m^2 took 26.4 hours to plough equivalent to 5.62 working days per hectare per ox (that is, 11.24 total ox days for the pair).

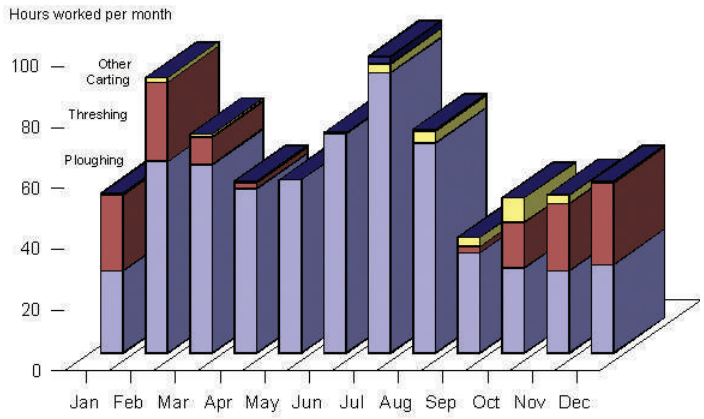

Figure 3. Number of work hours per ox per month in Ethiopia by type of work (GRM, 1994)

It is not only in ploughing that work oxen are used inefficiently. The use of capstans for seed decorticating, oil milling, lifting water and threshing would greatly increase output. The traditional method of threshing by trampling is very expensive in terms of both human and oxen power (Wilson, 1991). Modest use of technology such as a sled would halve the "cost" of threshing and use of a thresher would reduce it even further (Table 3).

Table 3. Time expenditure and costs of three methods of animal threshing

Method	Power source				Batch (kg)	Cost/100 kg (relative currency units)
	Human		Oxen			
	Number	Hours	Number	Hours		
Trampling	3	9	6	18	200	68
Sled	3	7	4	10	300	37
Thresher	2	4	4	8	400	28

Source: Wilson (1991)

Donkeys are used as equally inefficiently as oxen. In the Debre Berhan area of Amhara State they are used for about 433 hours per year or 8.3 hours per week on average. This work comprises 39 hours for transport of crops from field to farm, 46 hours for threshing, 40 hours for transport of hay and 308 hours for market transport (ILCA, 1988). These figures are considered to be above the national average (Crassly, 1991). There is thus a massive surplus of donkeys in the country. Further efficiencies would accrue if donkeys were used in carts which would enable them to move perhaps 10 times as much as by pack alone (Wilson, 1991).

One of the supposed benefits of integration of crops and livestock is the cycling of nutrients. In the case of draught animals much of this supposed cycling is nutrient transfer and a not inconsiderable amount of nutrient depletion takes place. Transfers of nutrients are from natural grazing lands -- as if there were not already enough problems there -- to the crop lands as draught and transport animals usually graze farther away from the homesteads than younger stock and sheep and goats. As an example of this transfer there is the case of West Africa where "Natural forages from rangelands and fallow lands provide important livestock feeds, and through manure, nutrients for cropland" (Powell et al., 2004). It is not, however, a one to one transfer as some nutrients are used by the animal in its metabolism and, as is clear from the preceding paragraph a lot of nutrients are dissipated as global warming gases. Further nutrients are removed from the grazing areas if they are enclosed and hay is made and then carted back to the farm. So transfer equates to mining. Mining of nutrients is also axiomatic in higher yields although this point again seems to have escaped the notice of or is ignored by the promoters of animal power. In the Kenya coastal area, for example, farmers without cattle suffered a net outflow of nitrogen from grazing of crop residues by the animals of others (Reynolds and De Leeuw, 1993). Manure is said to increase

not only soil fertility but also soil structure but this claim too rests on dubious premises. There is virtually no straw or other fibrous organic matter in the dung of Ethiopian livestock -- it is not farmyard manure in the generally understood sense of a mixture of dung or faeces and urine and fibrous material -- as such straws and materials are mainly eaten by the animals. The dung that goes on the soil is either fresh material or a dry fine powder from which many of the nutrients have already been leached. Not all of the dung does go back on the land as much of it is burned for heating and cooking and for plastering of buildings. In addition to home use there is a veritable cottage industry in dung fuel in the Ethiopian highlands (Figure 4). Burning dung does confer a small advantage in that it reduces the need, but perhaps not by much, for wood to be collected from the already denuded and eroded hillsides.

Figure 4. Dung dried for fuel and crop residues for animal feed for home use and for sale in local markets (in both cases plant nutrients are removed from the land) (photo by the author)

Negative environmental effects resulting from the need for and use of animals for draught are not confined to the mixed crop livestock systems of the highlands. In many areas highland cattle herds are unable to maintain themselves from internal resources due to the low proportion of breeding females and their poor reproductive performance. Work oxen or young males to be reared for work thus have to be imported from the lowland pastoral areas (see Figure 1 for an "Afar" ox ploughing in Tigray) . These extra animals add further stress to the highland systems. There is also a negative effect on the lowland systems as there are fewer animals to produce meat for the home or export markets: the example of only 11 per cent of male cattle of 3-10 years in Afar Regional State that has already been cited (CSA, 2006) is eloquent testimony to this.

Discussion

Working animals receive priority in supplementary feeding in that they are the first class of stock to be fed hay and crop residues. The amounts available, however, are inadequate to mitigate the stress resulting from the under and malnutrition that is compounded by subclinical disease and the presence of internal and external parasites. Draught oxen in particular are most debilitated at the time of year they are needed for work. This reduces further their already limited power output due to low body weights as output is directly proportional to body weight. Inefficiency in conversion of feed resources is further compounded by the fact that the average working day for an ox is little over five hours but effective time is reduced by frequent stoppages. In addition to the biological constraints there are social ones associated in particular with the culture and tradition of the region. Under this scenario even during peak periods no productive work is performed on several days of holidays enforced for religious reasons. Greater use of cows for work would also increase the efficiency of the whole herd.

Tigray is the archetypal highland Ethiopia where work animals are crucial to agriculture. Increases in the human population and therefore density leads to greater -- and unsuitable for the purpose -- areas being taken into cultivation. This creates a need for yet more draught power. Cattle herd composition is such that for much of the year it is non productive in both abstract and literal senses. This is because the oxen that constitute almost half of the cattle herd in numbers and in live biomass are used for only about a quarter of the potential working time and are idle for long periods. A similar scenario applies to equines.

A definition of sustainability is that "it meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). In addition to higher crop output, increased income and improved food security, afficionados of animal power emphasise that integration of crops and livestock contributes to sustainable production. Integration may be as much fallacy as fact as it is applied mainly to oxen whose demands on the supposedly holistic system may be greater than the supply that is given in return (Wilson, 2003).

Conclusions

Do, then, animals used as power and energy sources contribute to a sustainable ecosystem? If animals and their owners cannot be induced to work a great deal more efficiently than using only 24-27 per cent of the total time available that is now the norm and if the feed used for maintenance of draught animals remains at 85 per cent leaving as little as 15 per cent for productive work the answer is almost certainly no. The solution to the problems facing livestock and range production cannot be

achieved in isolation. Crop production and soil conservation are intimately linked to the livestock sector. Degradation of large areas of already lower quality land results from nutrient transfer and nutrient depletion. Sustainable crop agriculture may be being achieved at the expense of unsustainable animal agriculture.

There is no doubt that it is very expensive in terms of global warming to cultivate land in the Ethiopian highlands. An integrated approach is the only way to which long term development can be achieved.

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A Framework for Community Based Management of Indigenous Cattle Genetic Resources in Dano District, Central Ethiopia

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Abstract

This paper presents a framework for Community Based Management (CBM) of indigenous cattle in Dano district of West Shoa Zone in Central Ethiopia. Results of multi-disciplinary research conducted over three years served as a foundation for this framework. It outlines the essential activities and components needed to be considered to empower the cattle keeping community for effective collective action in the conservation and sustainable use of indigenous cattle. Community based initiatives stand a better chance of success with positive effect on the sustainable use of the genetic resources under stressful environments. CBM of animal genetic resources (AnGR) is responsive to the dynamism within the community, AnGR and the eco-system. The most important institutions with strong bearing on the community's management of AnGR are the informal institutions (herding groups, social gatherings, etc.), the formal institutions in the locality (cooperatives, financial or religious institutions, etc.), the market, the administrative (political) entities, the research and extension institutions, and the interactions among the crop, natural resource and livestock sub-systems. Assumptions of favorable political environment, complementarity among the different stakeholders, continuous capacity building, and access to comprehensive market information were made in developing this framework.

Keywords: Animal genetic resources, Community based management, Informal and formal institutions, Sustainable utilization.

Introduction

An essential element for the continued contribution of livestock to supporting rural livelihoods in developing countries is the maintenance of genetic diversity in the livestock population. Genetic diversity in domestic animals encompasses the

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spectrum of measurable genetic differences among species and across all breeds within each species as well as within each breed[2] differences which are of interest for food and agricultural production (Köhler Rollefson, 2004). Variation in the types of animal used enables the production of different combinations of products, product attributes and services that suit local community needs for consumption, savings and disposal.

The poor livestock keepers that live in usually low potential and unfavorable agricultural areas depend directly upon genetic, species and ecosystem diversity for their livelihoods (Anderson, 2003). Despite the paramount importance of diversity of animal genetic resources (AnGR) to the livelihoods of rural communities in developing countries, and the uncertainty about the actual magnitude of the loss, Tisdell (2003) argues that the continued loss of this diversity is undoubtedly of considerable significance even based on conservative estimates. According to FAO (2007), one breed becomes extinct every month and so its genetic wealth is irretrievably lost. Livestock genetic resources underlie the productivity and resilience of local agricultural systems. Thus, genetic erosion within livestock and their wild ancestors is of particular concern because of its implications for the sustainability of locally adapted agricultural practices and the consequent impact on food supply and security (Rege and Gibson, 2003).

Ethiopia is said to have the largest volume and diversity of livestock resources than any other country in Africa. An estimated number of 40.3 million cattle, 20.7 million sheep, 16.25 million goats, 6.2 million equines, and 32 million poultry were reported to exist in private holdings in 2005/06 excluding the Afar and Somali pastoral areas (CSA 2006). A conventional livestock population survey done in 2004 in the pastoral regions of Afar and Somali, reported 2.12 million cattle, 2.6 million sheep, 4.14 million goats, and 1.02 million equine populations (CSA 2004). The overall camel population was estimated to be 2.3 million in 2004 (CSA, 2004). The national AnGR status report by the Institute of Biodiversity Conservation (IBC) shows that there are at least 25 cattle, 13 sheep, 15 goat, four camel, four donkey, two horse, two mule and five chicken indigenous breeds in Ethiopia. There are also three dairy cattle, 7 sheep, 7 chicken and two goat exotic breeds used for food and agriculture (IBC, 2004). This wealth of genetic resources is reported to be shrinking due to genetic erosion (ESAP, 2004).

Major causes threatening diversity of genetic resources in Ethiopia include poorly designed and managed introduction of exotic genetic materials, droughts and consequences of drought associated indiscriminate restocking schemes, political instability and associated civil unrest, and weak development interventions (ESAP,

2 Breed is either a homogenous, sub-specific group of domestic livestock with definable and identifiable external characteristics that enable it to be separated by visual appraisal from other similarly defined groups within the same species, or it is a homogenous group for which geographical and/or cultural separation from phenotypically similar groups has led to acceptance of its separate identity (Turton, 1974).

2004). The effects of the misguided and uncontrolled introduction of exotic genes and that of interbreeding among indigenous breeds might require application of molecular genetics for purposes of precision. In extreme scenarios, however, it could have a drastic effect leading to extinction of a breed within few generations. The application of artificial insemination in indigenous cattle using semen from exotic cattle breeds is, for instance, resulting in unforeseen substitution of indigenous genes by exotic genes (ESAP, 2004; IBC, 2004).

More important is the fact that Ethiopia is yet to develop and enact a binding livestock breeding policy. The limitations in skilled manpower and facilities are also paramount bottlenecks for the aspired development in the livestock sector. However, the relative importance and level of threat to maintenance of animal genetic diversity in Ethiopia is not precisely known. Encouraging, but far from sufficient, effort has been made to comprehensively document the AnGR diversity in the country. In addition to their inconclusiveness, previous research and development efforts generally ignored the importance of adapted indigenous farm AnGR due to a general belief that they are not adequately productive and incapable of contributing to increased agricultural production (IBC, 2004). The past and present neglect of local knowledge regarding AnGR and traditional breeding practices causes major difficulties to develop and implement appropriate participatory strategies at national and local level (Wollny, 2003).

Conserving AnGR Diversity

The irreversibility of extinction of AnGR and continuity of the undesirable reduction of the genetic diversity necessitate holistic and participatory approaches to conservation. FAO defines conservation of AnGR as all human activities, including strategies, (management) plans, policies and actions undertaken to ensure that the diversity of AnGR is maintained to contribute to food and agricultural production and productivity now and in the future (FAO, 2000). There are strong scientific arguments for conservation of AnGR. Apart from their known use values, AnGR are carriers of numerous genes that can serve current as well as future emerging needs. There are several strategic options discussed as regards how to maintain AnGR. In the short term a pragmatic option is the conservation of AnGR by maintaining genetic diversity of local breeds within their production systems (Gandini and Oldenbroek, 1999; Rege, 2003).

It is also argued that AnGR conservation aimed at sustaining livelihoods needs to take an approach that recognizes the array of contributions livestock make to livelihoods and the genetic characteristics related to these (Anderson, 2003). There are two broad approaches through which AnGR can be conserved: ex-situ and in-situ (Rege and Gibson, 2003). Ex-situ approaches to conservation include cryopreservation of semen, oocytes and embryos, and keeping of live animals in designated localities, e.g. government

farms or ranches. In marked contrast to the situation in plants, cryopreservation is technically feasible for very few livestock species at present. In-situ conservation, also called 'on-farm conservation', can be defined as the continuous maintenance of breeding populations by farmers in the agro-ecosystems where those populations have evolved (Rege, 2003). Thus, in-situ conservation encompasses entire ecosystems, including immediately useful species of crops, forages, agroforestry species, and other plant and animal species that form part of the system.

Traditional practices of livestock keeping communities probably involve multiple breeding goals (i.e. multipurpose uses), aesthetic values and behavioral aspects. Likewise, village communities may have different needs, perceptions and preferences by which they make decisions for buying, selling or mating of animals. The bottom line here is that communities manage their livestock using a wide range of indigenous knowledge that emanate from varying socio-economic, cultural and bio-physical environmental conditions (ESAP, 2004).

Hammond and Leitch (1996) assert that although no compelling quantitative data is available, about 50% of the total genetic variation in AnGR is between species and the remaining 50% is variation among breeds within species. Yet, the focus on conservation of AnGR is on maintaining intra-specific variation (within species). The genetic variation between breeds is likely to be much more relevant when a global perspective is taken, and when more extreme traits such as adaptation to harsh environments and disease resistance are considered (Rege and Gibson, 2003). Moreover, Wollny (2003) argues that intra-specific genetic diversity in AnGR is a function of natural selection and random or systematic human interventions, hence with more direct links to current human livelihoods of poor livestock keepers.

Definition and Importance of CBM of AnGR

The essence of CBM of AnGR emanates from the meanings of the terms community, community-based, and management. The term community usually refers to a group of people living under similar circumstances with common primary objectives and interests in life. A community-based organization is an entity formed or recognized by a community based on communal interests and objectives and to implement agreed decisions on behalf of the community (Köhler-Rollefson, 2004). Management of AnGR is defined by Rege (2003) as the combined set of actions by which a sample, or the whole, of an animal population is subjected to a process of genetic and/or environmental manipulation with the aim of sustaining, utilizing, restoring, enhancing and characterizing the quality and/or quantity of the AnGR and their products. Thus, CBM of AnGR can be defined as a system of AnGR and ecosystem management in which the AnGR keepers are responsible for the decisions on identification, priority setting and the implementation of activities in conservation and sustainable

use of the AnGR (Rege, 2003; Köhler-Rollefson, 2004).

Community based initiatives are receiving growing attention as sources of creative and productive activities of individuals or groups in societies (Rege, 2003). Such initiatives stand a better chance of success with positive effect on the sustainable use of the genetic resources under stressful environments. The dominant contemporary arguments about maintaining domestic animal diversity advocate for support and provision of incentives to local communities so as to continue managing their AnGR in their respective ecological contexts, but with the opportunity to develop by responding to or taking advantage of changing marketing and macroeconomic situations (Köhler-Rollefson, 2003). According to Rege (2003), this is so because 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. The communities are also best placed to conserve them and have a better understanding than any other group of what it takes to manage their traditional resources sustainably.

CBM of AnGR responds to the dynamism within the community, AnGR and the ecosystem whilst keeping the current and future objectives and interests of the custodian human society. The dynamism in the framework is explained through its sensitivity for the changes in preferences of traits and or the natural or man-made changes that may occur in the AnGR populations, e.g. effects of flooding, disease epidemics, drought or market demand. Changes in trait preferences imply that transformation in the agricultural sector might alter the priorities in the current preference analyses (Girma Tesfahun, 2007). Mechanization of farms, for instance, would make suitability for plowing a less preferred trait. Establishing a CBM of AnGR is, therefore, a continuous process with its components changing in type and importance in response to decisions of the communities.

Relevance and Logical Link of CBM of AnGR to Livelihoods

Most of the livestock wealth in developing countries is owned by smallholder farmers, who are likely to maintain this essential role under prevailing socio-economic and cultural circumstances until substantial economic developments lead to drastic changes in the size and structure of household incomes. Thus, until more viable alternatives to smallholder subsistence livestock keeping come into play so as to transform rural livelihoods, the most reasonable option for sustainable use of AnGR is working with and for these rural communities who maintain them. Smallholder farmers have unique features, particularly as compared to pastoralists, in that they do not rely exclusively on livestock and therefore have to organize the management of AnGR in their possession in different ways (Bayer *et al*., 2003).

Attempts to substitute elements of the smallholder farming system with research generated technologies are associated with risks to smallholders. For instance, the livestock resources have evolved for centuries under the custody of smallholders in response to recurrent challenges of harsh environments where the majority of poor smallholders live in. The massive efforts to replace the indigenous livestock resources with 'improved' types developed for specific traits under ideal conditions were not only ineffective (Rege, 2003) but also resulted in erosion of valuable genetic diversity (FAO, 2000)3.

The scientific community has very recently realized the flaw in the conventional approach and agreed to start with what the communities can offer and to work with them. This is justifiable as indigenous livestock breeds play an important, even crucial, role for sustainable rural livelihoods and the utilization of marginal ecological areas (Köhler-Rollefson, 2003). In addition, rural communities and their livestock breeding strategies depend not only on natural and socio-economic conditions, but also on the abilities and interests of the livestock keeping families (Bayer et al., 20003). This growing interest in working with communities with due appreciation and use of indigenous knowledge has given rise to the concept of Community Based Management (CBM) of resources. Earlier applications are in the field of forestry and other environmental resources. Application on management of AnGR started very recently. The documented experiences in Africa are the CBM project to manage poultry diversity in Malawi (Gondwe et al., 2003), the one designed to improve and conserve the indigenous Djallonke sheep breed in Ivory Coast (Yapi-Gnaore et al., 2003), and the initial efforts on CBM of local goat genetic resources in Benin (Dossa, 2007). This specific framework is to be the first of its kind in Ethiopia.

Components of CBM of Indigenous Cattle in Dano District

Empowering, motivating, informing and building the capacity of the community for a sustainable management of the AnGR is the main purpose of a CBM of AnGR. For instance, in Dano district of central Ethiopia, smallholders own the entire cattle population. Thus, community refers in this case to these smallholders. The focus of the CBM framework discussed hereafter is on cattle, basically for two reasons. First, the study focused on cattle as these are by far the most important species of farm animals in the district. Second, this is the first initiative to implement a CBM framework in the country and so would be sensible to start with one priority species.

CBM of AnGR starts with careful analysis of the prevailing production system. The livestock production system in Dano district can generally be described as semi-subsistent,

3 In fact, in transforming or reorienting production systems, crossbreeding and AI can be implemented in a controlled manner to create the access for animals with functions and products the markets demand.

resource-constrained, cattle dominated and risk prone (Girma Tesfahun, 2007). The most important institutions with strong bearing on the community's management of AnGR are the informal institutions (herding groups, social gatherings, etc.), the formal institutions in the locality (cooperatives, financial or religious institutions, etc.), the market, the administrative (political) entities, the research and extension institutions, and the interactions among the crop, natural resource and livestock sub-systems. The sketch below shows the confluence of these forces (Figure 1).

Social institutions, both formal and informal, play a significant role in determining the effectiveness of a CBM of AnGR. These institutions can influence farmers' access to, and management of, household and community–level resources affecting their action regarding the farm animal genetic diversity. The way herding groups, religious institutions, and social norms and values operate determines the size and characteristics of livestock a household is willing to keep. For instance, in areas where black or white coated cattle are considered culturally or religiously bad, a selective culling would eventually minimize the numbers of cattle with undesirable coat colors in the herd[4]. This deliberate exclusion of animals based on a single attribute might eventually influence other characteristics. The effect of a single trait selection is prominent for a trait which has a negative correlation with a trait under selection. A two pronged intervention is required in this regard; i.e., first, identifying and analyzing the important traditional norms regarding management of AnGR; second, enhancing the useful traditions to make them quickly rewarding and sensitizing the community against harmful traditions. The emphasis should, however, be on harnessing the social institutions for the sustainable management of the genetic resources by the people.

Formal institutions such as cooperatives and rural credit institutions will also have a paramount role in conserving and sustainably using the communally managed AnGR. Voluntarily established cooperatives increase the bargaining power of smallholders and the access to inputs and intermediary outputs. Therefore, smallholders would be able to reduce unfair payments and can opt to postpone selling decisions thereby saving genetic resources from desperate and less rewarding marketing. Valuations of the unique traits, labeling products accordingly, and, if possible, certification of genetic property rights would obviously increase the market margins of smallholders at the same time improving marketability and hence utilization of the genetic resources.

Another crucial component influencing the community - AnGR nexus is the marketing system. The market forces do challenge conservation by smallholders of the genetic resources with no easily tradable uses and no immediate benefits. As a result, identifying sound reasons why society should preserve genetic resources that specialized formal markets have abandoned for some reasons is still an important challenge in conservation

4 Farmers in Dano believe that black coated cattle are susceptible to trypanosomosis and white coated cattle are considered inappropriate for fattening.

of AnGR (Mendelsohn, 2003). Efforts are needed in valuing the different attributes and functions of the AnGR owned by the smallholders as well as in availing timely, adequate, and precise (tap) market information for the community.

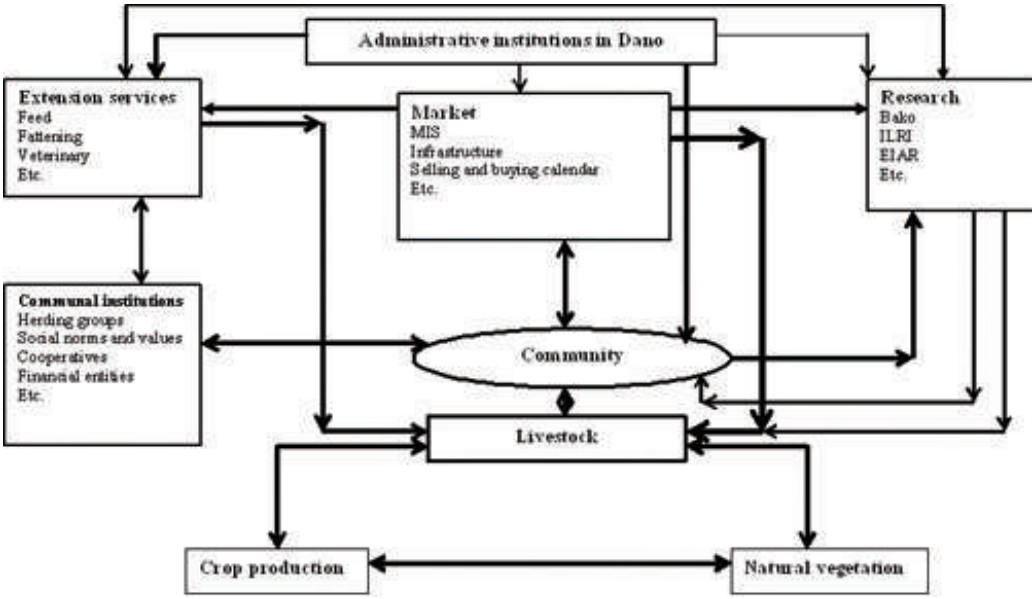

Figure 1: Schematic representation of the important actors and their interactions in the CBM of AnGR in Dano district

Source: Authors' formulation

Proper identification, characterization and valuation of the non-tradable traits of the genetic resources might facilitate the recognition and legal protection of livestock keepers' entitlements for the important characteristics of their genetic resources thereby securing a continuous market. Otherwise, the conservation of AnGR option values through livestock husbandry by the poor is a hitherto unrecognized and unrewarded service to society (Anderson and Centonze, 2006). Hence, all improvements that can be introduced into the production system based on the relative economic values of the traits of the indigenous AnGR might increase the marketability of the indirect and/or long term values of the AnGR. Inter-temporal and spatial patterns of supply and demand need to be analyzed and made available to the community to enable them to decide with full information. Equally important is identification or creation of niche markets and the development of the market infrastructure to avoid undermined prices as well as forced selling as the transaction costs are often unbearable in such remote rural areas.

Research and extension institutions are expected to describe and analyze the dynamism and the interactions within the livestock production system. Only after thorough

understanding of the system should interventions be made with a clear objective of empowering the community to sustainably generate greater benefits from their AnGR. Bayer *et al.* (2003) strongly advised that the current breeding strategies and breeding objectives of the smallholders should be clear before support is given to any specific type of breeding operation or suggestions are made for improvement. Interventions that have a bearing on CBM of AnGR cannot be confined to issues of breeding and have to fit into the wider livelihood systems of smallholders.

Research and extension procedures need re-designing so as to allow communities take greater roles in initiating the research process. The focus of research and extension has to be on the gaps and interests of the community. Concerted effort is needed among the research institutions (in this particular case, the International Livestock Research Institute (ILRI), Bako Agricultural Research Center (BARC), and the Ethiopian Institute of Agricultural Research (EIAR) and between the research institutions and the District Office of Agriculture and Rural Development (DOARD) which handles all extension related activities in the district. A list of sample activities identified based on the discussions made with the community and that can be incorporated in the implementation of the CBM of AnGR are indicated in Table 1.

The administrative entities are also very powerful part of the system enormously influencing the community and the AnGR through the official policies and strategies they implement. The most important influences are related to rights to own and use the basic means of production such as land and credit. Farmers in Ethiopia have only usufruct right on the land and hardly have access to affordable rural credit scheme. Changes that empower the smallholders for a better utilization of the basic resources would significantly contribute to the success of the communal management of the animal genetic resources.

On the other hand, although Ethiopia is yet to enact a livestock breeding policy, the overall tendency for the last four decades in the area of genetic improvement has been limited to loose AI services and crossbreeding of some indigenous breeds with supposedly improved exotic breeds to increase milk production with little (if any) consideration to other production and service functions of cattle. Sustainable management of the AnGR requires policy formulation to be based on the objectives of the livestock keepers and their manifestations through trait preferences for bulls and for cows. Suggesting such a major re-orientation of the policy setting procedure in developing countries like Ethiopia is easier said than done in practice. Nonetheless, it would be much less costly to carefully design the policies that help avert the continued loss of genetic diversity in indigenous cattle.

In general, the important components of the livestock production system and their interactions have both direct and indirect influences and they need to be manipulated

to enable the community own, manage and benefit from the AnGR in a sustainable manner. As the genetic resources are crucially important to the livelihoods of the community in all aspects of the socioeconomic setup, CBM of AnGR appears to be a promising alternative as compared to the traditional approaches which focused less on the immediate and long term objectives of the communities they were supposed to benefit. In fact, capacity building and awareness creation on all aspects of the CBM of AnGR framework are essential for the community in order to boost confidence and transparency. Similarly, modalities for communication and protocols of accountability among the stakeholders need to be clearly stated and made known to all.

Table 1: Sample activities in the CBM of AnGR in Central Ethiopia

Interventions	Leading Stakeholders
Empowering	Community
Sharing the results of technical analysis of livelihood systems	Research and extension organizations
Developing existing communal bylaws	
Capacity building in resource management	
Develop a manageable monitoring and evaluation system	
Research and extension assistance on, for instance,	
Improved forage species	
Efficient use of crop residues and natural vegetation	
Disease monitoring and veterinary service	
Sustainable use of AnGR	
Tailored training for the community	Community
Feed management	Research and extension organizations
Disease management	Brokers and traders
Controlling and recording animal movement	
Community based genetic improvement	
Safe management of newly introduced genetic resource	
Livestock marketing	
Market intelligence	
Market demand and supply assessment	
Identifying markets and time for marketing	
Communicating timely, adequate, and precise (tap) information	Community
Access to tap market information	Brokers and traders
Developing the traditional information management system	Research and extension institutes
Looping in brokers and traveling traders	
Access to tap research and extension information about	
Feeds and nutrition	
Disease management	
Maintaining preferred traits	
Livestock marketing	
Policies and strategies and their implication	

Genetic Improvement and Management Interventions

Empirical analysis of preferences done in the markets within and around Dano district show that cattle buyers assign high values for good traction potential, big body size, disease resistance, calf vigor and for places of origin when choosing bulls in the market (Girma Tesfahun, 2007). A similar study on traits of cows indicates

that fertility, disease resistance, and calf strength are equally or more important than milk (Girma Tesfahun, 2007). These results need to be used to articulate the improvements to be made on the AnGR owned and/or used by the community.

The operational unit for the appropriate interventions needs to be the herding group for the following two basic reasons. First, almost everyone in the group knows which animal belongs to whom and how many animals a household owns. Second, members know when new animals are brought in to the group and when animals are taken away for any reason. Accordingly, leading farmers within the herding group in collaboration with leaders in the cooperatives should be helped to select, develop, and share breed stock of cattle based on the preferred traits identified. Cattle herd formation and composition management needs high emphasis to ensure that the preferred traits of the cattle keepers are maintained with mechanisms in place to reduce the likelihood of inbreeding. The replacement rate and the dynamism in the preferences of the different adaptive and productive traits will have to be carefully investigated to understand the pattern in the genetic resources and the requirements for new trait introductions that might develop over time.

The research and extension institutes need to render assistance to the community in issues related to record keeping, developing and using breeding indices – with due consideration of preferred traits, performance evaluation, distribution and marketing management and controlling the use and conservation of AnGR. The record keeping shall be designed in a comprehensive and systematic way so that the not-so-literate community can easily manage it. Establishing a pilot breeding centre managed by leading farmers in particular and the community in general appears to be the best way to start up.

Implementing the CBM Framework in Dano District

Community based organizations principally aim at harnessing resources to achieve the short and long run objectives of the community they stand for. Therefore, the initial step in implementing a community based organizations like the CBM of AnGR has to be the full awareness, empowerment, and ownership of the whole process by the community. The communities, therefore, need to be assisted to develop breeding structures of their target AnGR so that breeding is fully controlled and parents of the next generation of animals can be selected from within the breeding population.

Concomitantly, communities will be encouraged to set minimum standards of management of their animals to improve efficiency of production and eventually increase level of production. In this way a village-as-a-herd scheme of breeding structures are organized within the village on voluntary basis. The community would then be able

to prioritize and refine the potential interventions to increase the productivity and marketability of the indigenous cattle population it owns. A participatory ex-ante evaluation of the identified interventions needs to follow to foresee the potential costs and benefits associated. Implementation plans will have to be developed for the interventions to be made at the end. A community managed participatory monitoring process needs to be established as well. Finally, evaluations will be made and plans will be designed to replicate the positive lessons to similar production systems. This will be a cyclical process in each community as long as the community keeps on benefiting from the collective action.

Usually the best way to enhance ownership and responsibility in such community based initiatives is to build up on the informal institutions and organizations governing the access, ownership and use of the resources in the community. Hence, clear understanding and promulgation of these informal entities of the community need to be given priority in the implementation of this framework. Moreover, building the communities in data and information management will need to be started at the outset of the implementation. This capacity is very important to make inter-generational transfer of knowledge and the resources associated with it.

A formidable challenge in continuously and effectively running a CBM of AnGR will be the access and use of local level financial resources. As indicated above in the sample list of activities, the way to start will be to invest on the traditional financial institutions which are usually meant to supporting mourning or wedding families. Small scale revolving financial schemes can be developed based on the traditional practices which are quite common in Ethiopia. The second option is to build the capacity of the cooperatives to manage small scale financial services for the community based on terms agreed by the community. Both options indicated above need intensive capacity building interventions from resourceful institutions particularly in the field of financial management. The last and most costly option is accessing financial resources from the formal rural financial institutes.

Finally, this framework is developed with the following assumptions.

1. Stakeholders with the financial resources would support and pursue the implementation of the CBM of AnGR framework developed based on over three years of multi-disciplinary participatory research.
2. The simmering political instability in the region would not interfere with effective implementation of the framework.
3. The research and extension institutions would keep up the collaborative and complementing activities in support of the collective action in CBM of AnGR.

4. The community and other stakeholders will have the required capacity to observe clearly the dynamism within the livestock production system and to deal with the emerging market trends.

5. Continuous and comprehensive market information will be available for the community and for the research and extension institutes to gauge the responsiveness of the marketers.

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The effect of honeybee (Apis mellifera L.) on seed production of Allium cepain the Ethiopian Rift valley

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Abstract

Shallot (Allium cepa var Adama Red) is one of the most widely cultivated and favorite vegetable crop in Ethiopia. The information on the honeybee pollination requirement of the crop with local honeybees is scanty in the country. The effect of honey bee pollination on seed yield of Allium cepa, Adama Red variety, was studied at Melkasa Agricultural Research Center for the period of 2000-2001 planting years to see the role of honeybee pollination in increasing seed yield of the onion and to identify the potential pollinators of the crop other than honeybees. The Adama Red variety was planted on plot size of $9m^2$ following the necessary agronomic recommendation. Three treatments were used and replicated three times in Randomized Complete Block Design. The seed yield was found to be significantly different between the treatments ($P< 0.05$). The yield obtained from the plots caged with honeybee pollination was highest with mean seed yield of 17.3 q/ha followed by plots left open under natural condition to be pollinated by all visiting insects with mean yield of 9.5q/ha. The lowest mean yield of 5.4 q/ha was recorded from the plots excluded from honeybees and other pollinators. With regard to 1000 seed weight, treatment three (caged with out honey bees) is significantly different from treatment one and two. Among the pollinators identified, honeybees and stingless bees are the major pollinators of the onion, and they have great contribution for seed yield of the crop. Therefore, on farm demonstration of this pollination technology to onion seed producers is highly recommended and honeybee pollination should be considered as one of the inputs for the onion seed production. Furthermore, investigation and domestication of sting less bee as potential pollinator of the crop is vital for better seed production and biodiversity conservation.

Key words: Pollination, Adama Red, Apis mellifera, Rift valley

Introduction

The survival and maintenance of genetic diversity of many crops and wild plant populations depend largely upon insect pollinators (FAO, 2004). Insect pollinators are essential for fruit, vegetable, oil crops, legumes and wild plant species. As a result the need for insect pollination is becoming popular by agricultural community to increase the productivity of the crops.

Lack of sufficient pollination is one of the limiting factors in agricultural crop productivity. According to Free (1970) and McGegor (1976), honeybee pollination not

only improves the seed production but also the quality of seeds. On the other hand, pollination deficiency in crops results in reduced yields due to lower fruit and seed set, longer germination ability and increased inbreeding depression within a crop population (Kozin, 1968).

A. cepa is one of the oldest cultivated cash crop species and the most popular vegetables in the world. It is believed to be a native to Middle East and India and now cultivated throughout the tropics in drier or under irrigation. It is also an important condiment and vegetable crop in Ethiopia (Getachew and Asfaw, 2000). It serves as a spice for flavoring local dishes and hence is highly popularized in the country. Though the price varies from time to time, it fetches very high price during rituals and holidays.

It is produced by small scale farmers, commercial growers and state farms for both domestic consumption and export purpose (Lemma, 1998). According to Ministry of Foreign Trade (1998 and 1999), a total of 13.4 and 15.8 thousand tons of vegetables with values of 25.4 and 30.5 million Birr, respectively have been exported of which onion had a share of 11 % (Dawit *et al*., 2004).

There have been a number of investigations on the pollination requirements of *A. cepa* in different countries. McGregor (1976) has summarized honeybees are effective pollinators on *A. cepa* flowers because both pollen and nectar are available from it. In tropics, Singh and Dharamwal (1970) also found that honeybees are the major pollinators of onion (Patna Red cultivar).

A. cepa is highly cross-pollinated and its out crossing rate is 93% (Frankel & Galun,1977) and the use of male-sterile plants is essential for the production of hybrid seed. Voss (1979) also reported that the cross pollination varies between 30 to 94% depending on availability of pollinators and its pollen is usually shed before the female part is receptive.

At present, the need for onion seed production is highly demanding by different individual farmers, farming communities and investors in the country. The seeds are imported from abroad with hard foreign currency. These have also been recognized to have problem of germination, and are easily susceptible to disease (Lemma, 1988). The productivity of the crop is very low under natural condition when the crop is left with inadequate honeybee pollination. The low seed yield of *A. cepa* has been reported from open pollination (at natural condition) from small scale producers and state farms (personal communication at upper Awash). Therefore, this study was designed to see the role of local honeybees pollination in increasing the yield of *A. cepa*, and to identify potential insect pollinators other than honeybees.

Materials and methods

Study area

The experiment was conducted at Melkassa Agricultural Research Center, situated at 8° 24 N latitude and 39° 21E longitude in the Upper Awash Valley 15km south-east of the town of Nazreth on the way to Asella. The Center is characterized with the soil types of Cambisols, intermediate altitude (1550m.a,s.l.), high daily mean temperature (20°C) and rain fall less than 500mm during the main season.

Experimental set up

The experiment was designed into three treatments and each treatment was replicated three times in Randomized Complete Block Design (RCBD). The *Allium cepa*, (Adama Red variety), was used for the purpose. The bulb was raised during the growing season and transplanted into 3mx3m ($9m^2$) seedling bed and recommended agronomic practices applicable to the crop were used. In the first treatment at the 50% of flowering of the onion flowers , honeybee colonies were enclosed with nylon mesh wire for the intensive pollination. In the second treatment, the plant was caged with nylon mesh without inclusion of honeybee colonies and other insect pollinators. In the third treatment, the plant was left open for natural pollination as control. The comparative efficiency of each treatment was evaluated on the basis of seed yield per plots and 1000seed weight.

Observation on the visits of pollinators were recorded daily from the day crop started blooming till the flowers were shade. Visiting insect were collected and identified by the entomologist at Entomological Laboratory of Holeta Agricultural Research Center

Statistical analysis

The data were analyzed using the Statistical Analysis System (SAS) computer package (SAS, 2002). The honey bee pollination effect (treatments) was considered as independent variable while seed yield and 1000seed weight are dependent variable.

Results and Discussions

The yield in terms of grain was found to be significantly different between the treatments ($P<0.05$). The yield obtained from the plots pollinated by honeybee colonies were superior with highest mean seed yields of 17.3 quintals per hectare followed by the plot left open to be pollinated by all visiting insects produced the yield of 9.5 quintals per hectare. The lowest yield 5.4 quintals per hectare was obtained from treatment with all pollinators excluded including honeybees (Table1). The seed

yield difference between the treatments indicated that the crop requires insect pollination particularly honeybees and other insect pollinators for seed production. This is in agreement with Free (1970), Jones (1963), and (leader house, 1968) who showed that *A. cepa* flowers are highly self incompatible with delayed female maturity (protandry) and hence the crop favors cross pollination. Consequently, pollinating insects particularly honeybees have a great contribution for improving the seed yield of the crop. McGregor (1976) and Pesson and Louveaux, (1984) have also investigated that honeybees are used to pollinate the *Allium cepa* in large cages for hybrid seed production.

With regard to 1000 seed weight, treatment three (pollinated without honeybees) was significantly different ($P< 0.05$) from treatment one (caged with honeybees) and treatment two (open pollinated) (Table 1). This may be due to smaller seeds in self pollinated flowers that might have less competition for food during the seed maturity stage as result seeds gained better seed weight. From this investigation honeybee pollination has no significant impact on quality of onion seeds. Similar finding was also reported by Admassu and Nuru (2000), in which they indicated that honey bee pollination has no significant effect on 1000seed weight and germination percentage of Niger (*Guizotia abyssinica).*

During flowering time of *Allium cepa*, various insect orders were recorded. The identified pollinators are butter fly, different flies, honeybees, sting less bees, wasps and carpenter bees. The number and percentage of insect visitors were shown in (Table 2). Among the insect visitors, honeybees and stingless bees (Meliponin spp) are the major pollinators of onion flowers due to their polylectic diet for pollen and nectar. This observation is in agreement with findings of Frankel and Galun (1977) who reported that the plant secretes the nectar with sugar concentration of 30 to 50% and hence it attracts many insect visitors. Trehene (1923); Free(1970); also found that honeybees, stinglees bees, Diptera and solitary bees are also important pollinators of the red onion cultivar in India.

Table1: The mean seed yield and 1000 seed weight of the Allium cepa (Adama red) from three treatments grown in 2000 and 2001 planting year

	Mean seed yield in (Quintal)			1000 seed weight (gm)		
Treatments	2000	2001	Combined	2000	2001	Combined
A	17.5±0.08**	17.1±0.70**	17.3±0.53 **	3.2 ±0.01ns	3.4± 0.03ns	3.4±0.5ns
B	10±0.08 **	9±0.70**	9.5±0.5**	3.2 ±0. 01ns	3.3± 0.03ns	3.3±0.5ns
C	5±0.08 **	6±0.70**	5.4±0.5**	3.9*±0.01	3.3± 0.03 ns	3.6 ±0.5*
CV	2.66	7.8	6.66	2.8	5.2	6.6
LSD	0.654	1.906	0.917	0.226	0.3	0.18

ns, *, ** indicates non significant, significant and highly significant differences, respectively.

A= With honeybees B= Open pollinated C= without honeybees

Table 2: The number and per cent of the visiting insects on Allium cepa, Adama Red Variety

Insect order	Common name	Number	Per cent
Lepidoptera	Butter fly	25	6.4
Diptera	Fly	75	19.2
Hymenoptera	Honeybees	150	38.4
Hymenoptera	Sting less bees	90	23.07
Hymenoptera	Wasps	35	8.9
Hymenoptera	Carpenter bees	15	3.8

In conclusion, the study revealed that Adama Red variety is largely dependant on honeybee pollination for increasing seed production and there fore moving honeybee colonies to the onion field during its flowering time is the most essential practice for onion seed production. It was also observed that onion flowers visited by various insect pollinators particularly stingless bees, and domestication and management of this beneficial insect is essential for increased production of crop.

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Growth and egg production performance of local ecotypes of chicken collected in the South Western part of Ethiopia

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Abstract

This study was conducted at Jimma College of Agriculture to evaluate the performance of local chicken in terms of growth and egg performance. The eggs were collected from villages located in different Agro ecologies and incubated artificially. The chicks were reared under confined management and evaluation was made on station. Mature weight of 1.30 kg was reached at about 8 months. There was a significant effect ($p<0.05$) of ecotype on growth performance of chicken. The birds from Dedo (highland) were superior in growth traits. The birds from Sombo were inferior at 8 months of age than birds from Dedo (1.2kg Vs 1.3kg). The males were significantly ($p< 0.05$) heavier than females at all ages. The males were heavier by 13% and 23% than females at maturity and yearling age, respectively. There was no significant ($P> 0.05$) effect of feather type on most growth traits. However, there was a tendency that normal birds were heavier than naked neck birds. Ecotype had a significant effect ($P<0.001$) on egg performance traits. Average egg weight was 44g. The number of eggs produced per hen per year was 90. The ratio of hen - day production (the number of eggs collected from a flock housed divided by number of birds alive) was 24%. The birds collected from Dedo showed higher egg weight and egg number /hen /year than birds from Gambella (45 vs 42g and 108 vs 78 eggs /hen /year, respectively). The birds collected from Gambella (humid) were inferior in percent hen-day production than birds from the other locations. The result in the present study was comparable to the previous reports on local chicken under station management condition.

Key words: Growth traits, egg performance, ecotype, Ethiopia, local chicken

Introduction

Local chicken represent a significant part of the national egg and poultry meat production. They also play a role in the provision of cash income to rural resource poor farmers. Local birds contribute 98.5% and 99.2% to the total egg and poultry meat production of Ethiopia, respectively (AACMC, 1984).

Local chicken are alleged to have poor performance under traditional management. Attempts made to evaluate the local chicken under intensive management (station management) condition in Ethiopia showed an improvement in egg performance

(Teketel, 1986; Abebe, 1992; Tadelle and Ogle, 2001). The highest egg production /hen /year produced was 100 eggs (Tadelle and Ogle, 2001) and the lowest recorded was 29 eggs (Mekonnen, 1998). Mebratu (1997) reported average annual egg production ranging from 34 to 80 eggs /hen /year with a very small egg size of about 45 g.

A consistent report by the various authors has shown that, local chicken are poor in survivability under confined management situations (Abebe, 1992; Mekonen, 1998 and Tegene, 2001). Tegene (2001) reported that more than 75% of local chicken died before they reached 8 months of age. The mortality rate of chicks up to 10 weeks of age was reported to be 60% in Tanzania (Mwalusanya et.al., 2002)

There is genetic diversity of local chicken in Ethiopia (EARO, 2000). The diverse ecological situation could contribute to the existence of various ecotypes in terms of survivability, egg performance and meat production. A comprehensive evaluation scheme has not been developed in Ethiopia for indigenous birds. There are limited studies that have evaluated local chicken under station and village scavenging situations in Ethiopia. The studies were conducted in limited locations namely Debrezeit (central highlands of Ethiopia), Alemaya (Eastern Ethiopia) and Awassa (Southern Ethiopia).

There is no report on the performance of local chicken under station and village management conditions in the southwestern part of Ethiopia. It is proposed in the National Poultry Research Strategy document of EARO (2000) that, the indigenous poultry population provides significant genetic variability that could be exploited for improving poultry production in the country. The objective of the present study is to evaluate the growth and egg performance of local chicken under station management conditions.

Materials and methods

The study area

The study was conducted in the Jimma Zone of the Oromia region between 2000 and 2001. The Jimma Zone lies at an altitude of 1710 m above sea level, 36^0 37 ̀E longitude and $75^0$55̀N latitude. The average minimum temperature is 11.8^0C and the maximum average temperature is 28^0C. The rainfall averages about 1500 mm per year. The season is divided into three. The main rainy season (June–September), cool dry season (October–February) and the early rain season (March–May). There is an extended period of rains for about eight months. The seasonal distribution of rainfall is 17.3% in the cool dry season, 56.3% in the main rainy season and 26.4% in the early rains. The mean relative humidity is about 68% (Jimma Metrology center, 2001).

The region is diverse with variable rainfall distribution, altitude, feed resource base and disease challenge. And as a result a wide range of genetic variation among local chicken could exist in the region with unique characteristics for adaptation to the diverse ecosystem.

Egg acquisition and handling

The foundation flock was established by collecting eggs from four locations representing different agro ecologies in South West Ethiopia. The climatic features of the collection sites were described below (Table 1). The locations represent highland, humid and sub-humid agro-ecologies.

Table 1. Eggs collection ecologies and climatic data

Agro-Ecology	Location	Climatic data		
		Maximum Temperature (°C)	Humidity (%)	Annual rainfall MM
Highland	Dedo	25	60	1200
Sub-humid	Tepi	30	69	1300
Highland	Sombo	28	65	1400
Humid	Gambella	41	75	600

The eggs were collected from individual households in the villages where exotic breeds of chicken were not introduced in the past. Farmers and Development agents had ascertained whether there had been any exotic blood introduction into the villages before deciding on egg collection from the local flock.

The eggs were purchased by going house to house with assistance from development agents. A total of 291, 166, 105 and 209 eggs were collected from Dedo, Tepi, Sombo and Gabella, respectively. The eggs were transported, cleaned, fumigated and then artificially incubated at the hatchery unit of the Jimma College of Agriculture. The experiment started with 95, 41, 34 and 55 day old chicks aquired from Dedo, Tepi, Sombo and Gambella, respectively. The chicks were reared artificially. The birds were housed in deep litter system and each house was provided with adequate feeders and waterers. The housing density was 0.25 m^2 /bird. All birds were offered standard commercial starter, grower and layer rations depending on their stage of growth. Water and feed was offered *ad-libtum*. The birds were allowed to graze freely for about an hour every day. The growth performance of the chicks was recorded from day old up to a year age at interval of one month using sensitive digital weighing scale. Eggs were collected and recorded twice a day at 10:00 and 16:30 hours. A sample of eggs were weighed right after collection every Friday using a sensitive digital balance. Egg traits generated included ratio of hen day production in a pen (number of eggs divided by the number of alive laying birds in a flock in a pen), Egg mass (weight of egg divided by 365 days), egg/hen/year and revenue of egg from each bird per year (the price of each egg) for analyses. The cost-benefit analyses was not estimated in the present study.

The mortality and manifestation of broody characteristics was recorded as it occurred. A detailed analysis of mortality was not presented in this report. The performances considered in the present study were only the growth performance of chicks at various ages and egg production.

The data collected were analyzed using GLM procedure of SAS (2000). The statistical model was explained as follows for growth and egg traits.

$$Yijklmn = \mu + E_i + F_j + S_k + N_l + Y_m + e_{ijklmn}$$

where *Yijklmn* is the weight at different ages and egg traits ; μ is the overall mean; E*i* is the fixed effect of the *i*th Ecotype of chicken (1…4) ; F*j* is the fixed effect of *j*th Feather type (*j* = 1,2); S*k* is the fixed effect of *k*th Sex of Chicken (*k* = 1,2); N*l* is the fixed effect of *l*th season of hatch (*l* =1,2,3); Ym is the fixed effect of Year of hatch (1, 2); e*ijklmn* is the random error attributed to the nth bird. The preliminary analyses did not show a significant effect among the interaction effects as a result the interaction effects were dropped from the model during the analyses.

Results and Discussion

The least squares means and standard errors for weight at different ages are presented in Table 2.

The explanatory power of the model was in the range of 10% at 2 months weight to 34% weight at six months. The explanatory power of the model was lower in the present study elucidating the fact that, other factors should be included to increase the accuracy of the model. The CV was in the range of 12% on weight at 2 months to 19% on weight at 12 months and there was an increase in percent CV as age advanced.

The weight at 2 months of age in the present study was 150.82 g. This result is less than the report of Tadelle and Ogle (2001) who had reported 185 g. The overall least squares means for weight at 6, 8 and 12 months of age in the present study were 1.18, 1.30 kg and 1.31 kg, respectively. Mature weight was attained at 8 months of age in the present study. The mature weight is the turning point where the growth rate is at decreasing rate (Fig 1). Mature weight in this study is close to the report of Tegene (2001) for local chicken in the southern part of Ethiopia at 40 weeks of age. The mature weight recorded in this study is larger than the Asella birds in central highlands of Ethiopia of 1.2 kg (Brannang and Pearson, 1990). The present study had showed lower performance of chicken as compared to the reports of Mwalusanya et.al. (2002) in Tanzania under village management conditions. The Tanzanian report showed a mature weight of 1948 and 1348 g for males and females, respectively.

Table 2. Least squares means and standard errors for weight at different ages of local chicken

Effect	Weight for ages (months)				
	2	6	8	10	12
Over all	150.82 ± 68.35 (153)	1183.07±197.68 (146)	1300.67±179.10 (124)	1321.18±282.12 (120)	1308.47±221.97 (104)
Ecotype	*	***	***	NS	*
Dedo (1)	166.30±85.73a (70)	1253.31±165.04a (63)	1320.32±127.74a (47)	1391.51±206.71 (49)	1351.21±192.59a (38)
Tepi (2)	144.18 ±39.73b (27)	1034.63±176.78b (25)	1360.74±244.74a (19)	1304.90±303.97 (21)	1365.88±153.96a (16)
Sombo (3)	132.24±41.71b (21)	1176.03±224.54a (29)	1222.51±183.71b (31)	1230.5±244.01 (30)	1204.75±235.40b (32)
Gambela(4)	136.14±52.69b (35)	1234.37±143.40a (19)	1314.14±178.00a (27)	1302.00±419.51 (18)	1351.61±257.70a (18)
Sex		*	***	***	***
Male (1)	-	1308.19±164.13a (66)	1392.74±180.17a (51)	1439.34±288.37a (55)	1454.67±188.24a (48)
Female (2)	-	1079.86±160.32b (80)	1236.86±149.49b (72)	1221.20±235.95b (65)	1183.16±165.37b (56)
Feather distribution	NS	NS	**	NS	**
Normal (1)	152.51±72.24 (136)	1182.78±190.54 (117)	1283.52±178.16b (109)	1329.07±293.84 (98)	1337.11±238.55a (84)
Naked neck (2)	137.35±11.53 (17)	1184.28±227.94 (29)	1325.33±134.27a (15)	1286.04±224.96 (22)	1260.74±245.72b (20)
Season of hatch	***	***	**	NS	***
Main rainy season (1)	219.282±90.28a (39)	1216.43±136.34 a (26)	1243.60±142.3b (43)	1219.07±220 (31)	1271.77±141.96b (18)
Cold dry season (2)	142.419±48.26a (44)	1172.38±158.45 b (15)	1316.24±132.82a (42)	1354.75±0.99 (29)	1292.72±214.24b (59)
Early rainy season (3)	117.97±24.24b (70)	1176.56±133.67 b (105)	1346.84±237.22a (39)	1282.81±325 (60)	1363.33±273.07a (27)
Year of hatch	*	***	**	NS	**
2000 (1)	185.96±91.49a (57)	1189.19±183.05a (68)	1297.24±194.71 (99)	1374.5±282.42 a (75)	1351.57±205.93a (65)
2001 (2)	129.95±36.87b (96)	1177.74±210.65b (78)	1314.28±94.68 (25)	1246.98±177.53 b (45)	1236.64±231.63b (39)

Least squares means in the same column of the same effect with different letters are significantly different.
The figures in parenthesis indicate the number of observations

There was a significant difference between ecotypes in growth performance ($P<0.05$) except growth at 10 months weight. The Sombo birds were the smallest of all the ecotypes under this study. The Dedo ecotype had better growth performance than the three genotypes under this study. These indicated that, there is variation on growth performance among local chicken found in the target agro-ecologies. This provides an opportunity to make use of the variability for genetic improvement of local chicken.

There was significant difference ($p<0.05$) in body weight between sexes in growth performance at 6-12 months. The males were found to be superior to females by about 23% at the age of one year and 12% at the age of 8 months. This report is in agreement with that of Mwalusanya et al. (2002) in Tanzania and showed that males were heavier by 44% than females at maturity.

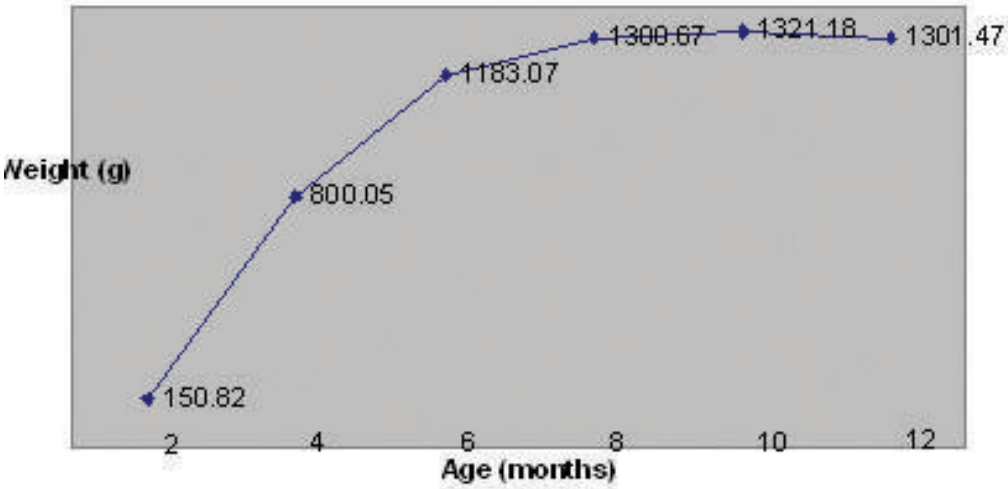

Figure 1. The growth curve of birds at different ages

There was no significant (p>0.05) difference between naked neck and normally feathered birds up to six months of age. The non-significant effect of feather distribution might be due to the fact that, the birds were not evaluated in their home of origin. These may necessitate to evaluating the local birds in their home of origin. This might be also be due to the small population size of the naked neck chicken under this study and the results of the present study should be interpreted with caution. However, normal birds had higher weights than naked neck birds in growth performance at all ages. The naked neck characteristic might have been associated with adaptation to hot and humid environments and reflected to their lower growth performance.

The effect of season was significant (p<0.05) with no clear cut trend for growth performance traits. However, there was a tendency that the birds hatched during the wet season showed better growth performance. The birds were allowed to scavenge in the yards and, as a result, got a chance to feed on forages and worms which might have resulted in better growth performance. The effect of year was significant (p<0.05) at all ages under this study except at 8 months of age. The difference in weight may be due to the variation in management offered to birds. The feed was a commercial ration purchased from Addis Ababa at Kaliti feed processing plant and there was no mechanism to check the quality of the feed from different batches.

The least squares means and standard errors for egg performance traits at different ages are presented in Table 3. The explanatory power of the model for egg performance traits was in the range of 5% on egg weight to 19% on egg revenue (Birr/year/hen). The explanatory power of the model for egg performance was also small, indicating the need to include more factors in the model to increase accuracy of the model. The CV was in the range of 12% for egg weight and egg/hen/year to 18% on egg mass (g/hen/day) and egg price (Birr/year/hen).

It was observed that, on the average, the birds began to lay eggs at 6.8 months of age. The Dedo birds seem to lay eggs earlier than the Sombo and Gambella birds (5.8 vs 7.2 months). The age at first egg in this study is in agreement with Tegene (2001) who reported age at first egg of 23 weeks (161 days) in Southern Ethiopia. The study conducted in Debrezeit showed age at first lay of 195 days (Tadelle and Ogle, 2001).

There was significant ecotype differences in egg weight between birds collected from different agro-ecologies. The overall least squares means for egg weight recorded in this study was 43.73+5.9 g. The highest egg weight was from Dedo birds and the lowest was from Tepi birds (45 g vs 41 g). This report confirms the earlier findings of Teketel (1986), Abebe (1992), Tegene (2001) and Mwalsanya et al. (2002). The average egg weight from local birds was reported to be 40g (Abebe, 1992) with similar figure of 46 g by Teketel (1986), 46-55 g Tegene (2001) and 44.1 g (Mwalsanya et al. 2002). The egg weight of 39g reported by Brannanng and Pearson (1990) was lower by 13% from the results of the present study.

Table 3. Least squares means and standard errors for egg performance traits

Effect	Egg weight(g)	Ratio of hen-day production	Egg mass (g/hen/day)	Egg/hen/year	Birr/hen/year
Overall mean	43.73±5.9	0.24±0.14	10.76± 6.10	90.98±52.60	29.57±16.38
	(4369)	(916)	(920)	(920)	(920)
Ecotype	**	**	**	**	**
Dedo	45.34±7.23 a	0.30±0.15 a	13.46±6.61 a	107.99±53.46 a	35.44±17.83 a
	(1443)	(293)	(293)	(293)	(293)
Tepi	41.48±7.23 b	0.26±0.14 a	10.4±6.01 a	94.40±50.96 a	31.15±16.66 a
	(486)	(116)	(116)	(116)	(116)
Sombo	42.34±4.19 a	0.23±0.12 a	9.75±5.24 b	84.24±44.68 a	27.80±14.74 a
	(1329)	(200)	(200)	(200)	(200)
Gambella	44.3±5.71 a	0.20±0.11 b	8.88±5.18 b	78.02±52.98 b	24.51±13.82 b
	(1111)	(307)	(311)	(311)	(311)
Feather Distribution	**	**	**	***	**
Normal (1)	45.34±7.23 a	0.26±0.14a	11.4±4.01a	101.40±32.16a	34.44±11.83a
	(3529)	(733)	(735)	(735)	(735)
Naked Neck (2)	41.14±7.23 b	0.23 ±0.14b	9.4±6.01b	84.40±50.96b	26.44±17.83b
	(840)	(183)	(185)	(185)	(185)
Season of hatch	**	**	**	***	**
Main rainy season (1)	45.34±5.23a	0.26±0.44a	11.64±9.01a	93.40±50.13a	34.44±17.85a
	(742)	(156)	(158)	(158)	(158)
Cold dry season (2)	42.34±8.23b	0.23±0.04b	10.44±3.01a	84.40±30.96b	26.44±11.52b
	(2490)	(486)	(515)	(515)	(515)
Early rainy season (3)	41.34±6.23b	0.24±0.24b	8.43±7.01b	88.44±47.83b	27.44±13.83b
	(1336)	(245)	(247)	(247)	(247)
Year of hatch	**	NS	*	***	**
-2000 (1)	42.34±5.12b	0.25±0.13	10.44±5.01b	98.44±47.83a	31.44±11.32a
	(1617)	(338)	(340)	(340)	(340)
-2001 (2)	45.34±3.23a	0.23±0.04	9.34±4.01a	86.77±36.43b	27.43±7.51b
	(2752)	(577)	(580)	(580)	(580)

Least squares means in the same column of the same effect with different letters are significantly different

The figures in parenthesis indicate the number of observations

The level of egg production, which is equivalent to 91 eggs/hen/year in this study, is comparable to the reports of Tadelle and Ogle (1996) and Tegene (2001). The former authors reported 88-100 eggs/hen/year under station and improved management conditions. Tegene (2001) reported 110 eggs/hen/year for local *Nech* ecotypes and 68 eggs/hen/year for *Gebissima* ecotypes in Southern Ethiopia. There are also reports of very low egg production by other workers working on other local ecotypes from other agro-ecologies in Ethiopia. Mekonen (1998) reported 29 eggs/hen/year and Brannaanng and Pearson (1990) reported 32 egg/hen/year. It seems that under improved management the performance of local birds in arid and humid environments are poorer in egg performance traits.

The overall least squares means of ratio of hen day egg production (the number of eggs collected in a flock housed divided by number of birds alive) in the present study is 0.24 ± 0.14. There was significant difference between ecotypes in hen- day egg production. The Dedo ecotype showed higher hen-day egg production of 0.30. The Sombo and Gambella chicken showed lower ratio of hen-day egg production of 0.23 and 0.20, respectively. This study demonstrated the presence of variation in egg performance traits and the birds from hot and humid environments tended to produce lower number of eggs than those kept in highland areas. It seems reasonable to argue that birds in hot environments are better in survival traits than production traits and these innate characteristics might have contributed to survive in the hot environment and produce egg and meat in hot environment where introduction of exotic chicken might not be feasible.

The total revenue that could be acquired from the sale of eggs from a bird is estimated to be 29 Birr per year (1 USD = 8.50 Birr). These were computed based on the market value of eggs, of 0.30 Birr per egg. There were significant differences in revenue from sale of eggs between birds from the different ecotypes. The Dedo can provide 35 birr per year under better management. The Gambella chicken produced lower number of eggs and thus lower revenue of 25 birr per year under the same management conditions. However, cost benefit analyses was not computed in the present study and there is a need to undertake a more detailed cost benefit analysis of rearing local ecotypes under intensive management.

The feather distribution has exerted a significant effect ($p<0.05$) on most of egg production traits. It was found that the normally feathered birds excelled the naked neck birds on egg traits in the present study.

The non-genetic factors such as season and year of laying had exerted a significant effect ($p<0.01$) on egg performance traits. The effect of season and year on egg traits did not show a clear cut trend. However, there was a tendency that, traits recorded during early rains showed higher performance. The effect of season and year could be due to irregularity of management offered to the flock that could call to put in place a standard management over seasons and years.

Conclusions

The study revealed that there was variation in growth and egg performance of birds collected from different agro ecologies of south western Ethiopia. The presence of such variability provides an opportunity for genetic improvement through selection. The Dedo birds seem to be better than the other ecotypes in egg and growth traits. The Sombo and Gambella birds were consistently poor in growth performance. There is also a need to evaluate the birds in their home of origin and increase the number of observation for conclusive recommendation. The normally feathered birds had excelled naked neck birds for egg and growth performance. The small amount of revenue obtained and the lower survivability of the local chicken under intensive management warrants a more detailed cost benefit analysis of rearing local ecotypes under intensive management.

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Feature Article: Climate Variability and Change

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Introduction

Climate variations and change affect human activities and life styles, which in turn affects development and economic production. Climate change is not easy to predict with precision because many variables involved are difficult to quantify. Climate change and variability brings impact on food security, natural resources leading to conflict and migration over limited resources (water, pasture etc) as well as health (Alemayehu and Peter, 2008).

Recent climatic patterns characterized by high temperatures, erratic rainfall and frequent and intense cyclones are global concerns due to interactions with all sectors of economy. Prolonged droughts especially in arid and semi arid areas of the tropical regions, increased frequency and intensity of EI Nino and tropical cyclones as well as emergence of highland malaria are attributed to the changing climatic patterns.

Problem statement

There is no clear distinction between climate change and variability. The questions being asked by users outside the climate circle are (i) what is the difference between climate change and variability? (ii) Which of these phenomenons contribute to recent observed climate patterns? To answer these questions an understanding of the difference between climate variability and change causes and how they are detected are important. The livestock sub- sector in East African is growing faster. In Eastern African Pastoralists depend entirely on livestock husbandly as their livelihood option. Pastoralists together with their herds are supported within the rangelands where the animals absolutely graze and browse. However, the 2006 FAO report highlighted by Steinfeld et al. (2006) has blamed the livestock sector as being the generator of green house gas on earth even than the automotive transportation sector. The report further blames the livestock sub-sector as a major source of land degradation and found to be the most significant contributor today's most serious environmental problems that lead to climate change. To curb the situation, the FAO report calls for urgent remedial actions.

This paper tried to use FAO document and other relevant available literature to address and present the information knowledge on climate change and variability and the contribution of livestock from Eastern Africa Rangelands Production System on climate change.

Objectives

Objectives of the paper include:

- To clarify the terms used to define climate change and variability;
- To identify and list the most possible livestock related activities that lead to green house gas emission as highlighted by Steinfeld et al. (2006) from the Eastern African Rangeland Perspective; and
- To propose priority research areas suitable to address issues on climate change related livestock activities in Eastern African Rangelands.

Definitions

Climate Variability

Climate is the average state of the atmosphere of an area over a long period of time preferably 30 years. On average climate of an area can be classified at wet, dry, cold, windy, hot and humid. However, the average value is sometimes exceeded or not obtained at all leading to surplus (above mean) or deficit (below mean). Fluctuations of climate parameters about the mean from time to time (season or year) of an area are known as *climate variability*. Climate variability is evident in seasonal or annual fluctuations about the mean associated with floods and droughts. It is cycle that recurs or repeats after a certain interval of time.

Climate Change

Unlike climate variability that fluctuates about the mean, climate change refers to long term or permanent shift in climate of an area. Some of the evidence of climate change includes, global temperature (min./max) rise; increased frequency in occurrence and severity of droughts, floods, tropical cyclones; reduced (decreased trends) in annual rainfall amounts; reduction in glacial cover over mountains and rising sea levels. Recent studies attribute the emergence of highland malaria to climate change.

Attributions to climate change and variablity

Causes of climate variability

Climate variability is caused by changes in the intensities in climate indicators such as EI Nino southern Oscillation (ENSO), Indian Ocean Dipole (IOD), Quasi Biennial Oscillation (QBO), Sea Surface Temperatures (SSTs), Tropical Cyclones (TC), Subtropical Anticyclones, Monsoons, Easterly waves, Meso-scale circulations and

Intra-seasonal Oscillations (MJO) and subtropical disturbance. Among the indicators, ENSO and IOD are the major modes of inter-annual variability (year to year) in the tropics while the MJO is the main mode of the intra-seasonal Oscillation. Warm ENSO (EI Nino) is associated with excessive rainfall in some parts of Eastern Africa and drought in other parts. Combination of these indicators increases the intensity of climate variability. For example, 1997/98 and 2006/09 rainfalls were caused by a combination of warm ENSO and positive IOD.

Causes of Climate change

Climate change is caused by accumulation of Green House Gases (GHGs) in the atmosphere, which leads to global warming. Based on IPCC report, some of the GhGs in the atmosphere include carbon dioxide (CO_2), methane (CH_4) and nitric oxide (N_4O).

Climate change and variability detections

Climate change detection refers to statistical methods of identifying the climate change and variability.

Detections of climate variability

Climate variability is obtained by plotting time series of climate anomalies (deviations). High deviations from mean indicate high variability while low deviations represent normal fluctuation about the mean.

Detections of climate change

Computer based climate models are used to project climate change based on the climate trends. The expected climate changes are developed based on population, technology and socio-economic scenarios.

Interactions between climate change and variability

Global warming has impact on most of climate indictors such as ENSO, IOD, SSTs and TC. Climate change is expected to intensify and increase the frequency of occurrence of climate indicators thereby increasing climate variability. In turn the frequency and intensity of extreme climate events and the associated impacts are expected to be on the increase. The indicators of climate change include climate/weather variability (floods, and droughts), increased greenhouse gas emissions and temperature changes (Alemayehu and Peter, 2008).

Eastern Africa Rangeland Livestock Production System and Climate change

Out of the six livestock related sources that lead to green house gas emission as highlighted by Steinfield et al. (2006) only three of them may apply to livestock production systems existing in Eastern Africa Rangelands. This is because livestock production in this region is mainly pastoral; thus, does not involve intensive management; and is neither industrial. In Africa, livestock, mainly cattle are herded in traditional ways and serve largely as tokens of their owners' wealth. The concerns in Eastern Africa Rangelands, considering the production system exiting in this region are outlined below:

- **Methane release from the break down of animal manure:** In developing countries, however, most manure is spread as fertilizer, emission from these practices is poorly quantified but likely is low since most decomposition takes place aerobically, however, this leads to more CO_2 emission (OTA, 1991)
- **Land use change for grazing** – Land transformations have characterized the entire 10,000- year history of agricultural development and continued on a large scale today, and the concern over deforestation now focuses on tropical areas, although many temperate forests have also been cleaned at least once during the last few hundred years. CO_2 is emitted in this process, and also when grassland and savannas are burned to enhance grazing conditions, and when carbon contained in soil organic matter is carried by erosion (OTA, 1991)
- **Land degradation-** Land degradation from over grazing is taking a heavy economic toll. In the early stages of over grazing, the cost shows up as lower. However, if the process continuous, it destroys vegetation, leading to the erosion of soil and the eventual creation of wasteland. In Africa, the annual loss of rangeland productivity is estimated at $7 billion (Brown, 2002). Thornton et al. (2002) report that, in Africa, most of the cattle are in or near the Sahel, the higher-potential areas of Eastern Africa (including Ethiopian highlands), Zimbabwe and South Africa. Sheep are also concentrated in these areas, and in parts of northern Africa. Therefore, with this regard, land degradation related to livestock in the Eastern Africa rangelands is of major concern.

Priority Research Areas

With emphasis on the impacts of livestock related activities on the world's climate from Eastern Africa rangelands perspective, research areas that need to be addressed include the following.

- Research to find impacts of livestock related activities on the world's climate, from Eastern Africa Rangelands perspective are needed. Along this, researches to quantity

the magnitude of green house gases emitted from disposed manure (e.g. in heaps and lagoons) in pastoral areas of eastern Africa Rangelands are recommended;

- Research on Land use change that favor grazing animals – on the amount of land converted from other uses to pastureland, emphasizing the emission resulting from burning forest and grassland in favor of re-growth for grazing livestock;
- The extent of land degradation tied to livestock in Eastern Africa Rangelands needs to be addressed. e.g. on blockage of soil efficiency in fixing above ground carbon dioxide due to compaction by livestock;
- Research on the reduction of efficacy of vegetation to assimilate carbon due to vegetation remora by grazing in the Eastern Africa Rangelands; and
- Study on climate change indicator and moodily are also needed.

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Information for Contributors

General

Ethiopia is one of the countries endowed with a large number and diverse livestock resources. The spectacular land formation, ranging from mountain chains with peaks of over 4500 m asl to areas below sea level, has created diverse climatic conditions with variable agro-ecological zones and rich biodiversity. This unique variability has afforded the country for the evolution and development of different agricultural production systems. Different species and breeds of livestock have been domesticated and used for various purposes. The different production systems and the economic and social roles that livestock play in the livelihood of millions of smallholder farmers is substantial. The proper exploitation of this large number and diverse livestock resource in the country has remained a great challenge to all professionals engaged in livestock production. This has also afforded a number of national and international organizations a great opportunity to undertake research and development activities to ensure proper utilisation and conservation of these resources.

In order to co-ordinate such efforts and to streamline the research and development agenda, The Ethiopian Society of Animal Production (ESAP) has been operational since its establishment in 1985. ESAP has created opportunities for professionals and associates to present and discuss research results and other relevant issues on livestock. Currently, ESAP has a large number of memberships from research, academia, and the development sector. So far, ESAP has successfully organised about 10 annual conferences and the proceedings have been published. The ESAP Newsletter also provides opportunities to communicate recent developments and advancements in livestock production, news, views and feature articles. The General Assembly of the Ethiopian Society of Animal Production (ESAP), on it's 7th Annual Conference on May 14, 1999, has resolved that an Ethiopian Journal of Animal Production (EJAP) be established. The Journal is intended to be the official organ of ESAP.

The ***Ethiopian Journal of Animal Production (EJAP)*** welcomes reports of original research data or methodology concerning all aspects of animal science. Study areas include genetics and breeding, feed resources and nutrition, animal health, farmstead structure, shelter and environment, production (growth, reproduction, lactation, etc), products (meat, milk, eggs, etc), livestock economics, livestock production and natural resources management. In addition the journal publishes short communications, critical review articles, feature articles, technical notes and correspondence as deemed necessary.

Objectives

- To serve as an official organ of the Ethiopian Society of Animal Production (ESAP).
- Serve as a media for publication of original research results relevant to animal production in Ethiopia and similar countries and contribute to global knowledge
- To encourage and provide a forum for publication of research results to scientists, researchers and development workers in Ethiopia

Columns of the Journal

Each publication shall include some or all of the following columns.

Research articles

Research articles based on basic or applied research findings with relevance to tropical and sub-tropical livestock production.

Short communications

Short communications are open to short preliminary reports of important findings; normally not more than 2000 words. They may contain research results that are complete but characterized by a rather limited area or scope of investigation, description of new genetic materials, description of new or improved techniques including data on performance. They should contain only a few references, usually not more than five and a minimum number of illustrations (not more than one table or figure). Abstract should not be more than 50 words.

Review articles

Review papers will be welcomed. However, authors considering the submission of review papers are advised to consult the Editor-in-Chief in advance. Topical and timely short pieces, news items and view points, essays discussing critical issues can be considered for publication

Feature articles

Feature articles include views and news on the different aspects of education, curricula, environment, etc will be considered for publication after consulting the Editor-in-Chief. Areas for consideration include education, society, indigenous knowledge, etc.

Technical notes

Technical notes relate to techniques and methods of investigation (field and laboratory) relevant to livestock production. Notes should be short, brief and should not exceed one page.

Correspondence

Letters on topics relevant to the aims of the Journal will be considered for publication by the Editor-in-Chief, who may modify them.

Frequency of publication

Once a year (May)

Guidelines to Authors

General

The ***Ethiopian Journal of Animal Production (EJAP)*** publishes original articles of high scientific standard dealing with livestock and livestock related issues. Reviews on selected topics on livestock research and development appropriate to Ethiopia and other similar countries will also be considered for publication. Short communication and technical notes are also welcome.

Manuscripts should be written in English, double spaced throughout and should be on one side of an A4 sheet. Authors are advised to strictly stick to the format of the journal. Submit three copies of manuscript and each page should be numbered. An electronic form in Word format should also accompany the manuscript. The disk should be clean from viruses, and should be labelled clearly with the authors' names and disk file name. Manuscripts submitted to the Editorial Office will be duly acknowledged. All articles will be sent to at least two reviewers (within or outside the country) selected by the Editorial Board and will be reviewed for relevance to the journal, scientific value and technicality. Rejected papers will be returned to the author(s)

immediately. Accepted papers will be returned to the author with the comments of the reviewer(s) for further improvement of the manuscript. EJAP has no page charge.

Proofs will be sent to the author. Typeset proofs are not checked for errors. Thus, it is the responsibility of the primary author of each paper to review page proofs carefully for accuracy of citations, formulae, etc. and to check for omissions in the text. It is imperative that the authors do a prompt, thorough job of reviewing the returned proofs to ensure timely publication. Authors are instructed to return the proofs to the Editorial Office within 15 (fifteen) days of receipt. Senior or corresponding authors will be provided with 25 (twenty-five) offprints free of charge for each published articles.

Format for Manuscripts

Research paper should be as concise as possible and should not exceed 6000 words or about 10 to 12 pages including illustrations and tables. Papers should be partitioned into sections including abstract, introduction, materials and methods, results, discussion, acknowledgements and references. Main text headings should be centered and typed in capitals. Sub-headings are typed in capitals and small letters starting from left hand margin.

Headings: Title of the paper should be in upper and lower case. Main headings should be in upper and lower case, centre.

Sub-headings: First sub-headings, flush left, separate line, capitalize main words; second sub-headings- flush left, same line as text, capitalize first word, followed by period; third sub-heading – flush left, same line as text, capitalize first word, italics followed by a dash.

Title: The title should be concise, specific and descriptive enough to contain key words or phrases including the contents of the article. A short running title of less than 50 characters should also be suggested.

Author and institution: The name(s) of author(s) and the institution(s) with which they are affiliated, along with the addresses, should be provided. Corresponding author should be identified in case of more than one author.

Abstract: Research or applied articles should have an abstract of no more than 300 words. The abstract should state concisely the goals, methods, principal results and major conclusions of the paper. Incomplete and uninformative descriptions should not be used. The use of acronyms is discouraged. Keywords of up to five words should be included.

Introduction: This part should be brief and limited to the statement of the problem or the aim of the experiment, justification and a review of the literature pertinent to the problem.

Materials and methods: The techniques and procedures of the research, the conditions under which the study was conducted and the experimental design are described under this heading. Relevant details about the animal should be given and the statistical design should be described briefly and clearly. Data should be analyzed and summarized by appropriate statistical methods; authors should examine closely their use of multiple comparison procedures. A measure of variability, e.g., standard deviation or standard error must be provided when reporting quantitative data. If standard methods of investigation and analysis are employed appropriate citation suffice.

Results: The summary of major findings and assessments of the investigation are given in this section. The results can be presented using tables, illustrations and diagrams.

Tables: Tables are numbered consecutively in arabic numerals (e.g., Table 1) and should bear a short, yet adequately descriptive caption. Avoid using vertical and/or horizontal grid lines to separate columns and/or rows. Metric units are clearly to be shown, abbreviated in accordance with international procedure. Footnotes

to tables are designated by lower case which appear as superscripts in appropriate entries. Tables should be compatible with column width viz. 140 mm, and should be presented on separate sheets, and grouped together at the end of the manuscript. Their appropriate position in the text should be indicated and all tables should be referenced to in the text.

Illustrations and diagrams: These should be inserted into the text using any suitable graphics programmes. Freehand or typewritten lettering and lines are not acceptable. Authors are requested to pay attention to the proportions of the illustrations so that they can be accommodated in the paper without wastage of space.

Figures: Figures should be restricted to the display of results where a large number of values are presented and interpretation would be more difficult in a Table. Figures may not reproduce the same data as Tables. Originals of figures should preferably be A4 size, of good quality, drawn or produced on good quality printer and saved in a separate file. There should be no numbering or lettering on the originals. Numbering and lettering, which must be kept to an absolute minimum, should be legibly inserted on the copies. Vertical axes should be labelled vertically. A full legend, describing the figure and giving a key to all the symbols on it, should be typed on a separate sheet. The symbols preferred are: ▲,■ ○ □, but + and x signs should be avoided. Figures should be numbered consecutively in arabic numerals (e.g., Figure 1), and refer to all figures in the text.

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Discussion: The reliability of evidence (result), comparison with already recorded observations and the possible practical implication is discussed.

Conclusion: Authors are encouraged to forward conclusion (two to three brief statements) from the study summarising the main findings and indicating the practical implications of the findings.

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Ethiopian names should be in direct order, i.e., the full first name followed by the father's name and should not be abbreviated. E.g. Zinash Sileshi and not Sileshi, Z.
(Tesfu Kassa and Azage Tegegne, 1998).

(Alemu Yami and Kebede Abebe, 1992; Alemu Gebre Wold and Azage Tegegne, 1995; Zinash et al., 1996)
– Chronologically
According to Zinash Sileshi and Siyoum Bediye (1995)

Where more than two authors are quoted in the text: - Zinash Sileshi et al. (1990) or (Zinash Sileshi et al., 1990). However, all authors' names should be given in the Reference list.

Examples

Journal article:

Zerbini, E., Takele Gemeda, Azage Tegegne, Alemu Gebrewold and Franceschini, R. 1993. The effects of work and nutritional supplementation on postpartum reproductive activities and progesterone secretion in F_1 crossbred dairy cows in Ethiopia. Theriogenology 40(3):571-584.

Crosse, S., Umunna, N.N., Osuji, P.O., Azage Tegegne**,** Khalili, H. and Abate Tedla. 1998. Comparative yield and nutritive value of forages from two cereal-legume based cropping systems: 2. Milk production and reproductive performance of crossbred (*Bos taurus x Bos indicus*) cows. Tropical Agriculture 75 (4):415-421.

Book

Steel, R.G.D. and Torrie, J.H. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., Inc., New York.

Chapter in a Book

Zerbini, E., Takele Gemeda, Alemu Gebre Wold and Azage Tegegne. 1995. Effect of draught work on the metabolism and reproduction of dairy cows. In: Philips, C.J.C. (ed.), Progress in Dairy Science. Chapter 8. CAB International. pp. 145-168.

Paper in Proceedings

Alemu Gebre Wold, Mengistu Alemayhu, Azage Tegegne, E. Zerbini and C. Larsen. 1998. On-farm performance of crossbred cows used as dairy-draught in Holetta area. Proceedings of the 6th National Conference of the Ethiopian Society of Animal Production (ESAP), May 14-15, 1998, Addis Ababa, Ethiopia, pp. 232-240.

Papers based on Theses

Papers based on theses should be presented with the thesis advisor as co-author and should indicate the institution, the year the work was done, and the full title of the thesis as a footnote.

Abbreviations

Follow standard procedures.

Units

All measurements should be reported in SI units. (e.g., g, kg, m, cm)

Table 1. The following are examples of SI units for use in *EJAP*

Quantity	Application	Unit	Symbol or expression of unit
Absorption	Balance trials	Grams per day	g d^{-1}
Activity	Enzyme	Micromoles per minute per gram	µmol min-1 g^{-1}
Area	Land	Hectare	ha
	Carcass	Square centimetre	cm^2
Backfat	Carcass	Millimetres	Mm
Concentration	Diet	Percent	%
	Blood	Gram per kilogram	g kg^{-1}
		International unites per kilogram	IU kg^{-1}
		Milligram per 100 mL	Mg dL^{-1}
		Milliequivalents per litre	Mequiv L^{-1}
Density	Feeds	Kilogram per hectolitre	Kg hL^{-1}
Flow	Digesta	Grams per day	g d^{-1}
	Blood	Milligrams per minute	mg min^{-1}
Growth rate	Animal	Kilogram per day	Kg d^{-1}
		Grams per day	g d^{-1}
Intake	Animal	Kilograms per day	Kg d^{-1}
		Grams per day	g d^{-1}
		Grams per day per kg bodyweight0.75	g d-1 $kg^{-0.75}$
Metabolic rate	Animal	Megajoules per day	MJ d^{-1}
		Watts per kg bodyweight	W kg^{-1}
Pressure	Atmosphere	Kilopascal	KPa
Temperature	Animal	Kelvin or degree Celsius	K or °C
Volume	Solutions	Litre	L
		Millilitre	ML
Yield	Milk production	Litres per day	L d^{-1}
Radioactivity	Metabolism	Curie or Becquerel	Ci (=37 GBq)

Units with two divisors should be written with negative indices (e.g., kg ha^{-1} yr^{-1}). The use of solidus (/) should be reserved for units written in full (e.g., mole/kilogram) or to separate a physical quantity and unit (e.g., yield/ha). Units should be chosen so that the numeric component falls between 1 and 10 or 1 and 100 when using one or two significant figures, respectively (e.g., use 31.2 mg than 0.0312 g).

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