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# Ethiopian Journal of Animal Production

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**Aims and Scope:** The Ethiopian Journal of Animal Production is a peer reviewed journal publishing original basic and applied research articles, short communications, technical notes, review articles dealing with livestock and livestock related issues. Although the journal focuses on livestock production in Ethiopia, papers from similar agro-ecological regions of the world are welcomed.

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# Milk Production Characteristics of Holstein Friesian Cattle at Holetta Government Dairy Farm, Ethiopia[a]

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## Abstract

*Data on milk production were collected from the Holetta Government Dairy farm for the years 1967-1991, and totally 1384 lactations were used. The milk production traits including total lactation milk yield, lactation length and annual milk yield were analysed to know the mean production level of the breed and the environmental components of variances. The independent variables examined were year and season of calving, parity and interaction between these factors.*

*The average lactation yield was 3357.9 Kg, average lactation length was 351 days and annual milk yield 2783.1 kg. These results are less than those obtained in most other tropical zones, indicating the need for improved management of the Holstein/Friesian cattle in the Ethiopian highlands.*

*The effect of year of calving was significant for all the traits and this was ascribed to drought cases in some of the years under study and the change in the ownership within the farm.*

*Least squares mean Lactation yields were 3160.3±71.7 Kg, 3314±76.5 Kg and 3395.0±85.2 Kg for 1st, 2nd and 3rd lactations respectively. Thereafter no increase was found, but a marked decrease was observed from the fifth lactation onwards. The study has shown that cows with at least seven parities had a significantly less milk yield than those cows with fewer parities due to aging of cows. Thus, there is a need for planned culling as of the seventh parity to avoid selection bias and competition of the limited concentrate feed with the productive animals.*

*The mean annual milk yield, which is a function of both lactation yield and calving interval was much less than the lactation yield indicating that factors affecting the reproductive traits should be treated to bring about an economic dairy productivity.*

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[a] The paper is based on M. Sc. thesis at Alemaya University of Agriculture, Ethiopia in 1994. The full title of the thesis is 'Milk production and persistency characteristics of purebred Holstein/Friesian cattle on the Holetta Government Dairy Farm, Ethiopia

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*In general the results in this study indicated the need for improved management, and the need for correcting effects of parity and calving year during selection of animals for dairy merit. In addition the mean results indicated in this study can be used to measure the prospective genetic progress in milk yield for Holstein Friesian breed.*

*Keywords*: Holstein Friesian, Holetta, dairy traits

## Introduction

The size and diversity of the major agro-ecological zones of Ethiopia, which vary from arid tropical to temperate climate, make it possible to support large numbers of different classes of livestock. However, milk production from a local cow rarely exceeds 250 kg per year (Brännäng et al. 1990). The low productivity in general is principally due to poor management practices, poor nutrition or low response to improved nutritional inputs, high disease incidence, and low genetic potential.

The problem with the genetic potential can be attributed to natural selection to the tropical environment of the local cattle types on one hand and lack of procedural selection method on the other (Mason and Buvanendran, 1982). Although selection using the local cattle types is helpful to the mixed farming and pastoral systems, the selection differential which can be obtained from local cattle types is so low due to lower mean milk production. Further, when these animals are kept in an improved environment, their production response is low as compared to the pure temperate breeds and their crosses. Thus for urban and peri-urban dairy production, where concentrates and good health management can be offered, keeping high grade dairy cattle is more preferable.

Although most of the milk in Ethiopia comes from private smallholder farms it is mainly state institutions which are involved in milk recording; still these records are not timely evaluated because of which timely correction of breeding and management conditions will not be possible. Therefore, the objectives of this study were to evaluate the milk performance of the Holetta Holstein Friesian in terms of lactation length, lactation yield and annual milk yield, to ascertain the existing production level of Holsteins in Ethiopia and to help estimate prospective genetic progress in milk yield, and to estimate the environmental components of variance.

# Materials and Methods

## The study site

The Holetta farm is located 44 km South-West of Addis Ababa at longitude $38^0$ 30' East and latitude $9^0$ 3' North. The maximum altitude is 2400 metres. The rainfall pattern is bimodal over the months; average moisture is 56% (Holetta, 1990). The farm was established by the Ministry of Agriculture in 1955 and was run by the Ministry till 1981. Thereafter, it has been transferred to the Ministry of State Farms. The farm called "Holetta 1 Dairy Farm", has an estimated land holding of 160 hectares, much of which consists of natural pasture grazed as open system.

## Cattle management

Feedstuffs for the herd include hay, green feed and concentrates. Dairy cows receive a daily maintenance ration of about 2 kg concentrate with an additional production ration of up to 1/2 kg per kg of milk yield. Cows over seven months pregnancy are provided with up to 4 kg concentrates per day. Bulls receive up to 6 kg per day depending on availability of feed. Feedstuff for the other classes of livestock include mainly hay and green feed.

Newborn calves suckle their dams until five days from birth to get colostrum. Thereafter they are bucket fed and the amount varies according to age. From 5 to 35 days of age calves receive up to 5 litres of milk per day, from 35 to 65 days of age to 4 litres and from 85 to 100 days of age up to 2 litres. Thereafter they are given about 1 liter of milk per day until they are weaned at the age of 120 days. Besides, both grazing and hay feeding is undertaken except for calves under the age of one month.

Diseases and parasites of economic importance in the area include black leg, CBPP, foot and mouth, mastitis, liver fluke, foot-rot and tick infestation. Black leg and CBPP are controlled using vaccinations. Treatment of the other diseases varies each year depending on availability of drugs.

## Breeding operation

The parent stock of these purebred Holsteins was imported from the USA and Kenya in 1955 and 1959, respectively. The aim of the farm was milk production. The breeding operation before 1980 was maintenance of the pure breed by using Friesian sires and deep frozen semen from Europe. Since 1980 Semen has been produced at and obtained from the AI center at Kallitti, Ethiopia.

Breeding weight for heifers is 300 kg. Rest period allowance for cows is 45 to 60 days. Cows are culled if they require greater than 4 insemination services per conception, attained the age of 10, and have serious mastitis infections.

Male animals not selected for future breeding purpose are culled under a yearling age.

## Data material and statistical procedures

The data used include individual lactation records and reproduction records for 25 years (1967-1991). The number of milking cows per day varied between 55 and 122. A data-base was built up using ILCA's Data Entry and Analysis System, IDEAS, 1986. Extraction of data from IDEAS was done using dBase IV programmes. Lactation length, lactation yield and annual milk yield were computed from the records.

The analyses were done by Mixed Model Least Squares and Maximum Likelihood Computer Program of Harvey (1990). The model to analyse the fixed environmental effects on each of the dependent variables can be described as

$Y_{ijkl} = u + b_i + c_j + d_k + (bc)_{ij} + Bx_{ijk} + e_{ijkl}$ where u = the overall mean of the individual observations; $b_i$ = the fixed effect of $i^{th}$ season; $c_j$ = the fixed effect of $j^{th}$ year; $d_k$ = effect of $k^{th}$ parity, $(bc)_{ij}$ the interaction between year and season; B = the linear regression coefficient of the traits on age at first calving; $x_{ijk}$ = the deviation of individual age at first calving from its mean; $e_{ijkl}$ = individual phenotypic deviation from the subgroup mean.

# Results

The overall means, standard deviations, and coefficients of variation for the whole data material are presented in Table 1. The least squares mean for lactation length was 327.5±4.3 days. That for lactation yield was 3157.4± 82.0 kg and for the annual milk yield 2771.5±165.0.

**Table 1**. Overall mean, standard deviation (SD), coefficient of variation (CV) and least squares means (LSM) of each trait for the Holetta herd

| Trait | Mean | SD | CV | LSM±SE |
|---|---|---|---|---|
| Lactation length (days) | 351.0 | 113.8 | 39.0 | 327.5 ± 4.3 |
| Lactation yield (kg) | 3357.9 | 1314.3 | 32.4 | 3157.4 ± 82.0 |
| Annual milk yield (kg) | 2783.1 | 927.7 | 33.3 | 2771.5 ± 165.0 |

In Table 2 the analyses of variance are shown, using the fixed model. It is indicated that parity and year of calving significantly affected all the traits.

Table 3 indicates the change in lactation yield, lactation length and annual milk yield in the different parities. Yield increment was indicated from first to third parity, followed by constant performance up to fifth parity, and then a decrease from the sixth parity onwards.

**Table 2**. Analysis of variance for dairy traits in the Holetta herd - Mean squares and significance levels

| Source of variation | Degrees of freedom | Lactation length (days) | Lactation yield (kg) | Annual milk yield (kg) |
|---|---|---|---|---|
| Calving year | 20 | 71566*** | 18647821*** | 9137272*** |
| Calving Season | 2 | 37179 | 4577140 | 1438009 |
| Parity | 6 | 99815*** | 4527269* | 4143538*** |
| Calving year x season | 40 | 16768 | 1791329 | 84408 |
| Remainder | 1315 | 12960 | 1727317 | 860736 |

* => p<0.1; ** => p<0.01; *** => p<0.001

**Table 3**. Least squares means with standard errors of dairy traits tested over parity in the Holetta herd

| Parity | No. | Lactation yield (kg) | Lactation length (days) | Annual milk yield (kg) |
|---|---|---|---|---|
| 1 | 372 | 3160.3±71.7[b] | 367.7 ± 5.9[c] | 2643.0 + 59.6[a] |
| 2 | 331 | 3314.5±76.5[b] | 351.0 ± 6.6b[c] | 2796.2 + 64.6[a] |
| 3 | 264 | 3395.0±85.2[b] | 328.9 ± 7.4b[c] | 2995.3 + 75.7[b] |
| 4 | 181 | 3474.8±102.1[b] | 334.5 ± 8.8b[c] | 3099.7 + 93.7[b] |
| 5 | 116 | 3328.2±126.6[b] | 332.8 ± 11.0[bc] | 2601.1 +121.8[a] |
| 6 | 72 | 3136.9±161.3[b] | 312.9 ± 11.0[b] | |
| 7+ | 48 | 2798.7±196.7[a] | 266.3 ± 17.0[a] | |
| | 1384 | | | |

Means followed by the same letter in each row within a trait do not differ each other at 0.05 level of significance

Season of calving did not affect the dairy traits significantly (Table 2). However, cows that calved during February to May (season 1) yielded less than those which calved in other seasons (Table 4). Lactation length also followed similar trend.

**Table 4**. Least-squares means with standard errors of dairy traits tested over calving seasons

| Calving season | No | Lactation yield | Lactation length |
|---|---|---|---|
| 1 | 518 | 3141.5 ± 71.0 | 318.5 ± 6.1 |
| 2 | 387 | 3200.0 ± 83.7 | 326.6 ± 7.3 |
| 3 | 479 | 3348.1 ± 73.3 | 337.5 ± 6.3 |

Year of calving significantly affected all the traits under study (Table 2). Further trend of each trait over the calving years also is shown in Table 5. Lower performance was obtained in 1974-75, and 1984-85. On the other hand, abrupt increment was indicated in 1980-81.

**Table 5**. Least-squares means with standard errors of dairy traits tested over calving years in the Holetta dairy herd

| Calving year | No. | Lactation yield | Lactation length | Annual milk yield |
|---|---|---|---|---|
| 1971 | 58 | 3114.4±172.4[abcde] | 298.5±14.9[b] | 2607.5±185.5[abc] |
| 1972 | 39 | 2832.8±210.3[abcde] | 305.5±18.2[b] | 2583.9±197.8 [abc] |
| 1973 | 62 | 2717.1±166.8[abcd] | 322.9±14.4[b] | 2529.2±156.7 [abc] |
| 1974 | 74 | 2648.5±152.6[abc] | 329.3±13.2[b] | 2348.4±135.3 [abc] |
| 1975 | 87 | 2524.7±140.8[ab] | 362.1±10.7[b] | 2153.6±132.5 [abc] |
| 1976 | 58 | 2617.8±172.4[abc] | 366.8±14.9[b] | 1912.6±131.2[a] |
| 1977 | 73 | 3083.8±153.7[abcde] | 371.6±13.3[b] | 1965.1±156.8[ab] |
| 1978 | 96 | 3294.2±134.0[bcdefg] | 359.0±11.6[b] | 2431.6±136.7[abc] |
| 1979 | 80 | 3341.1±146.8[bcdefg] | 317.1±14.1[b] | 2497.3±129.9[abc] |
| 1980 | 104 | 3938.9±128.7[fg] | 350.6±11.2[b] | 2648.5±146.7[abc] |
| 1981 | 113 | 3843.2±123.5[efg] | 362.1±10.7[b] | 3230.5±115.1[cde] |
| 1982 | 88 | 3721.6±139.9[defg] | 348.3±12.1[b] | 2965.8±115.9[bcd] |
| 1983 | 79 | 4046.8±147.7[fg] | 357.7±12.8[b] | 3200.2±143.1[cde] |
| 1984 | 58 | 3185.6±172.4[bcdef] | 329.2±14.9[b] | 2951.2±154.6[bcd] |
| 1985 | 49 | 3068.0±187.6[abcde] | 312.4±16.3[b] | 3023.9±141.4[bcd] |
| 1986 | 46 | 4228.9±193.6[g] | 335.9±16.8[b] | 3771.1±163.9[e] |
| 1987 | 65 | 3664.5±162.9[defg] | 317.3±14.1[b] | 3621.8±156.8[de] |
| 1988 | 55 | 3268.7±177.1[bcdef] | 333.4±15.3[b] | 2783.7±189.3[abcd] |
| 1989 | 46 | 3369.5±193.6[cdefg] | 287.4±16.7[b] | 3243.2±247.9[cde] |
| 1990 | 54 | 2168.5±178.7[a] | 209.2±15.5[a] | |

Means followed by the same letter in each row within a trait do not differ each other at 0.05 level of significance

# Discussion

## Lactation length

The lactation length obtained in this study was higher than 315.4±17.4 days reported by Parmar (1988) in India, 302.2±5.5 days by Dabdoub (1988) in Iraq, 316±5 days by Ribas *et al.* (1985) in Canada and 295 days by Alpan *et al.* (1971) in Turkey.

## Lactation Yield

In this study the least squares mean lactation yield was 3157.4±82.0 kg. This is lower than the results obtained by various researchers including Car *et al.* (1983) in Portugal, Ornelas *et al.* (1981) in Mexico and Moharram (1988) in Egypt who reported, 4330±230 and 4571±689 and 3201 kg, respectively. Higher yields were also reported in Brazil by Freitas *et al.* (1983) and by Combellas (1980) in Australia (as 4334±230 and 4213±120 kg, respectively). On the other hand, the yield in the present study is higher than 2827±617 kg, which is reported by Sitorus *et al.* (1983) in West Java.

### Annual milk yield

The annual milk yield is calculated as milk yield per day of calving interval times 365. It involves both milk yield and reproductive capacity although it has little inheritance due to environmental variation in both lactation yield and calving interval. The least squares mean annual milk yield was 2771.5±165 kg compared to 3157.6±82.0 for lactation yield, and this is due to the wider calving intervals.

### Factors affecting the analysed traits

The effect of calving year was highly significant for all traits ($P<0.001$). It was clearly indicated that there was a marked decrease of the traits in the drought years 1974-75 and 1984-85. There was also a significant increase in the traits in the first few years after exchange of ownership from Ministry of Agriculture to Ministry of State Farms.

The effect of season of calving was not significant for all the traits studied. However, calving in season 3 (October to January) gave the best yield. This is logical as cows calving in the dry season will at the end of the lactations benefit from the rains in seasons 1 (February to may) and season 2 (June to December) (Kiwuwa et al., 1983).

Parity had a significant effect on all traits ($0.05 < P < 0.001$)(Table 2). The effect of each parity is further differentiated to help indicate the time when significant deterioration of milk yield and milking duration take place. Each of the traits (Table 3) follows the trend which is generally known, i.e. they increase from the first lactation to the third and then are about constant in the following 2 parities. Thereafter they tend to decrease to the 6th and 7th parities. However, Table 3 also shows that significant differences only occurred between cows calving seven or more times and those with fewer calvings. The difference in yield over parities is due to the age of the cows. Mature cows require less energy for growth, and produce more milk. After the fourth parity production decreases as older ages predispose to weakness and diseases.

## Conclusions

Based on the results of this study the effects of calving year and parity were significant. The effect of calving year was due to drought cases in some of the years under study and also due to a change in the ownership within the farm. This indicates the need for improved management to increase milk yield performance.

The wider variation of the traits over calving years, as compared to performance in the tropics, may indicate that pure breed animals can be kept if the level of management is improved. The mean performance result in the present study is useful to know the prospective genetic progress with the breed.

The average level of yield, however, is evidently much below the genetic potential of the animals. The sparse yield of the cows in this study is more clear if the calving intervals are considered. The annual milk yield, which is a function of both lactation yield and calving interval was less than the lactation yield. Thus factors affecting the reproductive traits should be considered and resolved for an economic dairy productivity.

It was shown that cows which calved for at least seven times had a significantly less milk yield than the earlier ones due to aging of cows. Thus, there is a need for planned culling of cows with low production to avoid competition of the limited concentrate feed with the productive animals. On the other hand, old cows with good yield in early lactations are genetically valuable and may be kept as long as they are fertile considering the herd performance.

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# Comparison of the Efficiency of Compensatory Growth of Borana and Arsi Cattle in Ethiopia

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## Abstract

*The efficiency of compensatory growth of 50 Bos indicus (25 Arsi & 25 Borana) bulls with age 28 – 36 months following different levels of feed restriction for 90 days was studied. The bulls were blocked by weight and randomly assigned to five dietary treatments: ad libitum feeding for the entire period (A), maintenance requirement for 90 days followed by ad libitum feeding for 104 days (B), 15% weight loss in 90 days followed by ad libitum feeding for 104 days (C), 20% weight loss in 90 days followed by ad libitum feeding for104 days (D) and 25% weight loss in 90 days followed by ad libitum feeding for 104 days (E). The feed restriction imposed for treatments C, D and E during the initial period resulted in weight losses of 16%, 20% & 23% respectively. Both daily dry matter intake (DMI) and metabolizable energy intake (MEI) during the restriction period declined with increasing levels of feed restriction. Consequently average daily weight gain (ADG) and feed conversion efficiency (FCE) declined significantly (P<0.001). Total dry matter intake (TDMI) and metabolizable energy intake (MJ/day) during compensatory feeding period were significantly different among treatments (P<0.05) and breeds (P<0.001). ADG during the compensatory feeding period was also significantly different among treatment (P<0.001) and breeds (P<0.01). Feed restricted groups (C, D and E) exhibited rapid daily weight gains than those managed under ad libitum (control) and maintenance feeding levels. Recovery index was not significantly (P>0.05) different among treatments, but significantly (P<0.05) different between breeds. Arsi bulls had higher (59%) recovery index than Borana bulls (30%). Even though the overall TDMI and MEI during compensatory feeding were increased by four folds than during the restriction period, animals under treatments B C, D and E could not attain complete compensation within 104 days of compensatory feeding. But Arsi bulls managed under maintenance feeding level recovered 96% of their weight loss after 104 days of compensatory feeding as compared to Borana bulls (25%) managed similarly. The overall carcass weight indicated declining trend with increasing levels of feed restriction. The results of this study indicated that responses to compensatory feeding are influenced by either severity of under nutrition, breed type of cattle or duration of compensatory feeding. The optimum time and cost-benefit relationships at which complete recovery can be attained after a period of feed restriction require further investigation.*

*Keywords*: Arsi bulls, Borana bulls, compensatory growth, feed restriction, weight, carcass, concentrate, tef straw, recovery index;

## Introduction

Livestock production in Ethiopia is dependent mainly on natural pasture and is largely influenced by its availability, which fluctuates throughout the year. Obradovic and Abraham (1975) reported severe weight loss in their observation on 90 Borana cattle at Adami Tulu government ranch over an 11 months period. This observation that covered all seasons and grazing conditions, clearly demonstrated that live weight was related to grazing conditions. Grazing at certain times of the year, especially in the period January to May, was so inadequate and resulted in heavy live weight loss averaged 74. 9 kg per animal (Obradovic and Abraham. 1975). A preliminary result of the livestock production system survey conducted in the mid Rift Valley of Ethiopia strongly supports this report. Almost all-respondent farmers ascertained that feed is scarce or almost unavailable during the dry period in the area, that extends from December to May. Farmers give priority to supplement whatever they have to offer to their oxen and milking cows.

In the drier areas where drought is frequent, weight loss of animals seems to be inevitable. But the question arises as to how far, at what age, and how often may cattle be permitted to fall behind their normal growth rate before permanent damage is done to their ability to respond to better feeding. These questions can best be answered from a deeper knowledge of the fundamentals of production that influence growth and determine its subsequent development.

Although the exact phenomenon of growth and subsequent development is controversial, one of these is compensatory growth. Compensatory growth is a phenomenon that enables a starved animal to catch -up with the live weight of its un-retarded counterpart upon re-alimentation often with an advantage of superior food conversion rates for the period of most rapid growth (Ledger, 1976). It is the ability of animals to exhibit a higher growth rate after feed restriction than the unrestricted animals of the same chronological age (Wilson and Osbourn 1960). Compensatory growth is complex because it is associated with factors such as higher feed intake (Meyer *et al.*, 1965; O'Donovan et al, 1972; Wright *et al.*, 1986; Baker *et al.*, 1992;), increase in gut fill, better efficiency of feed use (Carstens *et al.*, 1991); change in the composition of tissue gained (Meyer *et al.*, 1965; Fox *et al.*, 1972; Baker *et al.*; 1985; Wright and Russel, 1991) or alteration in endocrine status (Blum *et al.*, 1985).

The Borana cattle are assumed to be the best available local cattle, they have received attention as the best beef animal due to their relatively large framed conformation. It has long been regarded as a standard for comparison in beef production programs in East Africa. The Borana is an excellent beef animal with good potential for improvement. Borana meat is not fibrous and is often Marbled (Alberro and Solomon, 1982). Borana cattle grew at a rate of 790 g per day compared to 1090g/d for cross breeds in the feedlot (Wagner *et al.,* 1968). It has an average mature weight of 311- 478 kg, cold carcass weight 149-206 kg and dressing percentage 45.5-47.9% (Jepsen and Creek 1976).

Arsi cattle seem to have evolved from the large group of small *Zebu* in the highlands of Ethiopia especially in Arsi, Shoa and Bale. They are small, short and compact with an average height at withers of 110 cm (Alberro and Solomon, 1982). They have an average birth weight of 21 kg and average mature weight 257 kg. On average they gain 554-619 g per day under feedlot condition. They have an average carcass weight of 115-155 kg with an average dressing percentage of 50.3. They have marbled, tender, palatable and very attractive meat (Jepsen and Creek, 1976).

However, There is scarce information on their response to different levels of feed restriction and subsequent compensatory feeding. This experiment was conducted to determine the nutrient requirement of differential body weight losses at different levels of feed restriction, understand the variation in body weight changes and body condition and examine the efficiency of compensatory growth and carcass characteristics of Arsi and Borana bulls.

# Materials and Methods

## Study Area

The study was conducted in the year 2000 at the Adami Tulu Research Center in the middle Rift Valley of Ethiopia 170 km on the way to Awasa. The area has an altitude of 1650 m above sea level (asl) and an annual rainfall of 500-760 mm. The average maximum and minimum temperatures are $27^{o}$ C and $12.7^{o}$ C, respectively.

## Animals and management

A total of 50 bulls (25 Borana and 25 Arsi) with an estimated age of 28-36 months and average weight of 230 ± 0.31 kg purchased from Borana and Arsi areas were used for the study. The bulls were separately blocked by weight and randomly assigned to the following five treatments: *ad libitum* feeding for the entire period *(A),* maintenance requirement for 90 days followed by *ad libitum* feeding for 104 days (B), 15% weight loss in 90 days followed by *ad libitum* feeding for 104 days (C), 20% weight loss in 90 days followed by *ad libitum* feeding for104 days (D) and 25% weight loss in 90 days followed by *ad libitum* feeding for 104 days (E).

The experimental rations were formulated from *Tef* straw (*Eragrostis tef)*, maize grain, noug seed cake (*G. abyssinica*) and common salt in the proportion of 42%, 32%, 25% and 1% respectively during the restriction period and *Tef* straw, wheat bran, noug seed cakes and common salts in the proportion of 29%, 53%, 17 and 1% during the re-alimentation period respectively. Composition of feed ingredients is shown in Table 1. The animals were drenched and sprayed against internal and external parasites before the commencement of the experiment. The animals were individually penned, fed and watered twice daily. During the restriction period, animals in treatments C, D and E were subjected to get below their daily maintenance requirements based on the recommendation of the NRC (1996). so as to obtain the desired live weight loss. Actual data collection started after 21 days of adaptation. Data on feed intake and oarts were collected on daily basis, while body weight changes were measured weekly. The animals were deprived of feed and water for 16 hours before each weighing. The feed provision was also adjusted weekly based on the live weight obtained. Estimated total daily metabolizable energy intake (MJ/day), total dry matter intake and ME intake per their metabolic body weight were calculated based on the proportions of the feed ingredients. Average daily weight gain was estimated by regression. Recovery index was calculated using the formula proposed by Wilson and Osbourn (1960) as follows;

[(Iwc-Iwcomp) – (Fwc-Fwcomp)]/ (Iwc-Iwcomp);

where, *Iwc* and *Iwcomp* are the weights of the control and compensatory group at the beginning of the compensation period respectively and *Fwc* and *Fwcomp* are the weights of these groups after the period of compensation. The restriction period of 90 days was selected to simulate the time of food scarcity in the area. All animals were fed to appetite for 104 days of re-alimentation following the restriction period. Two animals per treatment were then slaughtered for carcass characteristics evaluation.

**Table 1:** Chemical composition of experimental feeds (g/kg DM).

| Ingredients | DM | OM | CP | ADF | NDF |
|---|---|---|---|---|---|
| *Tef* straw | 902 | 899 | 56 | 446 | 794 |
| noug cake | 898 | 858 | 296 | 264 | 402 |
| maize grain | 880 | 963 | 105 | 58 | 242 |
| wheat bran | 880 | 959 | 172 | 93 | 378 |

## Carcass Evaluation

Two bulls from each feeding level were deprived of feed and water for 24 hours prior to slaughter. Each animal was weighed before slaughter. The major blood vessels of the neck were severed or cut with a sharp knife and the hide was then removed. The entire digestive tract (esophagus, reticulo-rumen, omasum and abomasum, intestines) was removed with rumen contents and weighed. The rumen was emptied and the gastro-intestinal tract was weighed separately. Internal organs (lung, heart, liver, kidney and spleen) and internal fat deposits surrounding the stomach (omental), the intestine (mesenteric), fat lining the pelvic arch (channel fat) were also removed. Head, hide, feet including hooves, penis and bladder and tongue were also weighed. The carcass was then split two halves. Each half was weighed. The left side was then deboned and the bone, lean meat and trimmed fat separated manually and weighed.

### Statistical Analyses

Data was analyzed by the general Linear Model (GLM) procedure of SAS (SAS, 1987). Analysis of variance was used to compare the effect of different feeding levels on live weight change and carcass characteristics during restriction and re-alimentation. The model used was as follows:

$$Y_{ijk} = \mu + B_i + F_j + B_i * F_j + e_{ijk;}$$

where; $Y_{ij}$ = individual observation, $\mu$ = over all mean, $B_i$ = effect of breed, $F_j$ = effect of feed , $e_{ij}$ =estimated experimental error; $B_i$ * $F_{j=}$ interaction between main effects.

## Results

*Dry matter intake:* Least square means for total daily dry matter intake (TDM1), metabolizable energy intake (MEI), total dry matter and metabolizable energy intakes per metabolic body weight, average daily weight gain (ADG), feed conversion efficiency (FCE) and recovery index are presented in Table 2. Most variables measured were significantly different among treatments (P<0.001) and breeds (P<0.01) during the feed restriction period as expected. The feed restriction imposed for treatments C, D and E during the initial period (0-90 d) resulted in weight losses of 16%, 20% and 23% respectively. TDMI kg/head/day and MEI MJ/day during the compensatory feeding period were significantly different among treatments (P<0.05) and breeds (P<0.001). TDMI per unit metabolic weight ($W^{-0.75}$) was also significantly different among treatments (P<0.001) and breeds (P<0.01) during both periods. TDMI declined with increasing levels of feed restriction during the initial period and the trend was reversed during the compensatory feeding period. There was interaction between level of nutrition and breed on total dry matter intake and average daily gain during the restriction phase.

**Table 2**: Estimated daily total dry matter intake (TDMI, total metabolizable energy intake (TMEI), average daily weight gain (ADG) and feed conversion efficiency (FCE) of Arsi and Borana bulls after different levels of feed restriction and compensatory growth

| | TREATMENTS | | | | | SE | LS | BREED | | SE | LS | Trt* Breed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | | | Borana | Arsi | | | |
| **RESTRICTION** | | | | | | | | | | | | |
| N | 10 | 10 | 10 | 10 | 10 | ------ | ----- | 25 | 25 | ------ | ------ | ----- |
| TDMI (kg/day) | $5.98^{a}$ | $3.89^{b}$ | $1.78^{c}$ | $1.50^{d}$ | $1.25^{e}$ | 0.01 | *** | 3.37 | 2.38 | 0.01 | *** | *** |
| TMEI (MJ/day) | $51.4^{a}$ | $33.4^{b}$ | $15.1^{c}$ | $12.9^{d}$ | $10.7^{e}$ | 0.11 | *** | 28.94 | 20.46 | 0.07 | *** | *** |
| TDMI /$W^{0}.^{75}$ (g/g) | $115^{a}$ | $74^{b}$ | $34^{c}$ | $30^{d}$ | $24^{e}$ | 0.94 | *** | 57 | 54 | 0.59 | ** | *** |
| TMEI/$W^{0.75}$ (MJ/kg) | $0.99^{a}$ | $0.64^{b}$ | $0.30^{d}$ | $0.25^{d}$ | $0.21^{e}$ | 0.01 | *** | 0.49 | 0.47 | 0.005 | ** | NS |
| ADG (g) | $768^{a}$ | $74^{b}$ | $- 380^{c}$ | $- 471^{d}$ | $- 524^{d}$ | 23 | *** | - 102 | - 111 | 14.59 | NS | *** |
| FCE (kg gain/kg DMI) | $0.13^{a}$ | $0.02^{b}$ | $- 0.22^{c}$ | $- 0.32^{d}$ | - 0.42e | 0.01 | *** | - 0.15 | - 0.18 | 0.007 | ** | NS |
| **COMPENSATORY** | | | | | | | | | | | | |
| N | 10 | 10 | 10 | 10 | 9 | ------ | ----- | 25 | 24 | ----- | ------ | ------ |
| TDMI (kg) | $5.50^{a}$ | $5.24^{ab}$ | $4.86^{b}$ | $5.13^{ab}$ | $5.24^{a}$ | 0.13 | * | 5.80 | 4.58 | 0.08 | *** | NS |
| TMEI (MJ/day) | $51.20^{a}$ | $48.79^{ab}$ | $45.24^{b}$ | $47.8^{ab}$ | $48.79^{a}$ | 1.21 | * | 54.03 | 42.69 | 0.79 | *** | NS |
| TDMI /$W^{-0.75}$ (g/g) | $85^{d}$ | $96^{c}$ | $109^{b}$ | $120^{a}$ | $124^{a}$ | 2.69 | *** | 104 | 110 | 1.72 | ** | NS |
| TMEI /$W^{-0.75}$ (MJ/kg) | $0.79^{d}$ | $0.90^{c}$ | $1.02^{b}$ | $1.12^{a}$ | $1.15^{a}$ | 0.03 | *** | 0.96 | 1.03 | 0.02 | ** | NS |
| ADG (g) | $532^{c}$ | $722^{b}$ | $751^{ab}$ | $913^{a}$ | $911^{a}$ | 57 | *** | 836 | 697 | 37.6 | ** | NS |
| FCE (kg gain/kg DMI) | $0.10^{c}$ | $0.14^{b}$ | $0.15^{ab}$ | $0.18^{a}$ | $0.18^{a}$ | 0.01 | *** | 0.14 | 0.15 | 0.006 | NS | NS |
| Recovery index | ---- | $0.60^{a}$ | $0.32^{b}$ | $0.40^{ab}$ | $0.45^{ab}$ | 0.084 | * | 0.30 | 0.59 | 0.06 | ** | * |

Means followed by different super script letters within rows are significantly different ($p<0.05$)

**NB:** NS = P>0.05, *** = P<0.001, **= P<0.01, * = P<0.05; SEM= Standard error mean, LS= Level of significance

*Body weight change*: Average daily weight gain was significantly different among treatments (P<0.001) and breeds (P<0.01) during the compensatory feeding period. Feed conversion efficiency (FCE) was highly significant (P<0.001) among treatments but the difference was not significant (P>0.05) between breeds. Arsi bulls had faster weight loss during the restriction period and higher recovery index during compensatory feeding than Borana bulls. After 90 days of feed restriction, Arsi bulls managed under maintenance feeding level recovered 96% of their weight losses in 104 days of compensatory feeding compared to Borana bulls that recovered only 25% under similar treatments (Figure 1). There was no interaction either between level of nutrition or breed except the recovery index during the compensatory period.

*Carcass evaluation:* The effects of different levels of feed restriction and subsequent compensatory growth on carcass characteristics of Borana and Arsi bulls are presented in Table 3. The interaction between feeding levels and breeds of animals were consistently non-significant (P>0.05) for carcass parameters measured except for internal organs (IO) and external organs (EO) slaughter weight (SLWT) and empty body weight (EBWT) were significantly (P<0.001) different among treatments and breeds. Both declined with increasing levels of feed restriction. Consequently, total carcass yield was significantly (P<0.01) with increased levels of feed restriction. Total carcass was also significantly (P<0.001) different between breeds. Dressing percentage, fat, lean and bone yield were significantly different among treatments (P<0.01) and between breeds (P<0.05); and showed a declining trend with increasing levels of feed restriction. Although the Borana and Arsi bulls were at the same age at the commencement of the study, the preparation of lean and bone of the Borana was 27.7% and 43.2%, respectively, which was higher than the Arsi. The quantity of injesta was significantly (P<0.01) affected by breed but the difference among treatments was not significant (P>0.05). Internal organs were not significantly (P>0.05) affected by treatments but affected (P<0.01) by breeds. External organs had also similar trend with the live weight of animals at slaughter and total carcass. The overall carcass characteristics indicated declining trends with increasing levels of feed restriction.

**Table 3**: Effects of different levels of feed restriction on carcass characteristics of Arsi and Borana bulls.

| Carcass characteristics | Overall Mean | TREATMENTS | | | | | SE | LS | BREED | | SE | LS | Trt* Breed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | | | Borana | Arsi | | | |
| N | 20 | 4 | 4 | 4 | 4 | 4 | ----- | ----- | 10 | 10 | ------ | ------ | ----- |
| Slaughter weight (kg) | 251.8 | $301^{a}$ | $266^{b}$ | $231^{c}$ | $241b^{c}$ | $219^{c}$ | 9.02 | *** | $292^{a}$ | $211^{b}$ | 5.7 | *** | NS |
| Empty body weight (kg) | 225.0 | $276^{a}$ | $235^{b}$ | $204^{c}$ | $215^{bc}$ | $194^{c}$ | 9.05 | *** | $261^{a}$ | $189^{b}$ | 5.7 | *** | NS |
| Total carcass (kg) | 124.9 | $154^{a}$ | $142^{a}$ | $110^{b}$ | $116^{b}$ | $104^{b}$ | 5.64 | ** | $147^{a}$ | $103^{b}$ | 3.5 | *** | NS |
| Dressing % | 49.2 | $50.7^{ab}$ | $53.0^{a}$ | $47.2^{c}$ | $48.0^{bc}$ | $47.3^{c}$ | 0.92 | ** | $50.2^{a}$ | $48.3^{b}$ | 0.58 | * | NS |
| Lean (kg) | 82.7 | $108^{a}$ | $101^{ab}$ | $55^{c}$ | $80^{abc}$ | $70^{bc}$ | 10.3 | * | $92.8^{a}$ | $72.6^{b}$ | 6.48 | * | NS |
| Fat (kg) | 14.6 | $22^{a}$ | $15^{b}$ | $10^{b}$ | $15^{b}$ | $11^{b}$ | 1.89 | ** | $16.7^{a}$ | $12.6^{b}$ | 1.2 | * | NS |
| Bone (kg) | 26.2 | $30^{a}$ | $27^{ab}$ | $26^{ab}$ | $24^{b}$ | $24^{b}$ | 1.75 | * | $30.8^{a}$ | $21.5^{b}$ | 1.11 | * | NS |
| Injesta (kg) | 26.8 | 24 | 31 | 27 | 26 | 25 | 2.3 | NS | $30.8^{a}$ | $22.8^{b}$ | 1.46 | ** | NS |
| Internal Organs (kg) | 8.3 | 8.9 | 8.6 | 8.8 | 7.6 | 7.5 | 0.44 | NS | $9.0^{a}$ | $7.5^{b}$ | 0.27 | ** | * |
| External organs (kg) | 38.5 | $44.0^{a}$ | $40.4^{b}$ | $35.6^{c}$ | $37.3^{c}$ | $35.4^{c}$ | 0.98 | *** | $45.4^{a}$ | $31.7^{b}$ | 0.62 | * | |

Means followed by different super script letters within rows are significantly different ($p<0.05$)

**NB:** NS = $P>0.05$, *** = $P<0.001$, **= $P<0.01$, * = $P<0.05$; SEM= Standard error mean, LS= Level of significance

## Discussion

Though it was found difficult to manipulate feed restriction to obtain the predetermined weight losses of 15, 20 and 25% exactly, the results attained were very close to the expected live weight losses. Body weight of the bulls was affected by feed restriction. One Arsi bull from treatment E (severely restricted) group died at the beginning of the compensatory feeding period due to metabolic disturbances caused by sudden changes in the amount of concentrate offered. The significant ($P<0.05$) difference in TDMI during the compensatory feeding period was inconsistent with the reports of Lopez and Verde (1976).

Even though, the overall TDMI and MEI were increased by four folds during the compensatory feeding period, restricted animals under treatments B, C, D, and E could not attain complete compensation with in the given 104 days of compensatory feeding. This may be due to severe starvation and weight losses imposed during the restriction period. There is agreement with the reports of Wilson and Osbourn, (1960) in which response to compensatory growth may vary depending on the duration or intensity of under nutrition before re-alimentation. Growth response to additional crude protein may also be poor on low-density diets (Smith and Broster, 1977; Drouilard *et al* 1991). Inability of complete compensation in this work is similar to the reports of several authors (Abdala *et al* 1988, Carstens *et al* 1991; Chilliard *et al* 1998).

Both ADG and FCE were directly proportional to the levels of feed restriction. Better FCE of restricted animals during compensatory feeding was reflected in fast daily growth rates of the restricted animals during the compensatory feeding period (Ledger 1976; Carstens *et al* 1989). Though not significantly ($P>0.05$), Arsi bulls had better feed conversion efficiency (FCE) compared to Borana bulls. This result is consistent with the reports of Payne (1990) and Tesfaye (2000) in which slower maturing types of cattle respond better than fast maturing ones in terms of compensatory growth after a period of under nutrition. The different level of restricted planes of nutrition imposed on animals in this study are similar to the natural effect of nutrition on animals in the drier parts of the tropics that are caused by seasonal fluctuations in feed availability.

The overall carcass characteristics indicated declining trend with increasing levels of feed restriction. The lower values of carcass characteristics of Arsi bulls were justified by their lower body size relative to Borana bulls.

This result provides information on the performance of animals that pass through varying degrees of starvation under natural grazing prior to fattening. Except Arsi bulls on maintenance feeding treatment which attained 96% recovery index (Figure 1), there was no complete compensation by other treatment groups. These results suggest that response to compensatory feeding could be influenced by either severity of under nutrition, breed type or duration of compensatory feeding. Therefore, optimum time and cost-benefit relationships at which complete recovery can be attained after a period of feed restriction have to be investigated further.

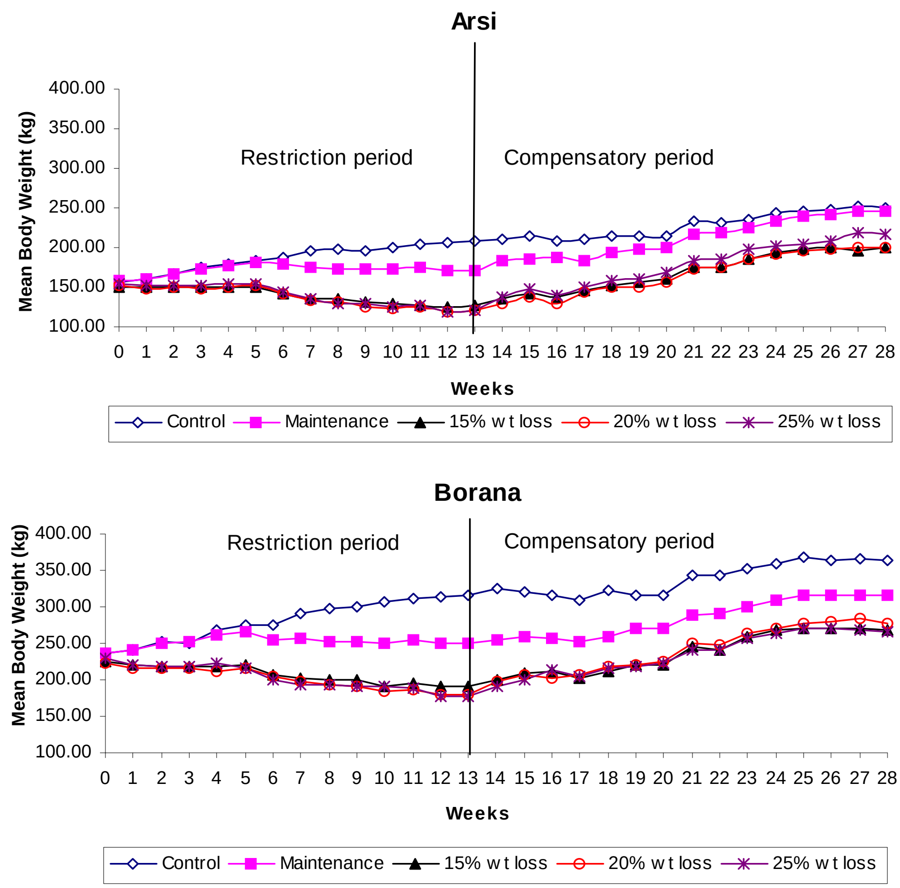

**Figure 1.** Weekly live weight changes of Borana and Arsi bulls fed *Tef* straw and industrial by-products during restriction and compensatory growth periods.

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# Lessons learned from implementation of the Ethiopian Fourth Livestock Development Project: Experiences and Results

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## Abstract

*Prior to the implementation of the Fourth Livestock Development Project (FLDP) the World Bank had assisted three livestock development projects in Ethiopia. The first had concentrated on dairy development and milk processing, the second on livestock marketing and domestic abattoirs and the third on rangeland management; all had enjoyed some limited success but their achievements had been dissipated by socio-economic and political circumstances. In the wake of the drought and famine situation of 1984, it was considered appropriate to focus livestock development attention on peasant areas, where livestock and crop production are intimately interdependent. In this respect the Fourth Livestock Development Project was prepared, appraised and implemented from1987-1994. The primary objectives of the FLDP were to increase livestock and agricultural production by improving animal health and nutrition. Project components comprised: animal health; animal nutrition; pilot – range land management; credit for livestock development; institutional development and a livestock export trade development. At project implementation the project has generally achieved it broad objectives, but the experiences and results differed between components. The paper provides the details of FLDP's implementation experiences, results and lesson learned.*

*Keywords*: Ethiopian Fourth Livestock Development Project, Lesson Learned, Implementation, Experiences, Results.

## Introduction

During the 1970s World Bank had assisted livestock projects, which were concentrated on improving dairying, marketing, abattoir facilities and on rangelands. All projects had enjoyed some limited success but their achievements had been dissipated by socio-economic and political circumstances. After the disastrous famine of 1984/85, it was considered appropriate to focus livestock development attention on peasants' areas. This approach was sound, because most of the livestock in the Ethiopia are found in the peasant areas, and improvement of livestock means improving agricultural

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production and the well being of peasants. The Fourth Livestock Development Project has made a complete turn round from the objectives of the previous World Bank Credit- assisted livestock projects, which concentrated on improving dairying, marketing, abattoir facilities and on rangelands. The FLDP has aptly focused on peasants in the highlands, where the bulk of the farmers and livestock are found, and aimed at tackling the main problems of livestock, i.e., diseases and under nourishment. Testing some innovation on Southern Rangelands Development Unit (SORDU) was also relevant at this program was a relatively successful undertaking within the range development activities under the Third Livestock Development Project. FLDP was implemented from 28 April 1987 to December 31, 1994 with the following objectives and components.

### Project Objectives and Components

The main objectives of the Fourth Livestock Development Project were to increase livestock and agricultural production by improving animal health and nutrition. Project components comprised: (i) animal health improvement which include strengthening of field services, national disease investigation, laboratories, epidemiological services and vaccine production; (ii) animal nutrition improvement through improved forage production, intensive small scale fattening; (iii) pilot range management and utilization by agro-pastoralists in southern rangelands; (iv) credit for peasant livestock development, including for fattening and veterinarian needs; (V) institutional support to the Ministry of Agriculture (MoA) through staff, technical assistance and provision of equipment; and (Vi) a livestock export trade development study.

## Materials and Methodology Used

### Location of the project area

Fourth Livestock Developmental Project (FLDP) was focused predominantly on high potential areas within four of the more productive zones established by Government of Ethiopia (GOE) for development purposes and containing six of Ethiopia's 14 administrative regions. While the national dimensions of the animal health component covered most of the country, the animal health field services concentrated in about 140 Woredas in the following zones: Central (Shewa), Western (Welega-Illubabor-Kefa), North Western (Gojjam), Eastern (Hararghe). The project animal nutrition activities implemented largely in Shewa, Hararghe and Gojjam regions. These zones are currently largely accommodated in Regions 3, 4 and 14. In addition FLDP provided support in the form of a pilot project to Southern Rangelands Development Unit at Borana. The project area average population density at that period was 15% above the national average as shown in Table 1. These data, however, distort the picture especially in Hararghe, where the great majority of the population was found in the comparatively small highland area.

**Table 1:** Fourth Livestock Development Project (FLDP Area and Population (1984)

| | Hararghe | Gojjam | WIK | Shewa | Total Project Zones | All Ethiopia |
|---|---|---|---|---|---|---|
| Area (sq. km) | 254,800 | 64,400 | 174,000 | 86,000 | 578,000 | 1,220,000 |
| % of Ethiopia | 21 | 5 | 14 | 7 | 47 | 100 |
| Population ('000) | 4,152 | 3,245 | 5,783 | 9,503[2] | 22,683 | 42,000[1] |
| % of Ethiopia | 10 | 9 | 14 | 23 | 54 | 100 |
| Population | | | | | | |
| Density per $Km^2$ | 16 | 50 | 33 | 111 | 39 | 34 |
| Total Awrajas | 8 | 7 | 17 | 11 | 53 | 110 |
| Total Woredas | 34 | 25 | 122 | 105 | 296 | 586 |
| Project Woredas | 10 | 20 | 50 | 60 | 140 | --- |

1/ Based on the results of the May 1984 population census.

2/ Includes Addis Ababa

Source: CSA (1991).

**Topography, Rainfall and Soil:** Although altitudes in these zones vary from 500m to 3,000m above sea level, the high potential cultivated areas are on rolling high plateaus of between 1,500 and 2,500m. Water logging prevents cultivation in the valley floors. Rainfall averages between 800 and 2,000 mm annually in the majority of peasant farmers' areas in Go jam, Wellega, Illubabor and Keffa (WIK), Sheba and Hararghe. Except for WIK, Western Gojjam and Western Shewa, rainfall is largely bimodal with short rains in February and long rains between May and September. Soils are comprised largely of free draining Nitosols (red), although heavy vertisols (black) are found in large areas of Shewa and in valley bottoms throughout all six-project regions. In the areas with adequate rainfall soil fertility and suitability for agriculture was good.

## Project Costs and Financing

The FLDP was prepared under the Third Livestock Project (Cr. 603-ET) in 1984/85, and appraised in March 1986. This led to the approval of an International Development Agency (IDA) credit 1782-Eth finance on 28 April 1987. Subsequently an International Fund for Agricultural Development (IFAD) loan was also approved to provide livestock production credit. Both the credit and loan, which were to be disbursed over five years, accounted for about 82% of the total costs. The IFAD loan closed at the end of December 1992, as scheduled, while the IDA credit was closed on December 31, 1994, following two years of extension. Detailed Project Costs and Financing is shown in Table 2a and 2b.

**Table 2a**: Project Costs

| | Item | Appraisal Estimate (US$'000) | | | Latest Estimate US$'000 |
|---|---|---|---|---|---|
| | | Local Costs | Foreign Costs | Total | Total |
| 1 | Animal Health | 10,200 | 13,200 | 23,400 | 27,107 |
| 2 | Animal Nutrition | 2,400 | 2,800 | 5,200 | 2,985 |
| 3 | S.O.R.D.U. | 2,100 | 2,600 | 4,700 | 1,776 |
| 4 | Agriculture Credit | 3,100 | 3,200 | 6,300 | 6,395 |
| 5 | M.O.A. Institution Building | 2,200 | 3,100 | 5,300 | 1,568 |
| 6 | Livestock Export Trade | 0 | | 500 | 409 |
| | **Sub-total** | **20,000** | **25,400** | **45,400** | |
| | Physical & Price Contingencies | 4,100 | 7,700 | 11,800 | |
| | Sub-total:[a/] | 24,100 | 33,100 | 57,200 | |
| | Minus taxes and duties | (5,300) | | | |
| | **Total Cost[b/]** | **18,800** | **33,100** | **51,900** | **40,240** |

[a/] Including taxes and duties.

[b/] Excluding taxes and duties.

**Table 2b**: Project Financing (US$'000)

| Source | Appraisal Estimate | Latest Estimate |
|---|---|---|
| Government of Ethiopia[a/] | 5,200 | 1,362 |
| IDA | 39,000 | 32,483 |
| IFAD | 7,700 | 6,395 |
| Total | 51,900 | 40,240 |

[a/] Excluding taxes and duties

Source: FLDP Implementation Completion Report, November 1995

## Project Organization and Management

The project provided for a management arrangement in which the Vice-Minister of the Ministry of Agriculture (MOA) Animal and Fisheries Resources Development Main Department (AFRDMD) became the ex-officio Project Manager (PM). He was to be assisted by two Deputy Project Managers (DPMs); the head of the Veterinary Service Department and that of the Animal Production Department, to be responsible, respectively, for the implementation of the animal health and animal nutrition components. A Project Coordination Unit (PCU) was to be established, and two coordinators were to be appointed to assist the DPMs. Subsequently, only one Project Coordinator (PC) was appointed. The rangelands pilot component was to be implemented by the Southern Rangelands Development Unit (SORDU), a semi autonomous unit operating under the overall responsibility of the Vice

Minister of AFRDMD. The Agricultural Input Supply Corporation (AISCO) was designated to import all veterinary drugs and vaccines, while the Agricultural and Industrial Development Bank (AIDB) was to implement the credit component. The Institute of Agricultural Research (IAR) and International Livestock Center for Africa (ILCA) were to become cooperating institutions in forage systems development. The latter was also to implement SORDU's research/survey activities.

## Experiences and Results of project implementation

### General

The approval by IDA of a Project Preparation Facility (PPF) had enabled the project to commence early. One year before the project was approved, the PCU was already established, some in-service training was conducted, procurement of some vehicles completed and preparation of work programs and terms of reference for Technical Assistance (TA) personnel drafted. This progress continued in the following years with regard to animal nutrition, but not with that of animal health as it was saddled with serious problems in veterinary drug and equipment procurement and delay in civil works. Policy and government changes, civil unrest and the reorganization of the administrative structures into autonomous regions have interfered with the project's pace of implementation, and the extension of the project by two years was helpful. A brief account of project implementation experiences and results are discussed below.

### Animal Health

#### General

Prior to the early 1970's Ethiopia's veterinary services had concentrated on the control, by the delivery of free vaccination services, of the major epidemic infectious diseases. Primary attention had been directed to the control of rinderpest and pleuropneumonia. As a participant country in the African wide campaign to eradicate rinderpest (JP 15), this disease had been greatly reduced and remained only as endemic foci in areas where it was difficult to provide vaccination services. At this time curative drug supplies had been available through private suppliers and agencies of the major international drug manufacturers. After 1974, private drug suppliers were discouraged and the sole legitimate source of curative drugs was the government services, although cross border unofficial market supplies continued. FLDP proposals were to build on the existing services in the project area by making staff more effective by improved training and supervision; where applicable by deploying them closer to farmers; by providing appropriate equipment and transport; by ensuring that a reliable supply of drugs and vaccines was available; by improved diagnostic support and ultimately by concentrating on the control of the economically most important diseases. Continuity of these services was to be secured by improved cost recovery of expenditure on animal health. To further extend services to the farmer, Government of Ethiopia (GOE) employed Animal Health Technicians (AHT) and Service Cooperative employed Farmers Animal Health Representatives (FAHR) were to be trained in basic diagnostics and the dispensing of a limited range of drugs (largely anthelmintic for the treatment of endoparasites), and would staff SC retail drug stores. It was anticipated that between 5-8 SCs would be formed in each of the 140 project Woredas; giving a target of some 900 SC drug outlets over the project period (Table 3). Hierarchical supervision and support for these field staff was to be provided by GOE employed Animal Health Assistants (AHA) at the Woreda level, Assistant Veterinary Officers at the Awraja level, and Zonal Veterinary Officers (ZVO) at Zonal HQ. The ZVO had direct responsibility to the Chief Veterinary Officer (CVO) for technical matters, although for administrative purposes to the Zonal Administration. At the national level, and with a view to equipping the veterinary services for future demands, components were included to create a Veterinary Epidemiology and Economics Unit (VEEU); a Central Disease Investigation Laboratory (CDIL); to improve vaccine production capability at the National Veterinary Institute (NVI); and to assist the Tsetse and Trypanosomosis Control Unit and the Veterinary Faculty. The experiences and results of implementation of these components are described below.

**Veterinary Drug Procurement and Distribution**: Procurement of veterinary drugs fell far behind schedule and was major area of concern. Initially, the main reason for the delay was impractical veterinary drug testing requirements, which proved cumbersome, time consuming and unacceptable to some manufactures. This was exacerbated by lengthy bureaucratic procedures between the project and Agricultural Input Supply Corporation (AISCO). Due to this, a regular and sustained supply of drugs could not be accomplished. The major supplies arrived in two consignments in 1991 and 1992, but by this time the effort expended in training Farmers' Animal Health Representatives (FAHA) and in encouraging Service Cooperatives (SC) to retail drugs had been dissipated. AISCO did not become involved in drug distribution and all consignments received were passed to MoA. In respect of cost recovery, AISCO added a margin of 15% to the costs incurred of deliveries CIF Addis Ababa plus customs and clearance. MoA then distributed drugs to their outlets at cost and without clear instruction on any mark up procedures contrary to proposals at appraisal no revolving fund was established and proceeds accurate to treasury. The result is that MoA remains on donor agencies and NGOs for supply of drug at that time.

**Veterinary Field Services:** The main thrust of the Veterinary Field Services was to improve the delivery of services to the primary animal producer by providing drugs, basic equipment, vaccinations, trained advisers and diagnostic support at the local level. To this end GoE staff were trained and equipped with means of transport before they were redeployed into about 140 Woredas that were accessible to road transport. The impact of the veterinary field service was constrained by lack of drugs and their service limited to providing some vaccination services.

**Veterinary Epidemiology and Economics Unit (VEEU):** The importance of the VEEU and its potential cannot be over-emphasized. At establishment technical assistance expeditiously installed computer hardware and developed appropriate software. At the same time an intensive post-graduate training program ensured that trained Ethiopian staff were available to take over. An initial herd health and productivity-monitoring program prepared by VEEU, established baseline cattle productivity data from 9 regions in the project area. Complementary data collection, collation and dissemination programs were established for veterinary field services, diagnostic laboratories and meat hygiene service. The VEEU has recently been relocated to the new Animal Health Research Center (AHRC) building.

**Central Disease Investigation Laboratory:** This laboratory, now designated as the Animal Health Research Center (AHRC), was targeted to be used as a national disease diagnostic center tabbing over the diagnostic activities, which had been accommodated in the National Veterinary Institute (NVI). Its construction was the only major building program envisaged at appraisal, and preparatory work proceeded reasonably well as the construction contract was awarded in August 1989. In spite of an early start of construction works, the laboratory and associated buildings were not fully commissioned during completion of the project. The reasons for the delays in the earlier years are in part attributable to the lack of construction material. It is unfortunate that the TA input has not coincided with the full commissioning of the laboratory. However, at the end of the project completion the TA made a valuable contribution in installing some of the scientific equipment, training and preparation of manuals.

**National Veterinary Institute:** Project support to the NVI primarily directed to the rehabilitation and improvement of its existing vaccine production capability. Although there have been some shortcomings with the delivery of the appropriate equipment and some damage to equipment in transit, the NVI possesses considerably enhanced vaccine production capability. This is claimed to have doubled its potential output, increased the range of vaccines, and enhanced its export potential.

The anticipated addition of a Foot and Mouth Disease (FMD) and rabies vaccine production units were excluded from the project because of the doubts on their economical viability and the small requirement of the vaccine at that time. Instead strong support was given to the rehabilitation and expansion of the NVI vaccine production in complex, enabling it to up-grade it manufacturing practice to international standards and to double its production potential.

**Tsetse and Trypanosomosis Control Unit:** Tsetse fly transmitted Trypanosomosis is a major cause of losses and reduced animal production in western Ethiopia. FLDP committed support for field buildings, equipment, vehicles and overseas training. With this support Tsetse and Trypanosomosis Control Unit has established a field laboratory at Bedelle in the west of Region 4 with three supporting houses. With TA (FAO) this Unit has made considerable progress. On a trial basis 1000 square km were cleared with the use of insecticide impregnated odour baited targets in the Upper Dedessa valley. Latterly "spot on" treatments of insecticide have proved successful and more sustainable method. The materials from targets are frequently stolen, whereas, the treatment of cattle is less demanding in labour and insecticide. After the initial reduction of fly population by monthly applications, two monthly intervals have been found to be effective. 130-200,000 sq km of western Ethiopia are considered to be infested with tsetse fly. FLDP input has provided improved insight and trained staff to approach this problem, which will be invaluable for the expansion of tsetse control activities in the future. Vehicles, operational funds, field equipment and further staff training are considered to be continuing constraints.

**Veterinary Faculty:** The Veterinary Faculty was assisted with postgraduate training to augment their undergraduate teaching program and six staff obtained further degrees. Student transport was also improved with the provision of a 30 seater bus.

**National Artificial Insemination Centre (NAIC):** Although not originally supported under FLDP, funds were provided for some rehabilitation of the NAIC. Birr 1.1 million were utilised for foreign purchase of essential equipment to improve facilities and services. This equipment included spare parts for the liquid nitrogen plant, Artificial Insemination (AI) and office equipment, motor cycles and spare parts. As a result an improved service may be anticipated for the increasing demand of the dairy industry.

# Animal Nutrition

## General

Animal nutrition improvement activities were concentrated in (a) areas of soil conservation programs; (b) areas with intensive extension systems; and (c) areas where fattening and milk production systems were established. Consistent with the political philosophy of the time activities would focus on the Peasant Associations (PAs), Services Cooperatives (SCs) and Producer Cooperatives (PCs). Over five years it was anticipated that 630 PAs in 200 SCs would become involved. Three components were conceived for Forage Seed and Seedling Production, Forage Systems Development and a Small Scale Fattening Scheme. Throughout the project implementation period the responsible officials of formerly the Animal Production Department (APD) and latterly the Animal Production and Forage Team of the MOA, and their colleagues in the Zones and Regions, have shown commendable adaptability in the face of changing political and economic circumstances. A summary of the implementation experiences and results are given below.

## Forage Seed Seedling Production

Initially seed for forage and tree legumes, and grasses was available in very limited quantity or completely unavailable. Originally it was thought that seed and seedling production would be from small MoA production units and nurseries, and within PAs and PCs on a contract basis. As the project developed seed production by individual farmers has contributed to seed supply. Ninety four tons of seed have been imported but local seed production has risen continuously to a production of 160 tons in the year 1994/95. In the earlier years of the project locally produced seed included tree legumes, V*etch, Cowpea, Dolichos lablab, Siratro, Stylosanthes hamata cv seca and Verano, Green and Silver leaf desmodium, Lucerne* and tropical grasses. Latterly the varieties of locally produced seed have decreased although quantities have continued to increase. This reflects both the demand for seeds of the proven varieties, tree legumes, V*etch, Cow pea and Stylosanthes hamata cv Verano*; and the acceptance of contract production by individual farmers of the more readily harvestable characteristics of these species. Seedling production has been similarly rewarding. During implementation over 10 million seedlings have been raised, largely of *Leuceana, Sesbania* and *Tree lucerne*, and distributed and production has been shifted from government and non-government nurseries to private backyard production. The further development of seed production of the valuable perennial herbaceous legume and grass seeds which are less readily produced by contract growers is a recognised problem. This may have to be solved by other seed production systems. Project staff were also aware that seed quality was a concern when produced by contract growers and as yet there was no quality control. Small scale contract seed production has great advantage in widespread demonstration, distribution of seed to neighbours and provision of cash income. The further advantage of soil nitrogen fixation are yet to be fully demonstrated. Seed stores have been built at Kaliti, near Addis Ababa, and at Bahir Dar.

**Forage Development**

As the project started, a Forage Systems Development Unit (FSDU) was established to spearhead forage development. IAR provided two post-graduate students for field work and ILCA assisted with experimental design, advice on the choice or planting material and seed samples. After accomplishing field trials in the earlier years of the project, the importance of the FSDU was considered to be reduced, overshadowed by the rapid forage development in the project area. Seven forage introductory strategies have been developed under the project: a) sowing stock exclusion degraded grazing areas as a conservation measure (9,000 ha); b) over-sowing with grass or legumes seeds by broadcasting on communal pasture and on road sides (11,000 ha); c) establishing forage strips and alley strips (18,600km); d) back-yard forage production by providing an array of multipurpose tree (10 million seedlings) and forage legumes and grasses; e) under-sowing, particularly with annual legumes in maize and sorghum fields (17,500 ha); f) sowing of pastures with mixed grass and forage legumes (1,176ha); and g) growing of forage under perennial trees (82 ha). The estimated area covered is conservative as the project has supplied seeds to many institutions concerned in forage development. These activities are likely to make a major contribution to Ethiopian agriculture if pursued further (Table 3).

These strategies warrant some more detailed discussion as they were designed to be implemented widely by peasant association within crop/livestock cropping systems and natural resources management areas (Alemayehu and Robertson, 1988).

(a) Stock exclusion zones for the restoration of pasture and for the prevention of further erosion were practical under the discipline of the PA. Forage trees *Leucaena and Sesbania,* legumes: *Siratro and Stylosanthes* varieties and grasses *Phalaris, Rhodes grass and Setaria* were introduced both by hand planting and by seed broadcasting. Total livestock exclusion was enforced and the forage harvested and used by cut and carry. Technically this system was successful, but the benefits perceived by the individual have not allowed further expansion of this strategy currently.

(b) Broadcasting on communal pasture and on road sides with Stylosanthes and other species has also been extremely successful in introducing improved forage plants depending on the altitude. Again the individual farmer, whilst appreciating the benefit, does not enjoy sole privilege of the resultant fodder and this system will have to be expanded through community adoption.

(c) Forage strips: *Vetch, Siratro, Lucerne, Desomodiums* and alley strips *Lucaena* and *Sesbania* have some of the limitations of broadcasting. Sole use is assured only provided the forage can be harvested and conserved before the cultivated area is available to other grazers. The impressive alley strips of *Sesbania* planted on bunds as a soil conservation measure are reported to have been depleted by severe cutting for firewood.

(d) Backyard forage production was undoubtedly the major success from the adoption point of view. Varieties are influenced by the altitude but include *Sesbania*, *Leucaena, Tree lucerne*, and a variety of herbaceous legumes and grass. The participating farmer accrues the full benefit of the fodder produced and has sole use for his animal feeding.

(e) Under sowing of maize and sorghum particularly was being widely adopted. *Vetch*, being and annual, is most appreciated for this strategy. It may be harvested almost in entirety when the crop stover is conserved for forage and unlike a perennials legume it does not interfere with cultivation in the following season.

(f) Establishment of mixed grass legume pastures *Rhodes grass, Setaria, Siratro* and *Desmodium* is likely to remain applicable only on enclosed land where the owner has exclusive use of the fodder produced. The demand for this technique will certainly expand as the dairy industry grows.

(g) The production of forage under perennial tree crops is a strategy that is widely practiced in other countries. The experience in Ethiopia is currently limited to citrus. It should have greater opportunity as the tree crop owners should enjoy sole access.

The growing of oats both for grain and for livestock fodder has been long practiced in Ethiopia. The demand for cut and carry forage for dairy production is leading to the expansion of this technique as a cash crop. It is now common to see green oats being harvested and transported to the peri-urban dairy areas and for fattening. FLDP project staff have recognized an opportunity here to improve crop value and have introduced vetch to be grown with the oats. No estimate is available of the area currently sown in this way, but widespread adoption is reported.

**Small Scale Fattening**

This activity was based on the success of limited trials in the Nazareth/Modjo area of feeding crop bi-products supplemented with molasses and urea. Liquid molasses is produced by nearby sugar factories at Shoa and Wonji. Transport of molasses requires a tanker and although two PCs possessed small storage tanks, replenishing their supplies proved problematic. To resolve this, consultancy advice advocated the production of molasses/urea blocks. It was essential that a SC adopt this activity as the capital requirement was beyond that of the individual. There was also strong competition for the other ingredients of urea and grain bi-products for dairy and poultry rations. At this juncture the reintroduction of a more liberal economic environment saw a rapid growth of large-scale commercial cattle finishing in the Nazareth/Modjo area. The large scale feedlot could readily handle liquid molasses and dominated the market for this and other crop bi-products (There were 26 large scale feedlots in the area-Region 4 estimation). The block manufacturing concept, although sound technically, encountered practical difficulties in the supply of molasses. The project had made no specific arrangements for the supply of material or for the manufacturing of the block. The credit for fattening was later diverted to the purchase of draught animals, because of lack of demand from fatteners. FLDP staff thus focused on a forage finishing strategy based on the success of backyard forage production. Such fattening is a feature of traditional small scale production in Hararghe, using crop residues. FLDP staff have introduced the system throughout the project are using backyard produced improved forage. Some 8,000 cattle and 460 sheep/goats are reported to have been finished/fattened during the project period (Table 3). These figures are certainly an under estimate as many farmers are finishing cattle with out the awareness of the project staff. The system was seasonally practiced to fit in with cereal production and to meet the local peak demands for finished livestock.

## Southern Rangelands Pilot Project

Under the Third Livestock Development Project (TLDP), the Southern Rangelands Development Unit (SORDU) had become the most firmly established rangeland management unit. Other areas of activity in the North Eastern Rangelands (NERDU) and in the east Jijiga Rangelands Development Unit (JERDU) had encountered civil unrest and sociological problems.

Although completely unallied to the main thrust of FLDP, it was justified to provide continuing support to SORDU as it remained the sole repository of pastoral and rangeland experience in Ethiopia. Modified activities in the pilot project intended to introduce as much pastoralist participation as possible to address the long term sustainability of the project. Components included: a) animal health and nutrition. b) range management; c) cooperative development; d) cattle marketing and fattening; and e) research/survey work in cooperation with ILCA.

Physical achievements during the project period have been slow and modest, reflecting the accepted difficulties of working with pastoralist communities. Veterinary services provide a prophylactic vaccination service and rinderpest and contagious bovine pleuropneumonia are under control; from the pastoralist community 12 veterinary scouts have been trained to staff the SC drug stores and 20 pastoralists as Primary Animal Health Auxiliaries. The traditional range management strategies of transhumance have come under pressure by increasing livestock and human populations. Bush encroachment and hillside erosion are recognized as major problems. SORDU range management interventions concentrate on the development of bush control strategies, the most promising of which appears to be controlled burning (14,000ha). This is a proscribed activity under current legislation and review of this law is probably justified. Range monitoring sites (17) and the post-graduate training of a Range Ecologist has equipped SORDU for long term range assessment. Some progress has been achieved with supplementary hay feeding for calves.

Cooperative development has led to the formation of five SCs, one of which, now operates the Sarite finishing ranch (Table 3). The proposed transfer of two other ranches has not been realized. The SCs also operate veterinary drug stores and shops for small domestic requirements. Water development includes improvement of traditional wells, maintenance of ponds and the construction of cisterns. Much of this is achieved on a participatory basis with initiatives being generated by extension contact with the Borana pastoralists. Coppock (1994) describes the vulnerability of the pastoral system of the Borana and hypotheses that the pressure created within this society by population growth are now creating the conditions when collaborative interventions will be increasingly adopted. Six post-graduate students from the SORDU staff obtained MSc degrees, presenting their theses on studies in the project area. There is little doubt that SORDU should be maintained and strengthened as it remains as one of a unit continuing pastoralist and range management extension and research activities. This experience will be invaluable as further attention is directed to the large areas of Ethiopia with similar environments and problems.

## Livestock Production Credit

Medium-term loans were made available through Agricultural and Industrial Development Bank (AIDB) to SCs for on lending to producer cooperatives and individual farmers. However, about 90% of the loan were extended for purchasing draft oxen, in pursuit of a reportedly successful IFAD program, which preceded the project. Birr 1.7 million was advanced for animal fattening. The envisaged cooperative production of molasses-urea blocks did not materialize and this has slowed demand for fattening. This is because of the gradual introduction of improved forage technology has re-stimulated demand for the fattening of animals. After the collapse of the previous regime and the loss of disintegration of the SCs, the repayment of loans had deteriorated markedly.

## Institutional Development

A significant institutional strengthening input was provided under the project in the form of staff training, technical assistance, vehicles and other equipment, and this has boosted MoA's capacity to implement the project. About 130 people were sent abroad for degree courses programmes and for short term specialized training. A large number in service and on the job training were also conducted over 4,000 junior technical staff and 5,000 contact farmers participated in FLDP's training program. Technical assistance provided under the project was effective, and has been instrumental in transferring technical know-how, particularly in forage development and veterinary Epidemiology. The wide project area was well covered under the project thanks to the supply of a large number of vehicles. The extension effort of FLDP's staff was remarkable. The project produced over 30,000 extension materials, manuals and visual aids, which have raised extension agents to communicate well with farmers (Table 3).

## Livestock Export Trade Development Study

The study was successfully completed in 1990. Its major recommendations were to export live animals to the Middle East; cattle to be directed to the Yemeni market and small ruminants to Saudi Arabia and to the Arab Emirates. The study considered the only entry to the western export markets would be for canned products e.g. large tinned corned beef and other canned products. The findings and recommendations of the study are considered still valid and of importance to the future development of livestock industry and has provided the country with useful export trade strategies.

**Table 3**: Key Indicators for Project Implementation

| | Unit | Estimated | Actual |
|---|---|---|---|
| **I. PERFORMANCE INDICATORS** | | | |
| **A. ANIMAL HEALTH** | | | |
| Veterinary Field Services | | | |
| SC Animal Health Centres | No. | 90 | 211 |
| Training FAHRs | No. | 900 | 135 |
| Vaccinations 1992-95 | No. | not specified | 696,528 |
| Trypanosomosis treatments | No. | " | 42,605 |
| Internal parasites treatments | No. | " | 164,645 |
| Training farmers in animal health | No. | " | 4235 |
| VEEU | | | |
| Establish VEEU | Institution | 1 | 1 |
| Train epidemiologists | No. | 3 | 5 |
| Animal Health National Elements | | | |
| AHRC Laboratory construction | complex | 1 | 1 |
| Rabies vaccine plant | No. | 1 | 0 |
| FMD vaccine plant | No. | 1 | 0 |
| Staff housing at Bedelle | No. | 6 | 3 |
| Artificial Insemination Centre | Set of equipment | Not foreseen at appraisal | Delivered |
| **B. ANIMAL NUTRITION PROGRAM** | | | |
| **Forage Seed Production** | | | |
| Seed stores | No. | 6 | 2 |
| Forage seed production | tons | 63 | 160 (1994/95) |
| Multi-purpose tree seedlings | No. | not specified | 10 million |
| Contact seed producers | No. | not specified | 2,500 |
| **Forage Systems Development** | | | |
| Forage strips | km | " | 18,629 |
| Backyard forage | No. of trees | " | 89,999 |
| | No. of sites | | 1,050 |
| Under-sowing | ha | " | 17,500 |
| Stock exclusion | ha | " | 680 |
| Over-sowing of grazing land | ha | " | 11,097 |
| Arial Seedling Operation | | | |
| - medium seeding rate | ha | ha | 5,000 |
| - very low seedling rate | ha | ha | 4,000 |
| Roadside sowing | ha | | 1,850 |
| Participating SCs | No. | | 332 |

**Table 3**: Key Indicators for Project Implementation (Continued)

| | Unit | Estimated | Actual |
|---|---|---|---|
| **Small-Scale Fattening** | | | |
| By-product fattening scheme | No. of animals | 12,500 | 3,890 |
| Forage fattening scheme (cattle) | No. of animals | not foreseen at appraisal | 8,000 |
| Forage fattening scheme (sheep/goats) | No. of animals | not foreseen at appraisal | 460 |
| **Extension Material Preparation** | | | |
| Training | | | |
| - High level (BS & MSc) | No. | 50 | 130 |
| - Junior level (Diploma) | No. | 2,000 | 4,000 |
| - Contact farmer | No. | 2,500 | 5,000 |
| Forage Development Manual | copies | not specified | 2,000 |
| Fattening Manual | " | " | 983 |
| Forage Dev. Extension Manual | " | " | 22,000 |
| Forage Fattening Extension Manual | " | " | 5,300 |
| **C. SORDU** | | | |
| Establishment of Service Cooperatives | No. | 27 | 5 |
| Transfer of ranches to SCs | No. | 3 | 1 |
| Training of Veterinary Scouts | No. | not specified | 12 |
| Training of Pastoralist PAHC | No. | " | 20 |
| Range monitoring | sites | " | 17 |
| Manual bush clearing demonstration | ha | " | 75 |
| Bush control by burning | ha | " | 14,000 |
| **II. Civil Works Buildings (Animal Health)** | | | |
| **Purchasing, Processing & Distribution Vet. Drugs** | | | |
| Storage/Repackaging Plant | 800 $m^2$ | 1 | 0 |
| **Central Investigation Laboratory** | | | |
| Main Lab./Office | 1250 $m^2$ | 1 | 1 |
| Garage | 100 $m^2$ | 1 | 1 |
| Farm Animal Exp. | 100 $m^2$ | 1 | 1 |
| Animal Laboratory | 100 $m^2$ | 1 | 1 |
| Fencing | metres | 2000 | 1 |
| **Housing** | | | |
| Type A | 105 $m^2$ | 11 | 11 |
| Type B | 85 $m^2$ | 7 | 7 |
| Type C | 55$m^2$ | 7 | 7 |
| Hay Shed | 180$m^2$ | 1 | 1 |
| Small workshop | 10$m^2$ | 1 | 1 |
| Rabies Vaccine Laboratory | No. | 1 | 0 |

**Table 3**: Key Indicators for Project Implementation (Continued)

| | Unit | Estimated | Actual |
|---|---|---|---|
| **National Veterinary Institute** | Unit | | |
| FMD Vaccine Production | No. | 1 | 0 |
| Large Animal Housing | No. | 0 | 1 |
| **Tsetse & Trypanosomosis Control Unit** | | | |
| Bedelle Laboratory | 200m$^2$ | 1 | 1 |
| **CIVIL WORKS BUILDINGS (Forage Production)** | | | |
| **Forage System Development Unit** | | | |
| Field Laboratory | 70m$^2$ | 1 | 0 |
| **Forage Seed Production Unit** | | | |
| Seed Storage Office | 105 m$^2$ | 6 | 2 |
| Seed Drying | 225m$^2$ | 6 | 0 |
| Staff Houses | 50m$^2$ | 6 | Not Available |
| Covered Dry Racks | 20m$^2$ | 6 | Not Available |
| **SORDU** | | | |
| Laboratory | 100m$^2$ | 1 | 1 |
| Conference Hall | 100m$^2$ | 0 | 1 |
| **III. VEHICLES** | | | |
| Sedan (2 WD) | No. | 5 | 4 |
| Station Wagon (4 WD) | No. | 27 | 27 |
| Customised Pickup (4WD) | No. | 5 | 0 |
| Pickup standard (4 WD) | No. | 21 | 0 |
| Pickup Standard (2WD) | No. | 14 | 59 |
| Compact (4 WD) | No. | 27 | 0 |
| Vehicles (unspecified-drug procurement etc) | No. | 5 | 0 |
| Truck 3 ton | No. | 1 | 2 |
| Truck 7 ton 4 WD | No. | 4 | 6 |
| Double Cabin Pick-up | No. | 9 | 82 |
| Bus 30 seater | No. | 3 | 3 |
| Motor cycle | No. | 173 | 214 |
| Bicycle | No. | 443 | Not Available |
| Hard Top Pick-up | No. | 0 | 2 |

Source: FLDP Implementation Completion Report, November 1995

## Bank Performance

The World Bank mounted 10 supervision missions. The first 4, including one before project effectiveness, consisted of one person, specialist in livestock, while the remaining 6 were multi-disciplinary with an optimum mix of relevant specialization. The World Bank Supervision Missions were supportive and keen to assist the project understanding the prevailing difficulties in the country. Often they were instrumental in resolving financial and other difficulties by discussing with Government of Ethiopia higher authorities, and by recommending World Bank's management to raise the disbursement percentage and to extend the project. Overall they performed satisfactorily (Box 1).

## Borrower Performance

Considering the difficulties political and social situation that prevailed during the greater past of the implementation period, the Government of Ethiopia (GOE) performance can be generally considered satisfactory and generally in compliance with project covenants (Box 1). In spite of GoE's general skepticism as to the provision of large overseas training, vehicles and equipment procurement and technical assistance, it has been liberal with FLDP, indicating its commitment to the project, However the lack of authority given to project management and their subjection to the line department of the Ministry of Agriculture has limited project achievements in one way or another. The main difficulties in procurement, civil works and the delayed release funds are largely attributed to these factors.

## Conclusion

The overall outcome of the project is considered satisfactory (Box 1). The result would have been highly satisfactory if it was not for the disappointing achievements in strengthening the field of veterinary services and sustainable drug distribution. Fortunately, however, other animal health activities have been successful as the project has provided an improved national veterinary diagnostic and investigatory service, a national veterinary Epidemiology capability and enhanced vaccine production. The project has also succeeded in introducing a forage and forage seed production technology, hence mitigating the undernourishment of working and milking animals. This has become the basis for developing modern dairy farms using improved cows and/or conditioning/fattening animals for the local markets. The forage and forage seed production technologies have completely changed the outlook of farmers, who are appreciating the advantages of farming using few improved and well fed animals and the usefulness of growing forage crops by rotating or in association with food crops. The demonstrated forage and forage seed production technologies, together with the advent of economic liberalization and peace, have opened the eyes of traditional livestock farmers. Environmentally, the project has improved large areas of degraded land, using forages, and successfully undertaken shrub control trials in the southern rangelands. Furthermore, FLDP has demonstrated the validity of organizing pastoralists into cooperatives in order to help themselves and for the project to provide services. It has also contributed significantly to the country's economy by improving milk and meat production and in enhancing control of rinderpest.

**BOX 1- Summary of Performance**

| A. **Bank Performance** | **Highly Satisfactory** | **Satisfactory** | **Deficient** |
|---|---|---|---|
| Identification | | ✓ | |
| Preparation assistance | | ✓ | |
| Appraisal | | | ✓ |
| Supervision | | ✓ | |
| B. **Borrower Performance** | | | |
| Preparation | | ✓ | |
| Implementation | | ✓ | |
| Covenant compliance | | ✓ | |
| C. **Overall Performance** | | ✓ | |

Source: FLDP Implementation Completion Report, November 1995

## Suggested Future Operations

Most of the previous project activities are now under the responsibility of region 3, 4 and 14 and are being managed by them. All regions profess commitment to the advancement of the project findings in forage production. The Regions are expected to experience continuing shortage of operating funds, for which there will be many conflicting demands. This will necessitate affording priority to cost recovery of services and/or assigning some activities to the private sector. It is in the plan of the regions to introduce cost recovery systems in forage seeds and to gradually transfer the activities of seed production and distribution. Quality control and regulatory functions would remain with the public sector.

The current policy of encouraging the private sector to participate in the veterinary input distribution system, subject to regulation, will ensure a more sustainable supply. Government does not attempt to regulate price mechanisms or to compete unfairly in marketing. Animal health policy would be directed to providing a regulatory and facilitating role. There remain areas of responsibility, which the private sector cannot assume, include the control of epidemic disease. The provision of free vaccination for the endemic disease is expected to be progressively reduced.

In the long term, as recommended by bank mission and Ethiopian veterinarian professionals, AHRC may even be involved in providing hygiene control services to the meat and meat processing industries and in diagnostic services to private entrepreneurs against payment.

## Highlights of Lessons Learned from the project Implementation

Major lessons to be drawn from FLDP's implementation experiences and results are the following:

- Transfer of technology to local professionals and easy replicability of programmes, such as the forage and forage seed production and development and disease investigation components, found to be important ingredients for sustainability. Conversely, total dependence on public imports for inputs will prove unsustainable as demonstrated by the limited availability of veterinary drugs.
- A well-conceived and focused training program and production of extension manual and visual aids input contributed to a lasting impact on the subject programmes as demonstrated in the cases of forage development, seed production and integrated VEEU/AHRC components.
- Continuity of senior staff in Programme formulation and implementation was highly associated with successful results as shown by the animal nutrition component.
- Assigning project management responsibility to already fully engaged senior staff interfered their coordination role.
- A high level decision making body for policy guidance and for resolution of project problems was a must, particularly where the authority of project staff was limited.
- Considerable time and resources can be saved if dubious components, such as the FMD and rabies vaccine production, are excluded from the outset. Similarly, selection of implementing agencies with limited experience and technical capabilities should be resisted in order to avoid poor services such as that of AISCO.

- Project design should make specific provision for all the activities that were necessary for the successful implementation of the project.

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# Genetic and Environmental Trends in Growth Performance of a Flock of Horro Sheep

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## Abstract

*Phenotypic, genetic and environmental trends in birth weight (BW), weaning weight (WW), six-month weight (6MW) and yearling weight (YW) were studied on data collected from a largely closed flock of Horro sheep kept at Bako Research Center during the period 1978-1997. Average Information Restricted Maximum Likelihood (AIREML) program was used to solve linear mixed models for breeding value prediction. Regression of annual mean genetic, environmental, and phenotypic values on year was used to estimate trends. Genetic trends over the years showed increase with a slight decline starting in 1994. Mean predicted breeding values for animals born in the different years ranged between –0.037 to 0.151, -0.188 to 0.944, -0.133 to 1.121 and 0.401 to 1.906 kg for BW, WW, 6MW and YW, respectively. Individual breeding values for the total period ranged between –0.495 to 0.83, -2.685 to 3.07, -3.10 to 4.46, and –3.22 to 6.82, respectively, for BW, WW, 6MW, and YW. Regression of mean breeding value on year was 0.006±0.0007, 0.044±0.0050, 0.056±0.067 and 0.094±0.0106 kg for BW, WW, 6MW and YW, respectively. This indicates that genetic trends have been improving and there was about 6, 44, 56 and 94 g annual genetic gain in BW, WW, 6MW, and YW which represented an annual improvement of 0.2%, 0.2%, 0.2%, and 0.3%, respectively, of the base year average. Environmental and phenotypic trends showed a large decline and fluctuating patterns. The small improvement in genetic level could not compensate for larger decreases in environmental levels suggesting that genetic improvement work should be supported by improved environment.*

*Keywords*: Genetic trends, environmental trends, phenotypic trends, growth performance, Horro sheep.

## Introduction

Under the management condition existing in the smallholder production system selection within the indigenous breed seems better means of improvement than importing exotic germ plasm. This makes use of the environmental adaptation of the indigenous breed and could bring improvement in productivity in a sustainable way. Trends in genetic improvement help to decide how effective genetic selection could be.

Work on characterisation of Horro sheep breed has been underway since 1978 at Bako Research Center. Recent work on analysis of the data has shown that there was a declining trend, though not systematic, in growth performance (Solomon and Gemeda, 2000). In the years the work was done there was no meticulously followed selection. However, breeding rams were selected on visual appraisal and inferior ram and ewe lambs were also culled before yearling age. Inferior rams and those with defects (small testis, over and undershot jaws, hocked joint), and physically poor looking rams were culled. Thus, though superior progenies are not expected from such mating it is also unlikely that they will be genetically inferior with respect to the base population.

To determine the effectiveness of genetic selection, genetic trends in the population under consideration can be monitored (Van Wyk *et al*., 1993). According to Wilson and Willham (1986), trend lines may be used to compare alternative methods of selection or management and to reinforce the selection and management established. So far, no genetic, phenotypic and environmental trends have been estimated for growth traits in Horro sheep maintained at Bako Research Center. This study was, therefore, done with the objective of partitioning the phenotypic value into its components: environmental and genetic values and look into trends during the period the characterisation work was carried out. This may give some indication whether genetic improvement via selection would be appropriate in the improvement of growth performance of Horro sheep.

## Material and Methods

### Animals and Management

Data used in this study was collected from a flock of Horro sheep during the period 1978 to 1997. The flock was established with 100 ewe lambs (all milk teeth) purchased from different local markets around Shambo, Western Ethiopia, in 1977. The flock remained closed until 1994 when some ram and ewe replacements were purchased and introduced. The sheep management system was semi-intensive in that sheep grazed out-doors during the day (08:00 a.m.-08:00 p.m.) and were housed during the night in pens with bamboo walls and corrugated metal sheet roofs. The flock grazed natural pasture throughout the year with the exception of the mating period when they were kept indoors and fed on concentrates and hay. Lambs were weaned at about 90 days and thereafter they were kept on grazing. When pasture availability was low, 150g/lamb/day of the standard supplement was fed. The supplement was formulated from 49% maize flour or wheat bran, 49% Noug cake (*Guizotia abyssinica*), 1% salt and 1% blood and bone meal.

The ewe and ram flocks were herded and housed separately except during mating periods. Controlled single-sire mating was practiced with mating period of 42 days. With the exception of part of the flock mated thrice during the period 1982 to 1985 for study on frequency of lambing and another subset mated at nine months intervals between 1989 and 1991 for selection on yearling weight, mating generally occurred from mid November to early January for lambing in April and May. During mating, about 20 (occasionally 10-25) ewes were assigned to each ram based on a random procedure after they were stratified by age. With the exception of 1989 to 1990, there was no genetic selection. In the years 1989 and 1990 two groups of rams were used: one group comprised rams selected for yearling weight (to be mated with selection group ewes) while the other comprised rams of average yearling weight (to be mated with a control group of ewes). Due to the small number of rams available for selection the selection differential was low (2 to 3 kg). At times, when there were excess number of ewe and ram lambs than required for replacement some culling was applied based on visual appraisal between the age of six month and one year. Additionally rams to be used in mating and as stand-by (to replace those with poor libido in the course of mating) were also chosen before mating based on visual appraisal.

## Data Collection

A total of 4031 lambing records generated from 184 sires and 904 ewes during the period 1978 to 1997 were used in this study. Weight of lambs was taken once every four weeks for the total flock and fortnightly for lambs up to weaning age. All body weight measurements were taken in the morning after fasting the animals overnight (13-15 hr.). Weaning weights were recorded at an average age of 92.5±0.13 days with a range of 70 to 110 days while six month weights were taken at an average age of 184.4±0.26 days with a range of 150 to 210 days. For yearling weight the average age was 366.3± 0.31 days with a range of 322 and 408 days.

## Statistical Analysis

Estimated breeding value (EBV) of all animals was generated from a mixed model analysis by the AIREML program (Gilmour et al, 1995). Animal model where the additive effect of the animal was considered was used. Least square means for annual breeding values was calculated by the GLM procedure of the Statistical Analysis Systems (SAS, 1994) and deviations from the mean of the base year were considered as estimates of annual genetic value. Deviation from least squares means of growth performance from the base year were assumed to be estimates of annual phenotypic values. Annual environmental values were calculated as the difference between phenotypic and genetic values. Phenotypic, genetic and environmental trends were evaluated by regression of annual values (deviations from the base year) on year.

# Results

## Phenotypic, Genetic and Environmental trends

The phenotypic, genetic (breeding value), and environmental trends for the different traits are presented in Figures 1, 2, 3, and 4. Average breeding values over the years increased with some fluctuations at times. Mean breeding value estimates for animals in the different years ranged from -0.037 to 0.151, -0.188 to 0.944, -0.133 to 1.121 and 0.401 to 1.906 kg for BW, WW, 6MW and YW, respectively (Table 1). Individual breeding values for the total period ranged from –0.50 to 0.83, -2.69 to 3.07, -3.10 to 4.46, and –3.22 to 6.82, respectively, for BW, WW, 6MW, and YW. The regression coefficients of breeding value for BW, WW, 6MW and YW on year of birth were 0.006±0.0007, 0.044±0.005, 0.056±0.0067 and 0.094±0.0106, respectively. All coefficients were highly significantly different from zero ($P<0.001$) (Table 2). The annual genetic improvement in BW, WW, 6MW and YW was 0.2%, 0.2%, 0.2%, and 0.3% of the base year least square mean of 3.17, 19.1, 25.4 and 37.4 kg, respectively. There appears a slight decline in all traits after 1993. The regression value of environmental effect on year of birth was -0.050±0.0065, -0.674±0.0667, -0.898±0.1013, and -1.223±0.1451 for BW, WW, 6MW and YW. These values were very large in magnitude when compared to genetic value and couldn't be counteracted by the improvement in genetic value. Thus the phenotypic trend in all traits was shown to follow the pattern of the environmental trend.

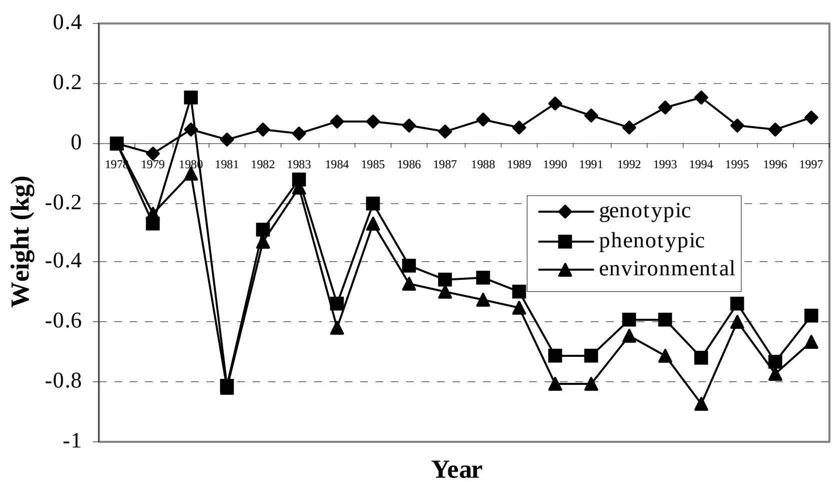


**Figure 1**. Phenotypic, Genetic and Envrionmental trends in BW of Horro sheep between 1978 and 1997 at Bako Research Center.

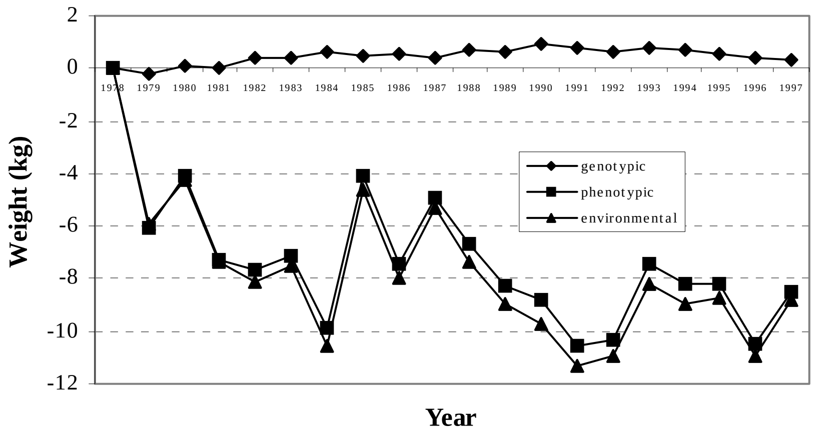


**Figure 2**. Phenotypic, Genetic and Environmental trends in WW of Horro sheep between 1978 and 1997 at Bako Research Center.

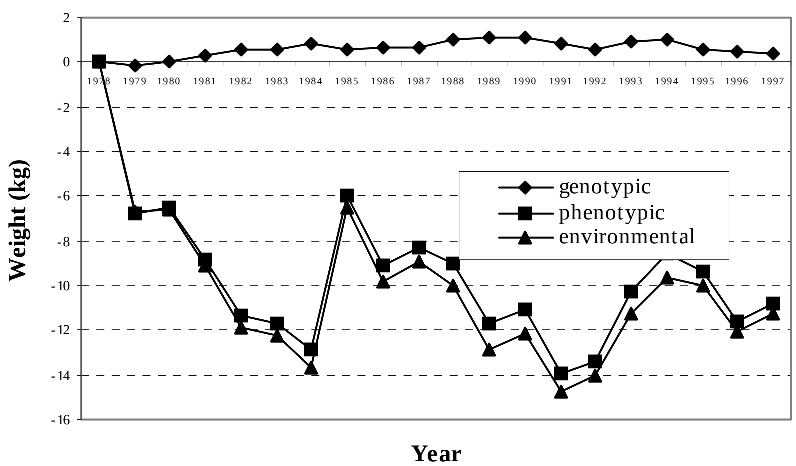


**Figure 3**. Phenotypic, Genetic and Environmental trends in 6MW of Horro sheep between 1978 and 1997 at Bako Research Center.

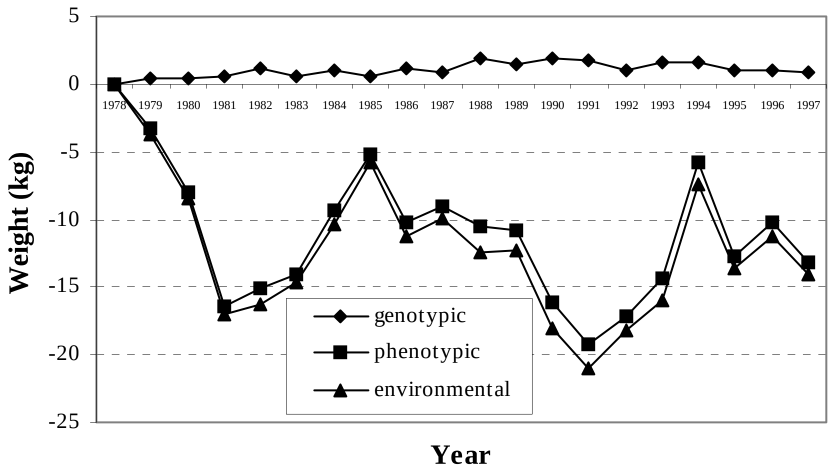


**Figure 4**. Phenotypic, Genetic and Environmental trends in YW of Horro sheep between 1978 and 1997 at Bako Research Center.

**Table 1.** Range of breeding values of animals born in the different years.

| Year of birth | No. of Animals | Range of breeding values | | | |
|---|---|---|---|---|---|
| | | BW | WW | 6MW | YW |
| 1978 | 96 | -0.330 to 0.294 | -1.783 to 1.568 | -2.112 to 3.135 | -2.848 to 1.773 |
| 1979 | 184 | -0.411 to 0.470 | -2.647 to 1.541 | -3.101 to 2.455 | -3.224 to 2.948 |
| 1980 | 218 | -0.353 to 0.556 | -2.685 to 1.853 | -2.667 to 4.458 | -2.761 to 2.784 |
| 1981 | 286 | -0.357 to 0.343 | -2.190 to 1.783 | -2.555 to 2.631 | -2.214 to 3.501 |
| 1982 | 267 | -0.308 to 0.678 | -1.301 to 1.889 | -1.547 to 3.097 | -1.357 to 3.196 |
| 1983 | 207 | -0.342 to 0.398 | -1.066 to 2.409 | -1.472 to 3.130 | -2.265 to 4.837 |
| 1984 | 162 | -0.493 to 0.830 | -1.315 to 2.347 | -0.951 to 2.841 | -1.618 to 3.322 |
| 1985 | 116 | -0.291 to 0.333 | -1.464 to 2.096 | -1.856 to 2.584 | -1.229 to 3.539 |
| 1986 | 203 | -0.320 to 0.518 | -1.569 to 2.658 | -1.571 to 2.472 | -1.561 to 4.683 |
| 1987 | 170 | -0.417 to 0.421 | -1.682 to 2.131 | -1.885 to 2.915 | -2.002 to 6.816 |
| 1988 | 253 | -0.393 to 0.569 | -1.972 to 2.306 | -1.587 to 2.892 | -1.857 to 5.638 |
| 1989 | 273 | -0.380 to 0.522 | -1.364 to 2.168 | -0.860 to 2.985 | -1.471 to 6.000 |
| 1990 | 367 | -0.378 to 0.697 | -1.659 to 3.072 | -0.814 to 3.205 | -1.672 to 4.957 |
| 1991 | 122 | -0.271 to 0.601 | -0.901 to 1.858 | -0.806 to 2.445 | -0.669 to 3.181 |
| 1992 | 147 | -0.355 to 0.518 | -1.381 to 1.931 | -1.184 to 2.185 | -1.251 to 3.143 |
| 1993 | 118 | -0.363 to 0.682 | -0.776 to 2.572 | -1.640 to 4.419 | -1.538 to 4.933 |
| 1994 | 98 | -0.294 to 0.529 | -1.093 to 1.991 | -0.953 to 3.427 | -2.682 to 4.191 |
| 1995 | 103 | -0.386 to 0.310 | -1.374 to 2.994 | -1.743 to 3.791 | -1.936 to 3.489 |
| 1996 | 134 | -0.495 to 0.438 | -1.345 to 2.277 | -2.275 to 2.372 | -2.335 to 4.663 |
| 1997 | 173 | -0.493 to 0.481 | -1.471 to 1.813 | -1.955 to 2.210 | -2.884 to 3.550 |

**Table 2.** Regression coefficients of phenotypic, genetic, and environmental trends in birth, weaning, six-month and 12-month weight (1978-1997).

| Component | Trait | | | |
|---|---|---|---|---|
| | BW | WW | 6MW | YW |
| Phenotypic [a)] | -0.044±0.0060 | -0.630±0.0643 | -0.842±0.0971 | -1.128±0.1380 |
| Genetic [a)] | 0.006±0.0007 | 0.044±0.0050 | 0.056±0.0067 | 0.094±0.0106 |
| Environmental [a)] | -0.050±0.0065 | -0.674±0.0667 | -0.898±0.1013 | -1.223±0.1451 |

[a)] All values are significantly different from zero.

## Discussion

It was shown that genetic trends have been improving and there was about 6, 44, 56, and 94 g genetic gain in BW, WW, 6MW and YW per year. In the period under the study some of the low growing ewe and ram lambs were culled mostly between the age of 6 and 12 month. Additionally, selection of breeding rams were based on visual appraisal for thrift and size. Thus, any genetic gain is most likely to be the result of correlated changes caused from the culling activities and visual appraisal of rams. Van Wyk et al. (1993) found similar genetic gain in Dormer sheep in the absence of direct selection for a number of traits. During the periods between 1989 and 1990 some selection was practised on unadjusted YW for both ram and ewe lambs. This fact could be one of the reasons for the relatively higher genetic gain in YW. In the current study, most of the culling was done between the age of six month and one year. Thus it was only YW that was subjected to any kind of selection. Due to the presence of higher genetic correlation between YW and 6MW (0.87) and WW (0.84) (Solomon et al, 2001) some genetic gain has been observed in both traits. As a result of low genetic correlation between YW and BW (0.31) the genetic gain was relatively lower in BW than in WW, 6MW and YW.

From an open nucleus breeding program for Djallonké sheep in Cote d'Ivorie Yapi-Gnaoré et al. (1996) reported an increase of 28, 11, and 14g per year for weight at 80, 180 and 365 days, respectively. Least squares means for weight at 180 and 365 days of age of the Djallonke sheep was 19.7 and 31.8 kg, respectively, and the genetic gain in YW was only an improvement of less than 0.1%. Cloete et al. (1998) reported annual genetic gain of 0.145 kg of yearling weight (mean weight of 55.8 kg) for Dhone Merino nucleus flock which is less than 0.3% improvement. The genetic gain of about 0.3% obtained under the current study suggests that under intense selection better genetic improvement can be obtained and it also implies that there is large amount of variability in Horro sheep in terms of WW, 6MW and YW. Relatively higher genetic gains were reported by Shrestha et al. (1996), for WW of three breeds of sheep (70 to 140 g) and by Saatci et al. (1999) in additive direct breeding values for 12-week weight of Welsh mountain lambs

(120 g). Due to the absence of intense selection the annual genetic gain in WW of 44 g (0.2%) in the current study was low.

Total heritability estimates of 0.17, 0.14, 0.21 and 0.24 were reported, respectively for BW, WW, 6MW, and YW for the sheep breed used in the present study using the same data set (Solomon et al., 2001). The standard deviation for BW, WW, 6MW, and YW were 0.49, 2.46, 2.98, and 3.86, respectively. If the top 25% of the males and 50% of the females had been selected as replacements the selection intensity will be about 1.2 and 0.8 units of standard deviation for the males and the females, respectively. Under such a selection scheme and with estimated generation interval of 4 years the annual response for BW, WW, 6MW, and YW will amount to 21, 86, 156, and 232 g. This is about 350, 195, 279, and 247 per cent of what was realised in the current study. Thus, under well designed selection scheme much more gain than observed in the current work could be achieved.

A slight drop in genetic trend has been observed for all growth traits starting from 1994. The flock was closed until 1993 and starting from 1994 some of the ram and ewe replacements were purchased and introduced to the flock. This fact was the major factor to account for the decline in genetic gain after 1994.

In spite of some amount of genetic gain in all the traits, the phenotypic trend has shown significant ($p<0.01$) decline. This was the result of very large decline in the environmental trend. Similar decline in the phenotypic trend in the presence of genetic gain have been reported for weaning weight in Dormer sheep (Van Wyk et al., 1993) for WW and YW in Boran cattle (Haile-Mariam and Philipson, 1996) and for milk yield in Sahiwal cattle in Kenya (Rege and Wakhungu, 1992). Increase in stocking rate as some of the pasture land in the Centre was turned into crop, deterioration of grazing area, fluctuations in climatic conditions, morbidity as a result of disease build up with time, the turnover of people who worked in the management of the flock, and more use of portion of the flock to stressful experiments (eg. use of the animals for different levels of feeding trails) in the later years as compared to the early years might have contributed to the decline and erratic nature of the environmental and phenotypic trend.

## Conclusion

Improved genetic trend was observed in this study, particularly between the years 1978 and 1994. However, this improvement could not counteract the high decline in environmental trend. There was very little, if any, selection for the traits studied and the observed positive genetic trends were the results of culling of ewe and ram lambs at the age of 6 to 12 month and selection of rams visually before mating commences. The overall genetic gain indicates that under well-designed selection scheme much more gain than observed in the present study could be achieved. Thus, selection can be an important means of genetic improvement in Horro sheep. The commonest sheep production system is the smallholder system and sound genetic selection should be done under this system. The result also suggests that improvement in genetic gain should be accompanied by either improvement or maintenance of the management environment. This ensures whatever is gained through genetic means may not be lost due to decline in level of management.

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# Level and Effect of Inbreeding in a Flock of Horro Sheep at Bako Research Center

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## Abstract

*Levels of inbreeding were calculated in a flock of Horro sheep kept at Bako Research Center during the period 1978-1997. Using regression methods, the effect of lamb and dam inbreeding level on weight at birth (BW), at weaning (WW), at six month (6MW) and one year (YW) of age, on survival to different ages (3 and 7 days and one, three, six and 12 months) and on litter size at birth were studied. Flock average inbreeding coefficient during the study increased to more than 2% in the year 1991 and decreased thereafter. Proportion of inbred animals also increased to about 81%. Regression of performance on inbreeding showed that 1% increase in inbreeding coefficient of the lamb resulted in a decrease in weight of -4, 6, 31 and 103g in BW, WW, 6MW, and YW, respectively. Except for YW which approached significant level (p=0.06) all effects were not significant. A percent increase in inbreeding coefficient of the dam has also resulted in a decrease in BW, WW, 6MW, and YW of -1, -4, 33 and 33g, respectively. All were not significant. The effect of individual and dam inbreeding on litter size at birth was also not significant (p>0.05). Significant (p<0.05) negative effect of both individual and dam inbreeding was observed on survival to 30 days of age. Dam inbreeding has also a significant (p<0.05) effect on survival to yearling. Effects on survival to other growth stages were all non significant. Analysis from categorization of inbreeding levels indicated that higher levels of inbreeding are detrimental. In spite of the low level of inbreeding in the current study there are some significant and non-significant negative trends due to inbreeding. Thus it is advisable to avoid particularly higher levels of inbreeding.*

*Keywords*: Inbreeding level, inbreeding depression, growth traits, survival, litter size.

## Introduction

In the smallholder sheep production keeping rams in small flocks to which they are related is common. Due to this it is likely that there exists high level of inbreeding. Economic importance of inbreeding in sheep has been shown in a number of works (e.g. Lamberson and Thomas, 1984; Ercanbrack and Knight, 1991). Under the management conditions existing in the smallholder production system selection within the indigenous breed seem better means of improvement than importing exotic germ plasm. Selection increases inbreeding. There exists breed variation in the effect of inbreeding on different traits (Ercanbrack and Knight, 1991; Boujenane and Chami, 1997).

Work on characterization of Horro sheep breed has been since 1977 at Bako Research Center. Though effort was made to avoid close inbreeding, due to the small size of the flock and due to the flock being closed for a long period of time it was not possible to avoid inbreeding completely. Recent work (Solomon and Gemeda, 2000) on analysis of the data from the Horro sheep characterization study has shown that there are declines, though not systematic, in growth performance, survival and reproductive performance. This study was done to determine the level and effects of inbreeding on early growth performance, survival and litter size.

# Materials and Methods

## Animals and Management

Data used in this study was collected from a flock of Horro sheep kept at Bako research center during the period 1978-1998. The flock was established with 100 ewe lambs (all milk teeth but some of them were pregnant when procured) and 4 rams purchased from different local markets around Shambo, Western Ethiopia. The sheep management was semi-intensive in that sheep grazed out-doors during the day (08:00 a.m.-08:00 p.m.) and were housed during the night in pens with bamboo walls and corrugated metal sheet roofs. The flock grazed natural pasture throughout the year with the exception of the mating period when they were kept indoor and fed on concentrates and hay.

Except during mating periods the ewe and ram flocks were housed and herded separately. Throughout the period of this study (1977-1997), controlled single-sire mating was practiced. The mating period usually lasted for about 42 days (minimum of two oestrous cycles). With the exception of part of the flock mated thrice during the years1982 to 1985 for study on frequency of lambing and another subset mated at nine months intervals between 1989 and 1991 for selection on yearling weight, mating generally occurred from mid November to early January for lambing in April and May. During mating, about 20 (occasionally 10-25) ewes were assigned to each ram based on a random procedure after they were stratified by age. With the exception of 1989 to 1990, there was no genetic selection. In the years 1989 and 1990 two groups of rams were used: one group comprised rams selected for yearling weight (to be mated with selection group ewes) while the other comprised rams of medium yearling weight (to be mated with a control group of ewes). The selection differential was low (2 to 3 kg) due to the small number of rams available for selection (low intensity of selection). Additionally correction of the data was done only for type of birth. Ewe lambs were culled and rams were also chosen before mating based on visual appraisal. At times, rams kept as stand-by were used to replace those with poor libido. The pedigree of each ram was checked for close relationships (closer relation than great grand parent) with the ewes in their respective groups. When such relationships exist ewes were switched between groups based on similarity in age and weight. The introduction of stand by rams, at times, resulted in some relationships to occur between some of the ewes in that group and the newly introduced ram. The flock was largely closed until 1994 when rams and some ewe replacements were bought from outside. Ewes were culled if they were found to be chronically sick, or aged. But culling for infertility or other lamb production traits was not practiced. Except in the first two years when rams were used for the second year all rams were used only once. Ewes were used repeatedly until they were culled or dead.

## Data Collection

A total of 4031 lambing records from 184 sires and 904 ewes were used in this study. Body weight measurement was taken once every four weeks for the total flock and fortnightly for lambs up to weaning age. All body weight measurements were taken in the morning after fasting the animals overnight (13-15 hr.). With the exception of monthly weights for three consecutive months in 1991 (which were not available), growth, reproduction and survival data recorded during the period 1978 to 1997 was used. Weaning weights were recorded at an average age of 92.5±0.13 days with a range of 70 to 110 days while six month weights were taken at the age of 184.4±0.26 days with a range of 150 to 210 days. For yearling weight the average age was 366.3± 0.31 days with a range of 322 and 408 days.

A score of unity or two was given to the ewe, which gave birth to single or multiples (twins or triplets), respectively. Triplets were rare in the data (33 out of 4031 lamb records) and were put in the same category along with twins. Type of rearing was scored as 1 for lambs born single and reared as single, 2 for lambs born twin and reared with the twin mate at least to 45 days of age and 3 for lambs born twin and the twin mate died before the age of 45 days. Ewe age was categorised into 7 classes in the analysis of litter size while parity was categorized into 5 classes in the analysis of survival and growth performance. Survival was coded as 0 for lambs died before a specified age and 1 otherwise.

## Statistical Analysis

Inbreeding coefficients were calculated from the relationship matrix used in animal model analysis by the Average Information Restricted Maximum Likelihood (AIREML) program of Gilmour et al. (1995). All animals present in 1978 were assumed to be unrelated. Inbreeding coefficients of lambs and dams were merged in the data analysis of lamb growth, survival and birth type. Effects of inbreeding were estimated by analysing performance data with inclusion of inbreeding coefficients of the lamb and the ewe in the model as linear covariates. The model used to analyse the effects of inbreeding on growth performance included the fixed effects of year, parity, type of rearing (litter size for birth weight) and sex, and age at measurement (Julian birth day for birth weight) and inbreeding coefficient of the lamb and the dam as covariates. In the analysis of litter size fixed effects of year of birth and ewe age were included in the model along with inbreeding coefficients of the individual lamb (foetus) and dam. A model similar to that of growth performance was used in the analysis of survival to different ages but parity was replaced by ewe age, and BW was included as covariate and litter size was used in all cases. In a separate analysis inbreeding coefficients of the lamb and the ewe were categorised into two ($F=0$ and $F>0$) classes. To see the effect of different levels of inbreeding, inbreeding coefficients of the lamb and the dam were categorised into 3 classes ($F=0$, $0<F\leq3$, and $F>3$).

# Results

## Level of Inbreeding

Average inbreeding coefficients during the study period are shown in Table 1. The overall average inbreeding coefficient was 0.78% and the annual average increased to more than 2% in the year 1991 and decreased thereafter. The proportion of inbred animals in each year also showed increase to as high as 81 per cent in 1990 and then decreased to zero in the year 1996. Annual increases in average inbreeding coefficient of the total and inbred animals, and in the proportion of inbred animals was $0.07\pm0.0129$, $0.37\pm0.173$ and $3.04\pm0.6$ per cent, respectively. All of the values were statistically significant ($p<0.05$).

## Effect of Inbreeding

Further analysis on the effect of individual and dam inbreeding on lamb growth, lamb survival and on litter size showed that 1% increase in inbreeding coefficients of the lamb resulted in an increase of 4 g in birth weight and a decrease of 6, 31 and 103 g in weaning, six month and yearling weight (Table 2). With the exception of yearling weight which approached significant level ($p=0.06$) all the effects were non-significant. A per cent increase in inbreeding coefficients of the dam has also resulted an increase of 1 and 4 g in birth and weaning weight, respectively, and a decrease of 33 g in each of 6MWT and YWT. All effects were non-significant ($p>0.05$). The effect of individual lamb (foetal) and dam inbreeding on litter size at birth was also found to be non-significant. Survival to 30 days of age was found to be significantly affected by both individual ($p<0.05$) and dam ($p<0.01$) inbreeding coefficients while survival to 1 year of age was also affected by dam regression coefficient

($p<0.05$). Survival to other ages studied was not affected by either of the coefficients.

**Table 1**. Annual average coefficient of inbreeding for the total flock, and for the inbred animals and proportion of inbred animals in each year (1978-1997)

| Year of birth | No. of animals | Average inbreeding coefficient (%) | Proportion of inbred animals (%) | Average inbreeding Coefficient of inbred animals (%) |
|---|---|---|---|---|
| Overall average | 3697 | 0.78 | 31.6 | 2.5(3.25) |
| 1978 | 96 | 0.00 | 0.00 | 0.0 |
| 1979 | 184 | 0.14 | 0.54 | 25.0(-) |
| 1980 | 218 | 0.46 | 2.75 | 16.7(6.45) |
| 1981 | 286 | 0.26 | 4.20 | 6.3 (2.31) |
| 1982 | 267 | 0.95 | 11.24 | 8.6(5.55) |
| 1983 | 207 | 0.44 | 8.70 | 5.1(3.17) |
| 1984 | 162 | 0.43 | 12.96 | 3.3(2.89) |
| 1985 | 116 | 0.81 | 35.34 | 2.3(2.28) |
| 1986 | 203 | 0.93 | 43.35 | 2.2(1.73) |
| 1987 | 170 | 0.81 | 64.71 | 1.2(1.32) |
| 1988 | 253 | 1.13 | 71.94 | 1.6(1.76) |
| 1989 | 273 | 1.56 | 68.50 | 2.3(2.86) |
| 1990 | 367 | 1.86 | 80.65 | 2.3(2.53) |
| 1991 | 122 | 2.18 | 64.75 | 3.4(4.93) |
| 1992 | 147 | 1.14 | 63.54 | 2.7(3.64) |
| 1993 | 118 | 1.34 | 61.86 | 2.2(2.15) |
| 1994 | 98 | 0.74 | 60.20 | 1.2(0.99) |
| 1995 | 103 | 0.05 | 4.85 | 1.5(0.67) |
| 1996 | 134 | 0.00 | 0.00 | 0.0 |
| 1997 | 173 | 0.13 | 0.58 | 25.0(-) |
| P-value [a)] | | 0.001 | 0.001 | 0.047 |
| Regression (± S.E.) on year | | 0.070 ±0.0129 | 3.044 ±0.6002 | 0.366 ±0.1727 |

[a)] = F-test for effect of year

**Table 2**. Partial regression coefficients (±S.E.) of weights at different stages, litter size and survival to different growth stages on lamb and dam inbreeding

| Trait | N | Lamb regression coefficient | Dam regression Coefficient |
|---|---|---|---|
| Birth weight (kg) | 3696 | 0.0035±0.0040 | 0.0012±0.0048 |
| Weaning weight (kg) | 2801 | -0.0063±0.0230 | 0.0036±0.0253 |
| Six month weight (kg) | 2220 | -0.0308±0.0324 | -0.0330±0.0332 |
| Yearling weight (kg) | 1440 | -0.103±0.0534 | -0.0329±0.0541 |
| Litter size | 3697 | 0.0009±0.0035 | -0.0016±0.0041 |
| Survival to 3 days | 3657 | -0.0003±0.0018 | 0.00005±0.0021 |
| Survival to 7 days | 3657 | -0.0009±0.002 | -0.0020±0.0024 |
| Survival to 30 days | 3656 | -0.0054±0.0024* | -0.0084±0.0028** |
| Survival to weaning | 3627 | 0.0009±0.0029 | 0.0054±0.0035 |
| Survival to 6 month | 3485 | 0.0014±0.0034 | -0.0040±0.0039 |
| Survival to 1 yr of age | 2912 | 0.0013±0.0036 | -0.0103±0.0043* |

* P<0.05 ** P<0.01 for means within a row.

Categorising the data into inbred and non-inbred classes has shown that, although most of these were not statistically significant, inbred lambs had better performance than non inbred lambs in almost all the traits considered and lambs from inbred dams had slightly lower performance than lambs from non-inbred dams in some of the traits (Table 3). The regression of performance on inbreeding coefficient was always very small in value and in most cases negative. This was found to contradict the result of the analysis from categorizing the data into inbred and non-inbred animals. An explanation for the contradiction was sought through a separate analysis where inbreeding coefficient of the lamb and the dam was categorised into three. This analysis showed that in most cases the effect of inbreeding of the lamb was positive at low levels and negative at higher levels (Table 4). There was no systematic effect in the case of dam inbreeding levels (Table 5).

**Table 3.** Least square means (±S.E.) of performance of inbred and non-inbred lambs and lambs from inbred and non-inbred dams.

| Trait | N | Lamb | | Ewe | |
|---|---|---|---|---|---|
| | | Non-Inbred | Inbred | Non-Inbred | Inbred |
| Birth weight (kg) | 3696 | 2.57±0.013 | 2.68±0.020** | 2.63±0.012 | 2.61±0.022 |
| Weaning weight (kg) | 2801 | 11.78±0.108 | 12.02±0.13 | 11.82±0.09 | 11.99±0.14 |
| Six month weight (kg) | 2220 | 15.44±0.16 | 15.48±0.19 | 15.57±0.14 | 15.4±0.20 |
| Yearling weight (kg) | 1440 | 23.99±0.27 | 24.18±0.32 | 23.8±0.24 | 24.4±0.35 |
| Litter size | 3697 | 1.44±0.012 | 1.49±0.017* | 1.46±0.012 | 1.47±0.018 |
| Survival to 3 days | 3657 | 0.93±0.007 | 0.94±0.009 | 0.94±0.006 | 0.93±0.009 |
| Survival to 7 days | 3657 | 0.91±0.007 | 0.93±0.010 | 0.92±0.007 | 0.91±0.011 |
| Survival to 30 days | 3656 | 0.87±0.008 | 0.86±0.012 | 0.88±0.008 | 0.86±0.013 |
| Survival to weaning | 3627 | 0.73±0.011 | 0.77±0.015* | 0.76±0.01 | 0.74±0.015 |
| Survival to 6 month | 3485 | 0.59±0.012 | 0.65±0.017** | 0.64±0.012 | 0.61±0.017 |
| Survival to 1 yr of age | 2912 | 0.44±0.014 | 0.50±0.019* | 0.49±0.013 | 0.44±0.019* |

* $P<0.05$ ** $P<0.01$ for means within a row.

**Table 4.** Least square means (±S.E.) of performance of lambs of different inbreeding levels

| Trait | Class of lamb inbreeding[a b] | | |
|---|---|---|---|
| | 1 (N) | 2 (N) | 3 (N) |
| Birth weight (kg) | 2.63±0.019 (2423) | 2.75±0.026 (972) | 2.66±0.037*** (301) |
| Weaning weight (kg) | 11.8±0.12 (1844) | 12.1±0.15 (740) | 11.7±0.20* (217) |
| Six month weight (kg) | 15.4±0.17 (1511) | 15.7±0.22 (538) | 14.9±0.288* (171) |
| Yearling weight (kg) | 24.0±0.30 (888) | 24.6±0.37 (428) | 23.4±0.47* (134) |
| Litter size | 1.44±0.015 (2424) | 1.50±0.021 (972) | 1.45±0.03* (301) |
| Survival to 3 days | 0.93±0.008 (2390) | 0.95±0.01 (968) | 0.93±0.02 (299) |
| Survival to 7 days | 0.90±0.009 (2390) | 0.94±0.012 (968) | 0.89±0.017* (299) |
| Survival to 30 days | 0.85±0.011 (2389) | 0.87±0.015 (968) | 0.81±0.020* (299) |
| Survival to weaning | 0.72±0.013 (2367) | 0.77±0.018 (963) | 0.72±0.025* (297) |
| Survival to 6 month | 0.58±0.015 (2261) | 0.65±0.020 (934) | 0.61±0.028** (290) |
| Survival to 1 yr of age | 0.42±0.016 (1812) | 0.49±0.023 (843) | 0.46±0.031* (257) |

[a] 1) F=0 2) 0<F≤3 3) F>3 [b] number of lambs within a class in parenthesis

* P<0.05 ** P<0.01 *** P<0.001 for means within a row.

**Table 5.** Least square means (±S.E.) of performance of dams of different inbreeding levels

| Trait | Class of dam inbreeding[a b] | | |
|---|---|---|---|
| | 1 (N) | 2 (N) | 3 (N) |
| Birth weight(kg) | 2.69±0.016 (2828) | 2.67±0.029 (671) | 2.68±0.039 (218) |
| Weaning weight(kg) | 11.8±0.11 (2208) | 12.1±0.17 (443) | 11.8±0.21 (150) |
| Six month weight(kg) | 15.5±0.16 (1820) | 15.3±0.24 (291) | 15.2±0.293 (109) |
| Yearling weight(kg) | 23.6±0.26 (1137) | 24.3±0.43 (228) | 24.1±0.51 (77) |
| Litter size | 1.44±0.015 (2828) | 1.50±0.021 (671) | 1.45±0.03* (218) |
| Survival to 3 days | 0.94±0.008 (2828) | 0.93±0.011 (671) | 0.93±0.02 (218) |
| Survival to 7 days | 0.92±0.008 (2828) | 0.91±0.013 (671) | 0.90±0.019 (218) |
| Survival to 30 days | 0.87±0.010 (2827) | 0.86±0.015 (671) | 0.80±0.023* (218) |
| Survival to weaning | 0.75±0.012 (2779) | 0.75±0.019 (635) | 0.72±0.028 (213) |
| Survival to 6 month | 0.64±0.014 (2659) | 0.62±0.021 (615) | 0.59±0.031 (211) |
| Survival to 1 yr of age | 0.49±0.016 (2185) | 0.46±0.023 (544) | 0.42±0.034* (183) |

[a] 1) F=0 2) 0<F≤3 3) F>3 [b] Number of records from dams in a class in parenthesis

* P<0.05 for means within a row.

## Discussion

Overall the level of inbreeding was low. However the proportion of inbred animals has risen to more than 80%. This is due to the mating design followed where pedigrees were checked for close relationship. The flock was kept closed until 1994 when some ewe and ram replacements were purchased from outside. Due to the small size of the flock and because it was kept closed for long, some relationship in most of the mates was likely to exist. The low level of inbreeding may explain why the effect of inbreeding in most cases was not significant. From a number of studies (Boujenane and Chami, 1997; Wiener et al., 1992a; Ercanbrack and Knight, 1991) it was shown that individual inbreeding could have sizeable effect when inbreeding levels are greater than 15%. In the current study the inbreeding level for inbred animals was 2.5%.

The regression analysis showed that there were non-significant effects (mostly negative) of inbreeding on performances evaluated. Values ranging from –14 to –2 g have been reported by Ercanbrack and Knight (1991) for the effects of individual inbreeding on lamb birth weight in Rambouillet, Targhee, and Columbia breeds. Boujenane and Chami (1997) reported values of 0.1 g and -6.1 g for effect of one percent of individual level of inbreeding on birth weight in Sardi and Beni Guil sheep, respectively, while Van Wyk et al. (1993) reported a reduction of 8 g in BW of Dormer sheep for 1% increase in level of inbreeding of the individual lamb. Analla et al. (1998) reported 11 to 76 g reduction in BW of various lines of Merino sheep. A review by Lamberson and Thomas (1984) revealed a range of -29 to 22g reduction in BW by one per cent rise in individual level of inbreeding. In the current study the figure obtained was low and positive but falls within the range reported by Lamberson and Thomas (1984). Other studies in sheep (Analla et al., 1999; Mirza et al., 1999) and in cattle (Pariacote et al., 1998) also reported on the effect of individual inbreeding on WW. Van Wyk et al. (1993) reported a reduction of 99g in WW in Dormer sheep while Boujenane and Chami (1997) reported an increase of 6g and a decrease of 45g per 1% rise in inbreeding in Sardi and Beni Guil sheep, respectively. Ercanbrack and Knight (1991) reported that there was a decrease of 59g for each 1% increase in inbreeding coefficients. The result in the current study showed lower decrease in WW than in most reports but in similar direction and it also falls within the range of –177g to 36g reported in the review of Lamberson and Thomas (1984).

Numerically the effect of dam inbreeding on WW in the current study was positive, though statistically not significant, but with relatively small value while the effect of individual inbreeding was negative. The effect of inbreeding of the dam on lamb growth is largely a result of a poorer supply of milk to their lambs (Wiener et al., 1992a). The positive effect of dam inbreeding on WW in the current study is inexplicable and could be a result of chance occurrence due to the low level of inbreeding. Lax and brown (1967; cited by Lamberson and Thomas, 1984) reported similar small positive effect of dam and larger negative effect of individual inbreeding for female Merino sheep. Effects of individual and dam inbreeding on 6-month weight were reductions of 31 and 33g, respectively, while for yearling weight the reductions were 103 and 33g, respectively. From a review work on a number of sheep breeds Lamberson and Thomas (1984) reported reductions of 25 to 272g in post-weaning body weight per 1% increase in individual inbreeding; the inbreeding depression on six month and yearling weight in the current study for individual inbreeding falls in this range. Reports of dam inbreeding depression on post-weaning weight are rare in the literature. In the review of Lmaberson and Thomas (1984) there was only one source (Lax and Brown, 1967) who reported reduction in post-weaning weight male animals but increase of this variable in female animals. Doney (1966) reported lower mean values for weight from birth to about 4½ years of age of inbred than non-inbred Blackface sheep.

With the exception of survival to 30 days and to 1 year of age, inbreeding depression due to individual and dam inbreeding on litter size and other categories of survival was non-significant. Inbreeding affects fitness traits (reproduction and survival) more than it does on production traits, which is also reflected in the present study (Tables 2 and 3), whereby the effect of individual and dam inbreeding on some of the traits was found to be significant even at this low level of inbreeding while the effect on growth traits was not significant. Similarly, Galal et al. (1981) reported significant effect of lamb inbreeding on survival to 7 and 120 days of age. Even though the average level of lamb inbreeding in the work of Galal et al. (1981) was 12% which is much higher than the level of inbreeding in the current study, there was similarity in the presence of significant inbreeding depression on survival to weaning. Significant inbreeding depression of dam on survival of lambs to 1 month of age was observed in ewe groups with inbreeding coefficients of greater than 3%. Krystyna et al. (1990) also observed increase in lamb losses during the first month of their life in the group of ewes with inbreeding levels of over 5%. In the same work the effects of dam inbreeding on survival to different ages have shown a negative trend but all were non-significant, unlike the observations in the current study. Van Wyk et al. (1993) and Boujenane and Chami (1997) reported non-significant linear effect of individual (foetus) and dam inbreeding on pre-weaning lamb survival and litter size.

Evidence from Coltman et al. (1999) suggests that inbred animals are more susceptible to parasites. In the current study the effect of individual inbreeding was significant only on survival to one month of age. Lambs are hardly grazing to the age of one month and difference in susceptibility to parasite as a result of inbreeding cannot explain the significant effect of individual inbreeding on survival. With respect to litter size, Wiener et al. (1992b) reported significant effect of dam inbreeding on litter size but the level of inbreeding was much higher ($F_D$>0.25) than the level of inbreeding in this study.

The apparently better but statistically non-significant performance of inbred than non-inbred animals shows that the level of inbreeding in the current study is below the critical range. This was confirmed by the out come of the re-analysis of the data set after the inbreeding level was categorized into three levels (Tables 4 and 5). A similar higher performance of inbred than non-inbred animals in terms of milk production and BW was reported for Sahiwal cattle in Kenya (Rege and Wakhungu, 1992). The trend in performance on growth and viability observed in Table 4 that performance tends to improve at the medium level of inbreeding and drop at the high level suggests a curvilinear relationship between level of inbreeding and performance in growth and viability. A similar curvilinearity in the effect of inbreeding on economic traits was reported in beef cattle (Dinckel et al., 1968). Krystyna et al. (1990) also found decreased ewe prolificacy and lamb survival in the group of ewes with a highest inbreeding (>5% Vs. 2%-5% and =2%) though the results were not statistically significant.

## Conclusion

The level of inbreeding in the current study is low and the effects were in most cases not significant. However, even at this low level there are indications that YW and survival could be negatively affected by inbreeding levels of the lamb and the dam. Under the traditional smallholder sheep production system, it is common that breeding rams came from the same flock. Due to small flock sizes the chance of build up of inbreeding is high, the consequences of which are hardly noticed in the production system. A system of ram exchange between villages and farmers could be considered as a remedial measure. While inbreeding depression at very low levels of inbreeding may have no or slightly positive effects, high levels of inbreeding are detrimental to production. The low levels of inbreeding are difficult to maintain at farm level since kinship is very close in small flocks. Thus, ram exchange should receive due attention and the exchange should take place before rams reach sexual maturity. Effects of inbreeding at levels which are expected to occur in the small flocks of the smallholder farmers are worth investigating.

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# Practicalities of sustaining a goat-crossbreeding programme in eastern Ethiopia

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## Abstract

*Crossbreeding of goats in traditional subsistence flocks had been promoted in selected villages of eastern Ethiopian highlands as a means to quick genetic progress based on the thesis that crossbreeding can increase the net contribution of goats. Observations on flock dynamics patterns of smallholder flocks with crossbred goats showed that the desirable attributes of crossbreeding had not been maintained after the promotion phase because: 1) the pool of crossbred goats was too small to maintain 50% exotic blood level in the crossbreds; 2) shortages of crossbred breeding males also led to gradual backcrossing of the does, resulting in an increasingly mosaic mix of crossbreds; 3) the small size of flocks as well as their rapid turnover limited the scope for any selective breeding and the maintenance of superior breeding animals; and 4) loose control on the breeding of various classes of crosses with indigenous goats posed undesirable dissemination of introduced genes into the indigenous genetic pool. Therefore it was concluded that crossbreeding of indigenous goats with exotic breeds, as a technology for genetic improvement of smallholder goat flocks of Ethiopian highlands, is not sustainable under subsistence mode of production.*

*Keywords*: **C**rossbreeding, indigenous goats, goat production, subsistence, sustainability,

## Introduction

There is a widely held belief in Ethiopia that, in the mild tropical climate of the highlands, modification of the traditional husbandry practices alone cannot bring about satisfactory increases in livestock production to meet the fast growing demand for milk and meat (McDowell, 1988; Teffera and Abay, 1995; Alemu et al., 1998; Getachew, 1998). Genetic improvement of indigenous

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livestock breeds by way of selection is also considered too slow to achieve desired levels of production. Consequently, crossbreeding of some native breeds under smallholder farmer management with selected exotic breeds has generally been practised as a shortcut to genetic improvement to increase their net contribution to family welfare, as in the case of the Chilalo Agricultural Development Project (CADU), the Dairy Rehabilitation and Development Project (DRDP), the Smallholder Dairy Development Project (SDDP) (Hizkias, 1998) and the on-going National Livestock Development Project (NLDP). This was also the concept of the Dairy Goat Development Programme (DGDP), which implemented improved management along with crossbreeding (indigenous x imported Anglo-Nubians) in selected sites of Ethiopian highlands between 1989 and 1997 (FARM-Africa, 1997). This paper will examine if this genetic improvement has been achieved.

## Background and Organization of the Goat Breeding Programme

The DGDP was designed to increase the contribution of goats to subsistence household welfare through crossbreeding of indigenous goats (in this case Long-eared Somali and Hararghe Highland) to increase milk and meat production. The main reasons for adopting crossbreeding for improving particularly milk production from goats were (FARM-Africa, 1990): (1) there was (and still is) little quantitative information on milk production characteristics of Ethiopian indigenous breeds of goats and so there was no way of knowing if any of the indigenous breeds would reward selection, and (2) it is likely that the variability of milk production within indigenous breeds when combined with the likely heritabilities of milk traits is not sufficient to achieve the level of desired improvement within a reasonable time. The heavy thrust on milk was later relaxed and meat was also given as much emphasis after recognizing that the subsistence farmers realize considerable benefits from sale of goats as well.

The initial plan of the DGDP included testing a number of exotic breeds for their suitability for one-way (simple) crossbreeding. However, delays in implementation with the first exotic breed (the Anglo-Nubian) as well as the long time it took to resolve policy issues related with crossbreeding did not encourage importing other exotic breeds. Therefore, the DGDP worked with only the Anglo-Nubian breed throughout the three phases of operation. This breed was selected for crossbreeding on the ground that it has proved to be well suited to tropical climates and has been used widely for the same purpose in other tropical countries like India, West Indies, Mauritius, Malaysia and the Philippines (Devendra and Burns, 1983) as well as Thailand (Saithanoo *et al.*, 1993) and Kenya (Ruvuna *et al.*, 1995). It also has a tropical ancestry (Peacock, 1996).

The DGDP was set to test (on-station and on-farm) F1, F2 and 75% Anglo-Nubian crosses, and effectively develop a gene pool of crossbreds around 50% Anglo-Nubian blood level. However, the small capacity to produce the first generation crosses and ambiguities on the appropriate level of exotic blood to maintain in the crossbreds limited the scope for any performance comparison between the crossbreds. Consequently, all the available F1 crosses were distributed to selected participant farmers (Workneh, 1996).

The DGDP wound down the scale of its involvement from March 1997 and finally phased out in June 1997 after having duly handed over all financial and supervisional responsibilities to local collaborating institutions.

The net benefits of the project to the smallholder were the subject of a PhD study (Workneh, 2000). In the process of the study, it was possible to observe the practicalities and organisational issues associated with the concept of exotic crossbreeding. These observations are presented below.

## The Study Area and Data Collection

The study was conducted in Gursum and Kombolcha districts of Eastern Hararghe. This area represents only the eastern wing of the DGDP, which had progressed better than the southern wing; however, the DGDP implemented its programmes using the same strategy and guidelines, and hence the concepts discussed are equally applicable.

Detailed data collection in flock dynamics of crossbred goats was done between July 1998 and June 1999 from a total of 121 DGDP participant (improved management) and 37 control households (traditional management) in the two districts. Out of the DGDP participants, 90 households owned crossbred goats and the other 31 households owned only indigenous goats. Previous population trends for the different classes of crossbreds during the DGDP promotion phase (1989-1997) were established from available background information and own observation. Descriptive statistics was used to compare attributes of flock dynamics between study groups.

## Observations on Sustainability of Crossbreeding in the Village Flocks

### Inadequate supplies of crossbred goats

During lifetime of the DGDP, a total of 914 F1 and F2 crossbreds were distributed to participant households in the east and south of the country. About 38% of these came from two crossbreeding stations (Alemaya University of Agriculture and Awassa College of Agriculture), 46% from 15 Anglo-Nubian buck stations set up in the villages, 14% from 12 private contract producers and the remaining 2% from farmer credit repayments. All these sources of improved stock were expected to continue to operate after the DGDP, under the supervision of the regular extension services (FARM-Africa, 1997).

However, in the eastern wing of the DGDP these sources of improved stock have been declining since the DGDP phased out, and particularly during this study period (1998-9). Unlike the pace during the lifetime of the DGDP when 40 to 70 crossbreds were distributed per annum around the study sites, only 14 crossbreds were distributed to farmers during the study period. The extension services were unable to maintain the flow of crossbred goats from commercial producers and the crossbreeding station at Alemaya University to the villages.

The production of crossbred goats in the crossbreeding stations had already been observed to have required strong technical and financial support, and made the cost of crossbreds too high for the smallholder farmers; for instance the average cost of production of crossbred yearlings was observed to be two to three times higher than the market price of similar local goats (Wagayehu and Habte-Mariam, 1994), which forced the project to set a highly subsidised price tag for crossbred goats of only 125% of the current market price of local breeding goats. Even at these subsidised prices, the transaction costs (organisation, transport and financial management) of delivering the crossbreds to the villages proved to be too high to bear for both the producers as well as collaborating institutions.

Setting up Anglo-Nubian buck stations provided cheaper and quicker means of producing and delivering F1 crossbreds than the crossbreeding stations. The initial costs of procuring the Anglo-Nubian bucks (the subsidised project price of Birr1600) and setting up the buck stations could easily spread over a large number of offspring born and managed in the villages. However, there had always been a high health risk for the bucks, and buck stations required central management for rotating the bucks in order to control inbreeding. Furthermore, shortage of Anglo-Nubian replacement bucks limited their continuity. Only one Anglo-Nubian buck station continued to operate in the study area out of six established in the villages.

The seven small commercial crossbred producer farms initiated with the support of the DGDP could not sustain their operations. Each of them had acquired the initial exotic stock of three to four female and one male Anglo-Nubian goats on credit. Gradually they procured indigenous does for crossbreeding. The DGDP had initiated a system of contractual agreement whereby these private producers would supply the DGDP with F1 crossbred and pure Anglo-Nubian goats at fixed prices. By the time the DGDP phased out, arrangements were made for similar contracts with the department of agricultural extension services to use some credit fund set aside by the DGDP for this purpose. The idea was the revolving credit funds with the farmers' groups could gradually be used in the same manner to procure improved stock through the extension services. However, none of these group funds were ever mobilised for the procurement of improved stock, although some crossbreds were made available at the nearby crossbreeding station as well as at two of the commercial producers. This failure was explained by the high transaction costs of operating the group funds as well as procuring and distributing the crossbreds. In fact, two of the private producers decided to quit before the DGDP phased out, for reasons of high management costs and shortage of feed. The remaining five farms, which continued to operate after the DGDP, have gradually scaled down their operations, to the extent that none of them supplied the villagers with crossbred goats during the study period.

Other potential sources of crossbreds were the farmers themselves, in the form of ordinary sales and re-distribution of credit repayments (in kind). This source of crossbred goats was not strong even during the implementation period of the DGDP. During the study period no crossbred goat was repaid or re-distributed, although in the observed groups a total of 83 crossbreds remain unpaid, and some women farmers were prepared to repay in kind from their current stock of crossbred goats. Neither the extension services nor the private commercial farms could help deliver some improved stock. In fact, even the opportunity of utilizing group revolving funds for the procurement of crossbred breeding males from the nearby commercial producers was lost, as the women groups were unable to mobilize their savings and directly deal with the commercial producers.

The total pool of crossbred goats in the 90 DGDP-participant study households was 158 at the end of the observation period, down from 171 a year earlier. The decline was common to the whole goat population in both DGDP participant and control households (Table 1). In the face of inadequate supplies, crossbred owners tried to maintain crossbreds by reducing voluntary disposals as attested by the observation that only 4.4% of the crossbreds were slaughtered compared to 9.5% for indigenous goats. Similarly the sales rates were 41% less among crossbred than indigenous goats. The reduced sales and slaughter frequencies of crossbred goats could be explained by farmers' interest to maintain them longer. However, the level of exotic blood in the crossbreds was very unstable, with the F1 bucks constituting only 0.6% of the crossbred population at the end of the observation period. This is inadequate to sustain the production and reproduction of 50% crossbred goats in the villages. The crossbreeding station at Alemaya University remains as the only source of Anglo-Nubian and crossbred stock, but could not produce more pure Anglo-Nubians than it needs for its own replacement.

**Table 1**: Breed composition of the study flocks at the start and end of the study period.

| Breed group | DGDP participants | | | Control households | | |
|---|---|---|---|---|---|---|
| | Initial stock (July, 98) | End stock (June, 99) | % Change | Initial stock (July, 98) | End stock (June, 99) | % Change |
| Crossbreds | 171 | 158 | -7.6 | - | - | - |
| Indigenous | 215 | 169 | -21.7 | 98 | 71 | -27.5 |
| Total | 387 | 327 | -15.5 | 98 | 71 | -27.5 |

## Maintaining 50% exotic blood level in the crossbreds

The goal of stabilizing the level of exotic blood in crossbreds around 50% with a maximum safe level of 62.5% had not been attained in the study flocks. The proportion of 50% crosses declined from 72% at the start of the study period to 61% at the end. The extent to which the desired exotic blood level was maintained in crossbreds needs to be viewed in the context of the general pattern during the DGDP implementation period (Figure 1). Some farmers opted to go up to 75% already in 1994, using the Anglo-Nubian buck stations in the villages. On the other hand, a large number of quarter-breds were produced from the F1 bucks, although this class of crossbreds had not been actively promoted. The proportion of quarter-breds reached an annual average of 17% in 1996, and declined thereafter with the shortage of F1 bucks. Quarter-breds emerged mainly out of two scenarios:

1. Some farmers attempted to upgrade their local goats by mating with F1 crossbred bucks put up in the villages. This highlights the practical problems of controlling dissemination of the exotic genes in traditional flocks, on one hand, and farmers' desire for getting hold of higher potential animals, on the other.
2. 50% crossbred does were backcrossed with local bucks in the absence of F1 breeding bucks.

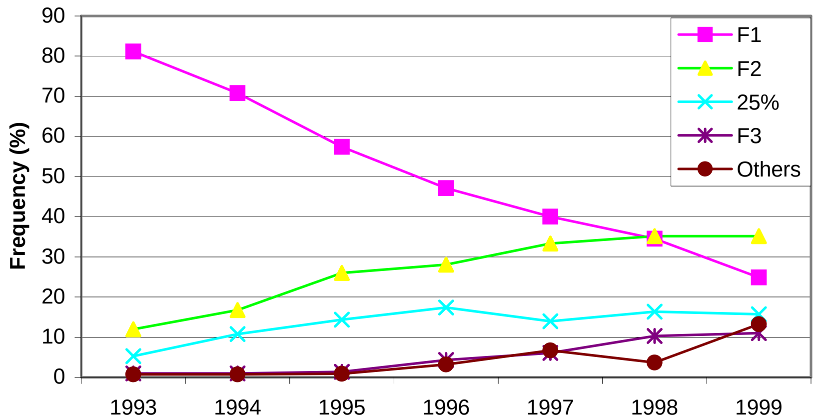


**Figure 1.** Changes in exotic blood level of crossbred goats between 1993 and 1999

The increase in the proportion of backcrosses and quarter-breds is related to the declining number of F1 breeding bucks. The larger F1 breeding bucks were difficult to maintain in smallholder flocks. The main reason appeared to have been the attractive high prices that castrated and fattened crossbreds fetch during religious festivities. The crossbred goats were observed in this study to reach maximum body weights of 72 kg compared to 41 kg for indigenous bucks. Finished F1 castrates were observed to sell at Birr 600, compared to Birr 250 for the indigenous fattened castrate of the same age in the same market. The smallholder households were therefore occasionally tempted to castrate the F1 bucks. The interest was so strong that young males were castrated at body weights of 8 kg for the F1 and 6 kg for the indigenous goats. As a result shortage of F1 breeding males was felt already in 1996 when the proportion of F1 bucks in the crossbred goat population decreased to 8.7%, compared to 28% in 1993. This shortage of crossbred breeding bucks also persisted during the current study period, and the proportion of F1 bucks in the crossbred population dropped from 5.1% at the beginning of the study to 0.6% at the end of the study (Table 2). The calculated sex ratio dropped from about 2 does to one buck in 1993 to 4.2 in 1997, with a dramatic drop to 75 does to one buck in 1999. Crossbred breeding females have therefore been gradually backcrossed to indigenous bucks; hence the proportion of backcross goats grew from 3.0% to 10.7% during the study period alone.

**Table 2:** Comparison of the proportion of F1 breeding males in crossbred goat populations during and after the DGDP around the study sites

| Indicators | During the DGDP | | | | | After DGDP | |
|---|---|---|---|---|---|---|---|
| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
| Number of F1 breeding males[1] | 62 | 47 | 34 | 21 | 20 | 10 | 1 |
| Total crossbred goat population | 219 | 229 | 252 | 240 | 177 | 196 | 158 |
| Proportion of F1 bucks among crosses (%) | 28.3 | 20.5 | 13.5 | 8.7 | 11.3 | 5.1 | 0.6 |
| Total breeding crossbred does[2] | 125 | 113 | 105 | 96 | 84 | 127 | 75 |
| Average sex ratio (Does to 1 buck)[3] | 2.0 | 2.4 | 3.1 | 4.6 | 4.2 | 12.7 | 75.0 |
| Proportion of backcrosses (%)[4] | 0 | 0.4 | 1.6 | 2.5 | 3.9 | 3.0 | 10.7 |

[1]Breeding males are taken to be all non-castrated males above 1 year of age.

[2]Breeding females are taken to mean all females above 1 year of age.

[3]Ratios were calculated from flock structures for June of each year, except for 1997 (March).

[4]Backcrosses are all crossbreds born with exotic blood levels less than their dams.

Source: Workneh Ayalew, Christie Peacock, Zewdu Ayele. (Unpublished observation).

The crossbreeding exercise in the villages therefore produced a mosaic of crosses with Anglo-Nubian blood levels ranging from 6.25 to 75% with no signs of stabilizing around 50% blood level (Table 3). The overall average exotic blood level in the crossbred population showed a slight decline from about 48% in 1993 to 43% in 1999. More importantly, the proportion of F1 stock declined from 80% in 1993 to about 22% at the end of this study. Owing to the dwindling supplies of crossbreds to the villages, the number of F1 and crossbreds in general is bound to decline even further.

**Table 3**: Frequency distribution of various crosses in study flocks at the start and end of the observation period

| Breed class | Initial stock 07/98 (n=171) | Final stock 06/98 (n=158) |
|---|---|---|
| F1 | 31.0 | 21.5 |
| F2 | 31.6 | 30.4 |
| F3 | 9.1 | 9.5 |
| 75% AN cross | 1.8 | 6.3 |
| 25% upgrade | 21.1 | 19.0 |
| 12.5% upgrade | 1.2 | 1.9 |
| 25% self cross | 0.0 | 0.6 |
| 62.5% backcross | 0.0 | 0.6 |
| 25% backcross | 1.8 | 8.2 |
| 12.5% backcross | 1.2 | 1.3 |
| 6.25% backcross | 0.6 | 0.6 |

## Rapid turnover of breeding goats and small flock sizes

The number of days goats stayed in study flocks over the study period ranged from 2 to 365 days, with an overall mean of 212 days. About 30% of those goats present at the beginning of the observation period were disposed of or lost during the observation period. In general crossbred goats stayed 42 days longer than indigenous goats, females stayed 48 days longer than males, and home-bred goats stayed 27 days longer than purchased/introduced goats. At the district level, goats in Kombolcha stayed longer than those in Gursum (Table 4). Such a high turn over of goats puts a restriction on opportunities for selective breeding and the maintenance of superior breeding animals, a necessary condition for organizing any crossbreeding programme.

**Table 4:** The number of days goats stayed in study flocks during the observation period of 365 days – means (standard errors)

| | Categories | N | Komolcha | Gursum | Total |
|---|---|---|---|---|---|
| Breed group | Indigenous | 537 | 227.1 (12.1) | 189.3 ( 6.3) | 198.0 ( 5.6) |
| | Crossbred | 275 | 252.4 (10.2) | 228.0 (10.8) | 240.1 ( 7.5) |
| Sex | Females | 506 | 251.6 ( 9.9) | 219.6 ( 7.1) | 230.4 ( 5.8) |
| | Males | 306 | 219.1 (12.8) | 166.9 ( 8.3) | 182.3 ( 7.1) |
| Source of goat | Home-bred | 543 | 250.8 ( 9.1) | 207.6 ( 6.4) | 219.8 ( 5.3) |
| | Purchased/Transferred | 269 | 222.7 (14.4) | 180.4 (10.4) | 193.5 ( 8.5) |

The small flock sizes and associated variabilities (Table 5) partly explain the rapid turnover of goats. Furthermore, examination of the overall off-take (outflow) reveals that about two-thirds of the sales, slaughter and transfer cases were prompted by short-term objectives of meeting subsistence needs, i.e. forced outflows (Table 6).

These flock dynamics patterns suggest that the short-term objectives of the farmers override longer-term benefits (for themselves and the community), and hence farmers' decision-making behaviour does not favour the keeping and selection of high performance breeding males just for the purpose of breeding But this does not mean that indigenous goats do not respond to improvements in the level of management. As a related study on comparison of the overall aggregate benefits from the same study flocks has shown, the indigenous goats do respond to improvements in level of management, leading to higher realised net benefits to their owners per unit of land and labour used; the increments in overall benefits came from horizontal (multiplication) rather than vertical (intensification) improvements, by keeping more goats for the land and labour available through a combination of reduced goat losses, more kids born, higher off-take and a bigger stock of goats (Workneh et al., 2002).

**Table 5:** Variation of changes in the annualised sizes of study flocks by study group.

| Descriptors | Improved management | | Traditional management | Total |
|---|---|---|---|---|
| | Flocks with crossbred goats | Flocks with only indigenous goats | Control | |
| Number of flocks | 90 | 31 | 37 | 158 |
| Annualised average flock | | | | |
| Mean | 3.16 | 2.90 | 2.61 | 2.98 |
| Minimum | 0.36 | 0.07 | 0.22 | 0.07 |
| Maximum | 9.02 | 7.68 | 6.75 | 9.02 |
| Standard deviation | 1.96 | 1.59 | 1.61 | 1.83 |
| Total inflow: | | | | |
| Mean | 0.81 | 1.35 | 0.97 | 0.96 |
| Minimum | 0 | 0 | 0 | 0 |
| Maximum | 5 | 5 | 10 | 10 |
| Standard deviation | 1.26 | 1.66 | 1.86 | 1.51 |
| Total outflow: | | | | |
| Mean | 1.98 | 2.55 | 1.73 | 2.03 |
| Minimum | 0 | 0 | 0 | 0 |
| Maximum | 7 | 8 | 7 | 8 |
| Standard deviation | 1.68 | 2.08 | 1.59 | 1.76 |

**Table 6**. Estimated value (Birr) of average total and forced goat outflow by study group.

| Descriptors | Cross/Improved | Mixed/Improved | Indigenous/Improved | Indigenous/Traditional |
|---|---|---|---|---|
| Number of flocks | 28 | 62 | 31 | 37 |
| Value of total outflow (Birr) | 75.66 | 180.66 | 156.30 | 102.23 |
| Value of forced outflow (Birr) | 55.76 | 109.88 | 112.53 | 63.10 |
| In per cent of total outflow | 73.7 | 60.8 | 72.0 | 60.0 |

## Discussion

Apart from the influence of farmers' behavior on the maintenance of F1 breeding males, the reason for the declining trends of crossbreeding lies in the weak supply of improved stock (F1 goats and Anglo-Nubian bucks). It was assumed that local institutions, which had been collaborating with the DGDP throughout its implementation, would take over the task of distributing improved stock to the villages. However, both the extension services and private commercial farms were unable to deliver adequate numbers of improved stock. In fact, even the opportunity of utilizing group revolving funds for the procurement of crossbred breeding males from the nearby commercial producers was lost.

Lack of effective control of the breeding process, and the difficulty of stabilizing the exotic blood level in the crossbreds are the major operational limitations of crossbreeding programmes. These difficulties have also been common experiences in many dairy cattle crossbreeding programmes. In their extensive review of crossbreeding programmes of the *Bos indicus* with *Bos taurus* in the tropics, Cunningham and Syrstad (1987) have concluded that the continuous production of F1 crosses is either operationally difficult to set up or economically difficult to justify even for the more important dairy cattle industry. Although the evidence indicates that heterosis realised from crossbreeding is higher in poor than in good environments**,** the breeding programmes in developing countries are generally constrained by both physical and social environments, lack of records of performance, ill defined breeding objectives, and small population sizes (Bondoc *et al.*, 1989).

To develop a new gene pool, and gradually a new breed, through crossbreeding as tested by the DGDP, the emphasis should be on producing the breeding males through nominated matings and then selecting the best for extensive use (Cunnigham and Syrstad, 1987; Taneja, 1999). This requires measurement of individual performance, evaluation of animals, choice of breeding stock and organization of their use. But judging by the experiences of managing the crossbreeding station in the study area and its working link with the pilot villages, organizing such a systematic selection of breeding males, distributing them to the villages and monitoring their performance is difficult to manage without firm institutional support. Although the preliminary forms of animal breeding in the form of culling of inferior animals and selective mating by the farmers are theoretically possible, systematic performance recording as part of a genetic improvement process has yet to be demonstrated and institutionalised. However, the limitations are logistical rather than technical. The recording exercise needs to be cost effective and sustainable.

Furthermore, although crossbreeding is often regarded as an alternative to selection, any crossbreeding exercise inherently requires a supporting selection programme, either in the parental pure breeds, or in the resulting crossbred offspring (Cunningham and Syrstad, 1987; Pagot, 1992). Ironically, these technical constraints of operating long-term breeding programmes are the very reasons for the general recourse taken to the introduction of blood from breeds already selected in developed countries. Introduction of high producing exotic breeds has been carried out since the nineteenth century by importation of male breeding stock, and more recently by semen. Experience shows that an essential condition for the success of a crossbreeding programme is the presence of an integrated selection programme in the pure indigenous breed (Pagot, 1992), which even provides for the basis of long-term improvement of the indigenous genetic resource itself.

There is no doubt that crossbreeding programmes involve capital-intensive interventions in the form of importing exotic breeds, provision of improved husbandry practices (e.g. health care) and technical supervision. Too often these genuine desires of basic development assistance are dependent on critical foreign donations and credit. However, these resources have rarely been directed to supporting the low-input traditional production systems. Therefore, the opportunity costs of introducing, promoting and supporting crossbreeding programmes should be critically re-examined. For instance, would it be more cost-effective to invest the same resources (foreign capital, trained man power and time) in the investigation of the biology, economics and sustainability of the traditional production systems? The indigenous goats maintained under the same improved management as the crossbreds were observed to have responded strongly to improvements in feeding and basic health care, so that there was no difference in the unit net benefits between the two genotypes (Workneh, et al, 2002). The larger body weight of the crossbreds can mean that fewer but larger crossbred goats could generate the same aggregate benefits per unit of inputs, but this possibility is constrained by practicalities of maintaining an effective crossbreeding programme.

The conclusion is that the introduction of supposedly more productive exotic breeds for purposes of crossbreeding does not necessarily lead to genetic improvement of the subsistent mode of smallholder production. Neopane (2000) also reported that crossbreeding of local goats with introduced breeds was not successful in increasing productivity in the hill goats of Nepal; after 14 years of trial with crossbreeding, decision was taken to set up selection within the local breeds in an open nucleus scheme as a more viable tool for making genetic improvement in these goats. Similarly, Chiche *et al*., (2000) reported that 20 years of promotion of a commercial dairy industry in Morocco, based on imported European goat breeds, could not lead to transformation of the traditional mountain and steppe goat husbandry. The local breed proved a better option to survive and produce in the low-input management environment, and to satisfy the needs of the poor villagers as well as those of the small local markets.

The question remains, would it be possible to bring about similar improvements in productivity without the incentive of introducing the crossbreds? What would it take to initiate sustainable improvement of the traditional low-input management regimes of smallholder farmers? The improvements in livestock production (or increase per animal) will have to be made within the constraints of the available feed resources, prevailing disease challenges and marketing difficulties. The smallholder production system tends to follow such production strategies that are risk-averse and use low external inputs. Under these circumstances indigenous animals provide more realistic and sustainable options of improvement of livestock production. Because farmers are increasingly using their animals to meet their short-term subsistence needs, to the extent that the scope for long-term livestock development is limited, a direct way of helping them is to assist in meeting the immediate consumption needs through micro-financing schemes (Zeller, 1999), which provides for reduced turn over of animals, and hence the opportunity for longer term improvement. Existing indigenous institutions for informal financing and insurance services may provide the basis for these micro-financing schemes. Marketing of livestock and livestock products is another avenue for longer-term improvement. The largely subsistence mode of production needs to be gradually transformed into one that is market-oriented, which then can generate the economic incentives for investment on indigenous animals. Significant improvements in subsistence goat production could be achieved through reduction of losses (mortality, morbidity, loss) and wastages (poor reproduction, slow growth, high maintenance costs from replacement flock, morbidity and associated sub-optimal production) in the production process.

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# Slaughter Component Yield Characteristics of Some Indigenous Goat Types in Ethiopia

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## Abstract

*Slaughter data from 1547 male indigenous marketable goats (406 Afar, 389 Long-eared Somali, 412 Arsi-Bale and 340 Woyto-Guji,) were analyzed to compare carcass and edible-offal component yields. Dressing percentage (DP) was determined based on slaughter weight (SW). Percentage total edible offal component (PTEOC) was obtained as the sum of weights of blood, lungs (with heart and trachea), liver (with gall bladder), kidneys, omental fat, spleen (with pancreas) and gut empty. Percentage total non-edible offal component (PTNEOC) was obtained as the sum of weights of head (HD), skin (SK), testis with penis (TP) and gut fill total (GFT). Percentage total usable product (PTUP) was calculated as the sum of DP and PTEOC. These variables were computed as proportion of SW. The Afar, Arsi-Bale and Woyto-Guji goat types showed similar ($P > 0.05$) DP values, and they dressed significantly ($P < 0.01$) higher than the Long-eared Somali goat type (45.5 ± 0.17 %, 45.4 ± 0.16 %, and 45.2 ± 0.02 % vs. 43.5 ± 0.16 %, respectively). However, when PTEOC were considered with the carcass components, and when comparison was made on PTUP basis, the Afar goat type (62 ± 0.18 %) was superior ($P < 0.01$), followed by Arsi-Bale, Woyto-Guji goats and the Long-eared Somali goat type. Any livestock breed evaluation studies for meat production should emphasize the need to pay attention to the total yield of usable products, rather than the carcass weight and dressing percentages alone, in cultures where edible offal component is traditionally consumed.*

*Keywords*: Dressing percentage, carcass yield, indigenous goats, Ethiopia.

## Introduction

Ethiopia has an estimated 16.9 million goats, which ranks 3$^{rd}$ in Africa (next to Sudan and Nigeria) and accounts for 8.3% of the continents goat population (FAO, 1999). Nevertheless, there are only few documented research reports on goats (Workneh, 1992). The available research work on small ruminants mainly focus, on carcass yield and quality and tend not to be concerned with the non-carcass (offal) components (Ewnetu *et al*., 1998), despite the fact that in almost all parts of Ethiopia the offal component yields are important. It is common to find dishes exclusively made from these items (*dulet, milasina-senber, tripa)* in the majority of the restaurants in Addis

Ababa and other big towns of the country (Ewnetu *et al.,* 1998). Moreover, research has shown that the nutritive value of edible offal component items is comparable or even superior to that of the carcass (FAO, 1996).

Singh *et al*. (1985), and Mahgoub and Lu (1998) reported significant breed effect on the yields of carcass and offal components and showed that comparison of carcass characteristics between breeds gives information on the suitability and performance level of these breeds. On account of this background, the present study was carried out to evaluate the slaughter component yields of four Ethiopian indigenous goat types (Afar, Long-eared Somali, Arsi-Bali and Woyto-Guji) using goats slaughtered at the abattoir of the HELIMEX PVT. LTD. Company in Debre Zeit town, Ethiopia.

## Materials and Methods

### The study location

The study was conducted at Debre Zeit abattoir of HELIMEX (Hashim Ethiopian Livestock and Meat Exporter) Pvt. Ltd. company, Debre Zeit town, which is located about 44 km south east of Addis Ababa, Ethiopia at an altitude of 1800-m. a. s. l. The area receives an annual rainfall of 850 mm in a bimodal distribution. The extended dry season (October to February) has mean minimum and maximum temperatures of 15 and 28°C, respectively and a mean relative humidity of 60 % (HELIMEX, 2000).

### Animal source, management and identification

Four Ethiopian indigenous goat types, namely Afar, Long-ear Somali, Arsi-Bale and Woyto-Guji were used in this study. These goat types currently contribute most of the market goats for meat export by the Company (Addisu, 2001). Male goats procured from recognized areas of distribution of these goat types and that fulfil key-identifying features (FARM-Africa, 1996) were selected and identified for the study. These animals are considered to have been maintained under traditional management. Habitually purchased animals are transported on specialized tracks from markets directly to the abattoir with provision of feed and water enroute. They are then maintained at resting pens for about 10 days with ad-libitum provision of feed (grass hay, crop residues) and water. Experimental animals were selected at this stage and transferred for slaughter.

### Data collection

Using goat type as the stratifying variable, a total of 1547 male goats, randomly selected from 13670 goats slaughtered during the study period (21 September to 30 December, 2000) were used for this study. By goat type the sampled population consisted of 406 Afar, 389 Long-eared Somali, 412 Arsi-

Bale and 340 Woyto-Guji goats. These animals were properly identified to follow them through the slaughter process. All of these animals were kept without feed and water overnight (about 12 hrs) to have fasted weight for slaughter. Slaughter weight (SW) was taken about 30 minutes before slaughter.

The weight of blood (BLD), skin (SK), head (HD), hot carcass (CAR), liver with gall bladder (LV), lungs with heart & trachea (LU), testis with penis (TP), spleen with pancreas (SPP), omental fat (FAT), kidneys (KID), gut fill total (GFT) and empty gut (EG) were recorded during the slaughter process to the nearest 0.05 kg. Dressing percentage (DP) was based on CAR. Percentage total edible offal component (TPEOC) was taken as the sum of BLD%, LU%, LV%, SPP%, GE%, FAT% and KID%. Percentage total non-edible offal component (PTNEOC) was computed as the sum of HD%, SK%, TP% and GFT%. Percentage total usable product (PTUP) was taken as the sum of DP and PTEOC.

### Data analysis

Data were analyzed by the General Linear Model procedures of Statictical Analysis System (SAS, 1999) to compare carcass traits between the goat types.

## Results and Discussion

Overall and sub-class least square means by goat type, coefficient of determination and coefficient of variation for some important carcass characteristics are presented in Tables 1 and 2. In addition plots of linear regression of SW on DP, PTEOC and PTUP presented in Figures 1, 2 and 3.

**Table 1**. Least square means (± SE) for some carcass characteristics of some indigenous goat types in Ethiopia.

| Traits | $R^2$ (%) | Mean (±SE) | CV (%) | Afar | L.E. Somali | Arsi-Bale | Woyto-Guji |
|---|---|---|---|---|---|---|---|
| SW[1] | 88 | 19.4 ± 0.03 | 5.6 | 18.6 ± 0.11[d] | 20.3 ± 0.1[b] | 21.0 ± 0.10[a] | 19.4 ± 0.09[c] |
| DP | 46 | 44.5 ± 0.04 | 3.9 | 45.5 ± 0.17[a] | 43.5 ± 0.16[b] | 45.4 ± 0.16[a] | 45.2 ± 0.15[a] |
| PTEOC | 26 | 16.1 ± 0.02 | 4.8 | 16.5 ± 0.07[a] | 16.3 ± 0.07[a] | 15 8 ± 0.07[b] | 15.9 ±0.06[b] |
| PTUP | 44 | 60.6 ± 0.05 | 3.1 | 62.0 ± 0.18[a] | 59.8 ± 0.18[c] | 61.2 ± 0.17[b] | 61.1 ± 0.16[b] |
| PTNEOC | 44 | 39.4 ± 0.1 | 4.7 | 38.0 ± 0.18[c] | 40.2 ± 0.18[a] | 38.8 ± 0.17[b] | 38.9 ± 0.2[b] |

**Note**: Means within a trait in the same row with different superscripts differ significantly (p < 0.05).

[1]=SW (slaughter weight), DP (dressing percentage), PTEOC (percentage total edible offal component), PTUP (percentage total usable product), PTNEOC (percentage total non-edible offal component0, CV, coefficient of variation; $R^2$ , coefficient of determination; SE, standard error of difference;

Even though significant (at least P < 0.05) difference exists in SW between types, Afar, Arsi-Bale and Woyto-Guji goat types had no significant difference (P > 0.05) in DP values; and they dressed significantly (P < 0.01) higher than the Long-eared Somali goats. However, if PTEOC were also considered with DP, and comparison was made on PTUP basis, then Afar goats become significantly ($P < 0.01$) superior, followed by Arsi-Bale or Woyto-Guji types (Table 1). The value of dressing percentage observed in this study for Afar goats (45.5 ± 0.17 %) was different from the report of Solomon *et al.* (1991), but only 18 samples were used in the latter compared to 406 in the present study.

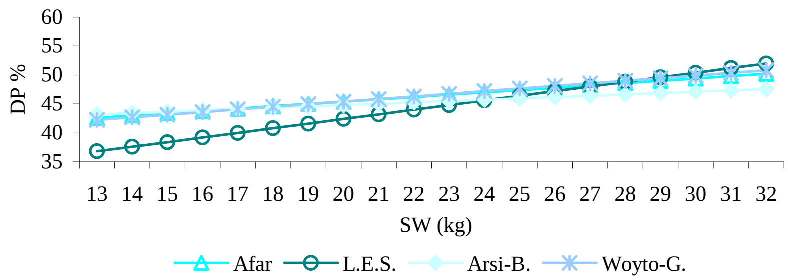
Despite the highest proportionate total non-edible offal component (PTNEOC) in the Long-eared Somali goat breed type, the share of proportionate values of head in the corresponding goat breed type (6.9 ± 0.06 %) was significantly ($P < 0.01$) lower than the values found in the other goat breed types. This could be attributed to the relatively short horns, and hence smaller head size of the Long-eared Somali goat type possesses as compared to the other goat breed types (Table 2). This result is consistent with an earlier report by FARM-Africa (1996), where it was reported that this breed type had the shortest male horn length among Afar, Arsi-Bale and Woyto-Guji. Among the means compared the most varied values were observed in spleen with pancreas and omental fat (FAT) which had coefficient of variation of 29.9 % and 17.4 %, respectively (Table 2).

**Table 2**. Least square means (± SE) for different carcass variables of indigenous goat types in Ethiopia.

| Variables | $R^2$ (%) | Mean (±SE) | CV (%) | Afar | L.E. Somali | Arsi-Bale | Woyito-Guji |
|---|---|---|---|---|---|---|---|
| BLD%[1] | 42 | 3.2 ± 0.01 | 8.5 | 3.5 ± 0.03$^a$ | 3.2 ± 0.03$^b$ | 3.0 ± 0.02$^c$ | 3.1 ± 0.02$^c$ |
| LU% | 35 | 1.8 ± 0.004 | 8.8 | 1.9 ± 0.02$^a$ | 1.7 ± 0.02$^c$ | 1.7 ± 0.01$^c$ | 1.8 ± 0.01$^b$ |
| LV% | 37 | 1.9 ± 0.01 | 9.7 | 2.0 ± 0.02$^a$ | 1.8 ± 0.02$^c$ | 1.8 ± 0.02$^c$ | 1.9 ± 0.02$^b$ |
| SPP% | 22 | 0.5 ± 0.004 | 29.9 | 0.6 ± 0.01$^b$ | 0.7 ± 0.01$^a$ | 0.5 ± 0.007$^c$ | 0.4 ± 0.01$^d$ |
| GE% | 13 | 7.7± 0.001 | 5.5 | 7.6 ± 0.04$^b$ | 7.8 ± 0.04$^a$ | 7.9 ± 0.04$^a$ | 7.9 ± 0.04$^a$ |
| FAT% | 66 | 0.7 ± 0.003 | 17.4 | 0.6 ± 0.01$^c$ | 0.9 ± 0.01$^a$ | 0.7 ± 0.01$^b$ | 0.6 ± 0.01$^c$ |
| KID% | 51 | 0.25 ± 0.0004 | 6.2 | 0.2 ± 0.002$^d$ | 0.2 ± 0.001$^d$ | 0.4 ± 0.001$^a$ | 0.3 ± 0.001$^b$ |
| PTEOC | 26 | 16.1 ± 0.02 | 4.8 | 16.5 ± 0.07$^a$ | 16.3 ± 0.07$^a$ | 15.8 ± 0.07$^c$ | 15.9 ± 0.06$^b$ |
| HD% | 50 | 7.6 ± 0.02 | 7.8 | 7.8 ± 0.06$^a$ | 6.9 ± 0.06$^c$ | 7.4 ± 0.05$^b$ | 8.0 ± 0.05$^a$ |
| SK% | 17 | 11.1± 0.03 | 9.1 | 10.7 ± 0.1$^b$ | 11.1 ± 0.1$^a$ | 11.1 ± 0.1$^a$ | 11.3 ± 0.1$^a$ |
| TP% | 95 | 1.3 ± 0.002 | 5.6 | 1.1 ± 0.006$^b$ | 1.0 ± 0.01$^c$ | 1.1 ± 0.06$^b$ | 1.2 ± 0.01$^a$ |
| GFT% | 20 | 19.5 ± 0.06 | 11.9 | 18.4 ± 0.2$^c$ | 21.2 ± 0.2$^a$ | 19.2 ± 0.2$^b$ | 18.6 ± 0.2$^c$ |
| PTNEOC | 44 | 39.4 ± 0.1 | 4.7 | 38.0 ± 0.18$^c$ | 40.2 ± 0.18$^a$ | 38.8 ± 0.17$^b$ | 38.9 ± 0.2$^b$ |

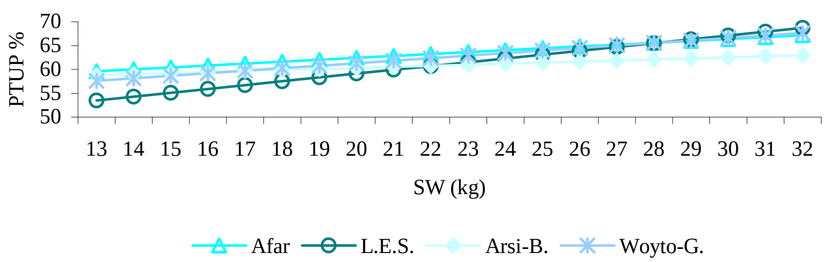
Note: Means within a trait in the same row with different superscripts differ significantly ($p < 0.05$).

[1]BLD (blood), LU (lung with heart), LV (with gall bladder), SPP (spleen with pancreas), GE (gut empty), FAT (omental fat), KID (kidneys), PTEOC (percentage total edible offal component), HD (head), SK (skin), TP (testis with penis), GFT (gut fill total), PTNEOC (percentage total non-edible offal component), CV, coefficient of variation; $R^2$ coefficient of determination; SE, standard of difference;



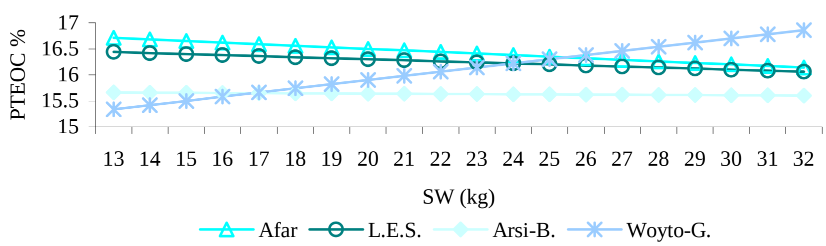

Note: DP, dressing percentage; SW, slaughter weight in kg; Afar, Afar goat type; L.E.S., Long-eared Somali goat type; Arsi-B., Arsi-Bale goat type ; Woyto-G., Woyto-Guji goat type;

**Figure 1**. Linear regressions comparing dressing percentage increase in relation to slaughter weight in indigenous goat types.




Note: PTUP, percentage total usable products; SW, slaughter weight in kg; Afar, Afar goat type; L.E.S., Long-eared Somali goat type; Arsi-B., Arsi-Bale goat type ; Woyto-G., Woyto-Guji goat type;

**Figure 2.** Linear regressions, comparing percentage total usable products increase in relative to slaughter weight.




Note: PTEOC, percentage total edible offal component; SW, slaughter weight in kg; Afar, Afar goat type; L.E.S., Long-eared Somali goat type; Arsi-B., Arsi-Bale goat type ; Woyto-G., Woyto-Guji goat type;

**Figure 3**. Linear regressions, comparing percentage total edible offal component in relative to slaughter weight.

Dressing percentage values were the least for the Long-eared Somali up to 24 kg slaughter weight, and it improved for higher weights. On the other hand, the Arsi-Bale goats had the lowest DP beyond 24 kg slaughter weight (Figure 1).

Because PTEOC appears to follow the same trend as DP, the Long-eared Somali had the lowest PTUP up to 24 kg and thereafter the Arsi-Bale had the lowest value (Figure 2). The explanation for this trend is presented in Figure 3 where the proportion of edible offal is more stable over the observed range of SW for the Arsi-Bale goats whereas it declines for the Long-eared Somali goats. A more striking observation was the continuous rise of PTEOC for the Woyto-Guji goats over the same SW range. These relationships combined with ages of slaughter animals could have provided the relative production potential for meat and edible offal; however, this study does not provide data on age of slaughter animals.

From these results on carcass traits, Arsi-Bale and Woyto-Guji goat breed types were more closely related than with the others, and this observation is consistent with earlier results of Workneh (1992), Alemayehu (1993), on breed similarities.

## Conclusion

From the results obtained under the conditions of this study, it can be concluded that, comparatively more proportionate total usable products was obtained in Afar goats up to 24 kg and this was mainly due to their higher values of DP with PTEOC up to 24 kg than the other goat breed types. The value of overall PTNEOC ($40.2 \pm 0.18$ %) was significantly ($P < 0.01$) different and was the highest in Long-eared Somali goat type. The low production of consumable slaughter component from these animals was a result of the greater share of PTNEOC.

Any goat breed evaluation studies for meat production should emphasize the need to pay attention to the total yield of usable products, rather than only to the carcass weight and dressing percentages, in cultures where edible offal components are traditionally consumed. Inclusion of this edible offal with carcass in breed comparison may help understand farmer and consumer preferences for certain breeds.

The data collection methodologies developed and tested in this study could well be used for related exploratory livestock studies in abattoirs.

Because the consumption of the non-carcass component widely differs from place to place, the figures reported in this study should be interpreted with caution. The items included in this work as edible may not be consumed in some parts of the country; and some of them, which were considered non-edible (e.g. testicles and the head), may be consumed in other parts. Furthermore, since the slaughter was not specifically designed for this purpose, items like tongue were not weighed individually and, thus, were not included in the analysis of edible offal. Additionally, the flesh on the head was not dissected and, thus, not included in the edible offal. On the other hand, because gall bladder and liver were weighed together, gall bladder was considered as edible offal.

**Pictures of representative goat breed types used for the study**

Afar goat breed type

Long-eared Somali goat breed

Arsi-Bale goat breed type

Woyto-Guji goat breed

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# Traditional Horro Cattle Production in Boji District, West Wellega (Ethiopia)

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## Abstract

*Inputs and outputs of traditional Horro cattle farming were monitored during the year 2001 in Boji District, West Wellega, located in the highlands of western Ethiopia. Inputs such as feeding and veterinary care were low. Milk and butter production, calf growth and animal work were also monitored. The mean lactation length was 314 ± 91 days. The total lactation milk yield was found to be 587 litres, 37% of which was suckled by the calf. The average yearly household butter production was 31.5 ± 8.9 kg. The retail butter price was 14.10 Birr/kg. The mean body weight one week after birth was 15.2 ± 3.0 kg and the daily weight gain from birth to 6 months was 110 ± 41 g. Oxen were worked seasonally for about 101.7 days per year, ploughing being the major (89%) activity. Low production performance is explained by prevailing feed shortage during dry season, inappropriate calf management, widespread animal diseases and low genetic potential. The urgency to increase livestock productivity in this overpopulated highland area by way of designing and implementing appropriate policies was recommended. In addition, the need to conduct on-farm productivity research was indicated as part of the means to find long term solutions to the existing constraints.*

*Keywords*: Productivity research, on-farm research, herd monitoring, Horro cattle, Boji

## Introduction

Livestock productivity in Africa is the lowest in the world. Of countries within the continent Ethiopia, in this respect, stands among the least (ILRI, 2000). In Africa, during the 1980's, more than 90% of all cattle were kept under traditional management system (De Leeuw and Wilson, 1987). Currently, in Ethiopia 85% of the 65 million inhabitants is a rural population, mainly composed of smallholder farmers whose livelihood is dependent on both agriculture and livestock. Prevalence of suboptimal nutrition and

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widespread animal diseases are the two major constraints on livestock productivity in Ethiopia (Zenash Sileshi *et al.*, 2001).

Most of the researches on cattle productivity in Africa, including Ethiopia, have been carried out on research station or on modern management systems (dairy farms, commercial ranches). In Ethiopia, few researches were undertaken to study livestock production under traditional husbandry mainly dwelling in the highlands mixed crop-livestock production system (Gryseels *et al.*, 1989; Mukasa-Mugerwa *et al.*, 1989). The latter generally showed low performances of zebu cattle in the country.

In Ethiopia, the population is growing at a rate of 3.2% per year (Cordellier and Didiot, 1997) and demographic projections show a doubling of the existing figure within the next 25 years. In this alarming context, on farm research aiming at optimising productivity of livestock is an urgent matter. The suggested productivity research first needs to quantify performance indicators and identify limiting factors leading to the formulation of appropriate recommendations.

On-station research on production of Horro cattle has been studied at Bako (Legesse Dadi *et al.*, 1992 ; Mulugeta Kebede *et al.*, 1993). In addition the reproductive and demographic performances of Horro cattle in Boji district (West Wellega) were described by Lesnoff *et al.* (2002). On farm research outputs on this indigenous cattle breed are virtually non-existent. The objective of this paper was therefore to quantify inputs to cattle farming and production performances (milk and butter production, calf growth and work) using recommended appropriate indicators (ILCA, 1990). In addition costs of inputs and monetary values of animal productions are estimated, limiting factors affecting performance discussed and recommendations made.

# Materials and Methods

## Description of the Study Area

### Geographic and climatic characteristics of the Boji district

Boji district is located in West Wellega (Western Ethiopia) at latitude of 9.36° N and longitude of 35.59° E and with a surface area of 966.1 km$^2$.

The district is inhabited by a population of 100,300 (CSA, 2001) corresponding to a density of 103.8 inhabitants/km$^2$. The area is predominantly classified as "Woynadega" (middle altitude) zone with an altitude varying from 1200 to 2100 m. asl. (Amare Getahun, 1978). The rain is monomodal in pattern and occurs mainly between May and October with a peak in July. The annual rainfalls in district vary between 1300 and 2000 mm (West Wellega Zonal Agricultural Office, 2002, personal communication). The year is divided into 4 seasons of 3 months: *Bona* (dry season) from December to February, *Arfasa* (beginning of the rainy season) from March to May, *Gana* (main rainy season) from June to August and *Birra* (spring) from September to November.

### The production system

The agricultural production system in Boji district is essentially mixed crop-livestock farming with small farm size and a subsistence economy. Cattle farming, with an average herd size of 10.5 heads of cattle, plays a major role in the production system (Laval et al., 2002). Livestock are mainly kept for farm works, oxen being used in ploughing activities. Manure, milk, butter and live animals are also important in the production system. Manure is used only as an organic fertiliser but never as fuel as is the case in other parts of Ethiopia. Milk is traditionally processed to butter and cottage cheese for both in house use and as a source of cash income for the family. Live animals may be sold at the local markets or slaughtered, the meat and hides being consumed by farm households. The demographic and reproduction parameters of cattle in the district were depicted by Lesnoff et al. (2002) (Table 1). An additional feature is the practice of oxen exchange (referred locally as *goubo* contract) through loans among individual farmers expressed in a form that a farmer lending an ox for traction in exchange for a share of part of the crop produced during the harvest period (Laval et al., 2002). Small ruminants production is not well developed in Boji district.

**Table 1.** Estimated annual probabilities of cattle mortality, slaughter, sale and lending out by age class (0 to 12 months, 1 to 3 years and ≥4 years (48 months) in 70 herds in Boji district for one year (2001).

| | Females | | | Males | | |
|---|---|---|---|---|---|---|
| | 0 to 1 | >1 to 4 | >4 | 0 to 1 | >1 to 4 | >4 |
| Mortality | 0.163 | 0.094 | 0.029 | 0.160 | 0.087 | 0.026 |
| Slaughtering | 0.000 | 0.000 | 0.012 | 0.000 | 0.000 | 0.010 |
| Sale | 0.009 | 0.062 | 0.044 | 0.010 | 0.045 | 0.115 |
| Lending out | 0.170 | 0.341 | 0.336 | 0.200 | 0.451 | 0.390 |

## Study Design

### Herd monitoring

The herd monitoring method was employed to quantify production performances and inputs of cattle farming in the study area as per the recommendation of Faugère and Faugère (1986), ILCA (1990), De Leeuw *et al.* (1995) and van Klink *et al.* (1996) for animal productivity research to collect reliable and accurate data.

Seventy selected herds as representatives of the highland at 15 km radius from the capital of Boji district (Bila) were monitored for one year (December 2000 to November 2001). Each animal was ear-tagged for permanent identification. The monitoring process had demographic and health components. Trained enumerators visited the herds every two weeks to record all demographic events, the reasons of these events (birth, death, slaughtering, purchase, sale or loan) and, in case of trade, the sale price. Clinical signs of sick animals and the type and cost of veterinary care applied were also registered. Animal production data were collected from the 13 of the 70 herds for a period covering from December 2000 to January 2002. The animals belonged to 18 smallholder farmers (some herds were shared between two or more farmers). Selection of these herds was based on the presence of cows beginning to lactate at the start of the monitoring. Animal production data collected included milk and butter production, calf growth, animal work and animal feeding. Manure production data was not monitored in this study. Required labour for animal keeping was investigated through interviews with farmers.

**Milk and butter production monitoring**

A total of 63 lactating cows with delivery dates accurately known were monitored. Of these, only 34 were monitored for the entire lactation period. 25 of the cows delivered during the period from October to December 2000, composing a cohort, whose lactation curve is shown on Figure 1. Two enumerators visited each farm morning and evening once a week. The quantity of milk collected for human consumption (milk off-take) from each lactating cow was measured with a calibrated glass (cl). The quantity of milk consumed by the calf was measured for 30 calves as per the method described by ILCA (1990). The latter consisted of weighing of calves before and after suckling with a scale (0.1 kg accuracy). Weekly butter production (sold or consumed) in 18 households was monitored from December 2000 to January 2002. It was measured with a scale (25g accuracy). The sale prices were recorded.

**Calf growth monitoring**

The weekly body weight of 19 calves (12 females and 7 males) was measured from first week after birth up to the age of 6 months. Due to deaths and animal movements (exchanges, sale), 17 calves only were present 3 months after birth and 12 at the age of 6 months.

**Animal work monitoring**

Number of days and length in a day of work, nature of the work and beneficiary (owner or other farmer) were recorded for 60 male cattle aged more than 4 years. Because of the high frequency of animal exchanges between farmers, only 12 oxen were available and monitored continuously for one year for the work provided at own farm and outside. Three types of work were distinguished, namely traction, threshing and trampling. The monetary value of traction work was estimated from 10 *goubo* contracts (animal loans) recorded.

**Animal feeding practice monitoring**

Supplementary feed given to cows and oxen (type, quantity, and price) was recorded weekly and compiled on monthly basis.

## Performance Indicators and Statistical Analysis

The total lactation milk yield and the lactation length are the most relevant indicators of milk performance in subsistence systems (ILCA, 1990). Hence, the total lactation milk yield in this study was calculated as the sum of the average weekly milk production (for lactating cows only) for the whole lactation period (from 1$^{st}$ week after delivery to last week of lactation). The annual milk yield per cow was calculated as total lactation milk yield multiplied by calving rate. The latter is computed for adult females (>4 years) as the average number of calving/year (Lesnoff et al., 2002). Calving rate was estimated to be 0.371 years$^{-1}$.

Calf growth is computed as the average daily weight gain, as per ILCA's (1990) recommendation. A weight/consumption conversion factor, defined as the quantity of milk (litres) consumed by a calf before weaning for 1 kg of body weight gain, was calculated for the first 3 months. T-test statistics was used to compare means of lactation lengths between cows of various lactation numbers and calf weight and weight gains between sexes.

Work performances were described with the total yearly work production per animal, calculated as the summation of the individual weekly average days of work (for working males only) in a year.

The rate of veterinary treatments use per animal was computed with the "hazard rate" (or instantaneous risk). For an homogeneous set of individuals, the hazard rate $\mu$ (if assumed constant with age) of a specific event (e.g. treatment) can be estimated by the ratio y/T, where y is the number of observed cases of this event (e.g. the number of treatments) and T the total time at risk (Lee, 1992).

Statistical analyses were performed employing SPSS Base 10.0 (1999), a computer-based statistical software.

# Results

## Herd Composition

The 13 herds selected for animal production monitoring were of various sizes from small (4 animals) to large (30 animals) with an average number of 17.5 heads of cattle. During the year 2001, each of the 18 farmers owned an average of 12.7 animals including 4.8 adult females (above 4 years), 50% were in lactating, and 2.6 adult males.

## Inputs

The inputs to livestock farming included labour, animal feed and veterinary care.

Labour was required for animal herding. The herders were often family members (young boys) who are always available when needed. For bigger herds, a herdsman, often a young boy from a poor family, was sometimes employed with the salary rate of 80 to 100 Birr per year plus full boarding provisions.

Pasture was the main feed in the existing traditional production system. Leaves from natural trees were also provided during the end of the dry season when the main feed-resource base was scarce. Lactating cows and working males were supplemented with crops grain (maize, sorghum and millet), at an average rate of 4 kg/working male/year (mostly in September), and 8.5 kg/lactation for cows. Lactating cows were also supplemented with residues of local brewery (arake) and maize or sorghum seedlings (all together on average 24 kg/lactation). Salt was provided to lactating cows and working males at an average rate of 2.3 kg/lactation and 3.8 kg/year, respectively. The supplementary feeding cost for the full lactation period was estimated to be 15.70 Birr (1 Birr = 0.118 US$ in 2001). Supplementary feeding of males was seasonally linked to the presence of agricultural activities and its cost was estimated at 9.70 Birr/animal/year.

The yearly hazard rate of treatment administration was 0.090 and the yearly average cost of veterinary care / animal (all categories considered) was estimated at 0.48 Birr. Only 7% of the antibiotics and 3% of other treatments were provided by the public services, while all other health cares were delivered either through private services or informal markets (smugglers, farmers themselves or healers). Veterinary inputs are shown in Table 2.

## Milk and Butter Production

The mean ($\pm$ SD) lactation length of Horro cattle in Boji was 314.3 $\pm$ 91.4 days with the median, minimum and maximum values of 291.5, 145 and 530 days, respectively. The lactation period was longer for cows at $\geq$ 4 lactation and lower for those at 2nd and 3rd lactation (Table 3). The variation, however, was not significant ($p>0.05$). The average total lactation milk yield calculated for 45 weeks was 587.2 litres. Out this, 369.1 litres (62.9%) were destined for human consumption and the remaining 218.1 litres was suckled by the calf. The average daily milk yield and milk off-take were 1.86 and 1.18 litre, respectively. The mean annual milk yield was 217.9 litres. Figure 1 shows a calendar related lactation curve for a cohort of 25 cows. The average household production of butter for year 2001 was 31.5 $\pm$ 8.9 kg/household, of which 12.9 $\pm$ 4.7 kg (41%) was sold. The average monthly butter sold at household level was relatively stable throughout the year, irrespective of the level of variation in the production (decrease at the end of the dry season).

**Table 2**. Yearly veterinary inputs of livestock farming in relation to categories of animal (age-sex groups) from 70 herds in Boji district (1st December 2000 to 30 November 2001).

| Animal categories | Type of treatment | Yearly hazard rate of treatment | Average cost of treatment (Birr) | Yearly average cost per animal (Birr year$^{-1}$) |
|---|---|---|---|---|
| Calves | ATB[a]: | 0.005 | 1.35 | 0.01 |
| | Other[b] | 0.033 | 1.25 | 0.04 |
| Heifers (1-4 years) | ATB | 0.031 | 6.13 | 0.19 |
| | Other | 0.031 | 2.71 | 0.08 |
| Females above 4 | ATB | 0.048 | 8.04 | 0.39 |
| | Other | 0.065 | 4.28 | 0.28 |
| Bulls (1-4 years) | ATB | 0.029 | 5.67 | 0.16 |
| | Other | 0.019 | 3.00 | 0.06 |
| Males above 4 | ATB | 0.067 | 7.63 | 0.51 |
| | Other | 0.058 | 3.93 | 0.23 |
| | Castration | 0.049 | 0 | 0 |
| All categories | ATB | 0.041 | 7.28 | 0.30 |
| | Other | 0.049 | 3.76 | 0.18 |

[a] ATB: Antibiotic treatments: they include oxytetracycline and penicillin

[b] Other: other treatments than antibiotics: they include anthelminthics, trypanocides, and traditional treatments

**Table 3**. Mean lactation length and total lactation milk yield in relation to lactation number in 13 herds, Boji district, West Wellega, Ethiopia (2001)

| | Lactation number | | | |
|---|---|---|---|---|
| | number 1 | number 2 and 3 | $\geq$ number 4 | All numbers |
| Sample size | 5 | 21 | 8 | 34 |
| Mean lactation length (days) | 320.2 (46 weeks) | 293.4 (42 weeks) | 365.4 (52 weeks) | 314.3 (45 weeks) |
| Standard Deviation (days) | 89.0 | 83.4 | 103.1 | 91.4 |
| Total lactation milk yield (litre) | 622.9 | 566.4 | 626.5 | 587.2 |

## Calf Growth

The mean body weights of calves at one week, three months and six months of age were 15.2 ± 3.0, 29.8 ± 7.1 and 35.0 ± 8.6 kg, respectively. The minimum and maximum body weight recorded at one week of age was 9.8 and 23.0 kg, respectively. Average daily weight gains of calves at the various ages are shown in Table 4. There was no statistically significant difference ($p>0.05$) in mean body weight and weight gains at various ages between male and female calves. The weight/consumption conversion factor amounted to 8.9 litres of milk/kg of weight gain.

## Animal Work

A total yearly work of 101.7 days, of which 90.5 days (89.0 %) for ploughing, 8.3 days (8.2 %) for threshing and 2.9 days (2.8 %) for trampling was obtained. The average daily ploughing duration was 4h33 ± 0h40, with a range of 2 to 6 hours and seasonal variation (Table 5 and Figure 2). The results revealed that months of maximal work were June, July and August with 13.3, 17.7 and 14.1 days of work, respectively. Conversely, the months of minimal work were March and April with 2.5 and 0.9 days of work, respectively. Oxen were used for threshing from December to March, after the crops harvest, and for trampling mostly during August at the time of preparation of *tef* fields.

From the data on 12 oxen (complete year-round information), it appeared that 78.4% of the traction work was done for the owner's benefit (ploughing own land), 15.3% was provided to another farmer through a goubo contract and 6.3% was provided to a neighbour or relative in kind or free of charge. An average of 14.8 ± 11.8 days of goubo contract per year was recorded.

**Table 4.** Average daily weight gain of Horro breed at various stages of growth in 13 herds in Boji district, West Wellega, Ethiopia (2001).

| Daily weight gain | Birth - 3 months | Birth – 6 months | 3 – 6 months |
|---|---|---|---|
| Average (kg) | 0.157 | 0.110 | 0.063 |
| SD (kg) | 0.061 | 0.041 | 0.046 |
| Minimum (kg) | 0.058 | 0.048 | -0.007 |
| Maximum (kg) | 0.242 | 0.186 | 0.133 |
| Number of records | 17 | 12 | 12 |

**Table 5.** Characteristics of on-farm traction activities in relation to the 4 seasons in 13 herds in Boji district, West Wellega, Ethiopia (2001).

| | SEASON | | | |
|---|---|---|---|---|
| | Bona (dry season) | Arfasa (beginning of rainy season) | Gana (main rainy season) | Birra (spring) |
| Work duration (hours) | 4:22 | 5:04 | 4:53 | 4:05 |
| Number of days of traction (days) | 21.3 | 10.3 | 44.2 | 15.9 |
| Distribution of traction days within the year (%) | 24% | 11% | 47% | 18% |
| Number of days of goubo contract[a] (days) | 1.8 | 2.8 | 8.2 | 2.1 |
| Distribution of contract days within the year[a] (%) | 12% | 19% | 55% | 14% |

[a] calculated from 12 oxen followed 365 days continuously during year 2001

## Monetary Value of Animal Production

The average producers' price of 1 kg of butter in the study area was 14.10 Birr during the year 2001. The monthly values varied from 17.30 Birr in April to 11.50 Birr in November. In January 2002, butter price was 13.00 Birr, which showed a decrease of 22% as compared to January 2001 (16.70 Birr) (Figure 3). In the year 2001 the average household yearly income from butter sale was found to be 185 $\pm$ 65 Birr.

Through *goubo* contract system, 160 kg of sorghum was exchanged for 30 days of traction work by a single ox. In monetary terms, a day of traction work by rented ox was thus estimated to be 2.70 Birr.

The estimated sale prices of live animals are shown in Table 6. About 72% of the cattle sales occurred in an official market often involving male animals. The rest of the transactions (28%) occurred directly at farm level and mainly referred to female animals.

**Table 6.** Average sale prices of live animals per age-sex class in 70 herds in the Boji district, West Wellega, Ethiopia (2001)

| | Categories of animals | | | | |
|---|---|---|---|---|---|
| | Bulls (1to 3y) | Males ($\geq$4 y) | Heifers (1 to 3y) | Females ($\geq$4 y) | All categories |
| Number of animals | 24 | 88 | 24 | 65 | 201 |
| Average (Birr) | 258.1 | 504.9 | 311.8 | 484.1 | 445.7 |
| Standard Deviation (Birr) | 60.1 | 117.7 | 90.2 | 164.2 | 156.2 |
| Minimum (Birr) | 170 | 200 | 190 | 200 | 170 |
| Maximum (Birr) | 420 | 830 | 500 | 800 | 830 |
| Median (Birr) | 247.5 | 500 | 300 | 465 | 450 |

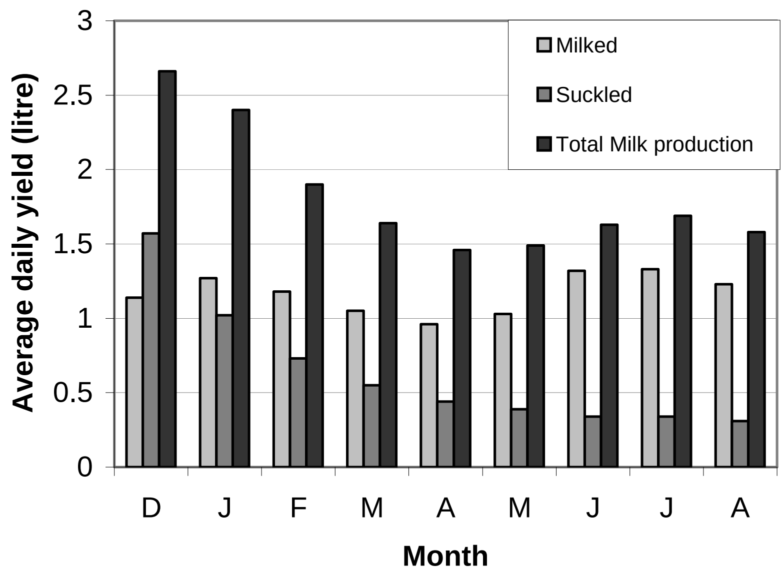


**Figure 1.** Average daily milk yield (milked and suckled) per month during year 2001 for a cohort of 25 cows under traditional management in Boji district, West Wellega, Ethiopia.

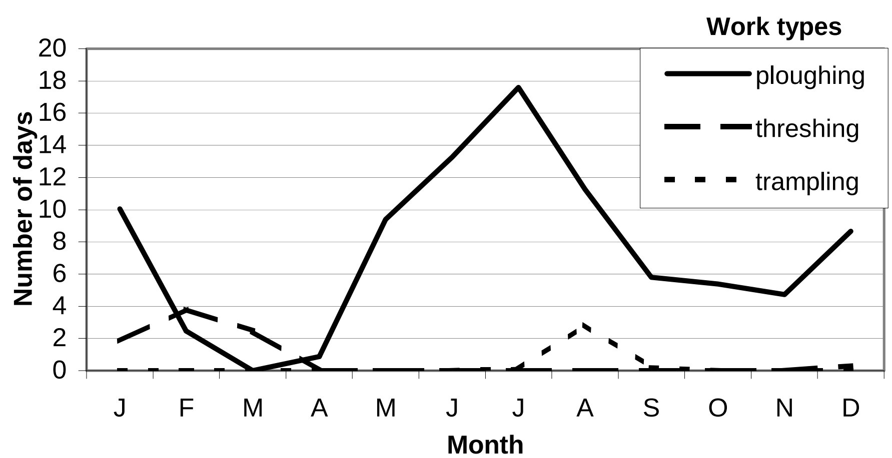


**Figure 2.** Monthly days and types of oxen work during year 2001 in Boji district, West Wellega, Ethiopia (from 13 herds).

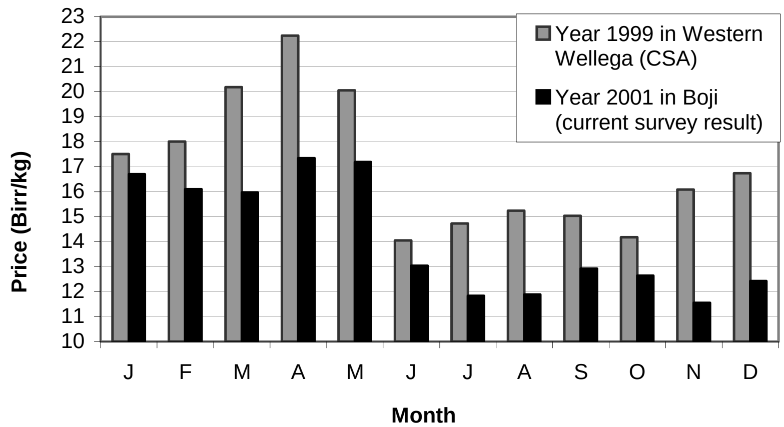


**Figure 3.** Comparison of the monthly average producers' price of butter in West Wellega during year 1999 (CSA, 1999a; CSA, 1999b; CSA, 2000) and the current (2001) survey findings from 18 households in Boji district, West Wellega, Ethiopia.

## Discussion

On-farm studies on cow feeding in Ethiopia mostly focused on crossbreed cows (Gashaw Geda *et al.*, 1991) and no quantitative data for on-farm zebu cows feeding were available for comparison. Feed inputs of cattle in Boji district are similar to the descriptions previously made for other highland areas in Ethiopia (Mukasa-Mugerwa *et al.*, 1989 ; Benin *et al.*, 2002), mainly composed of grazing pasture and various crop by-products. Supplementation of cattle with small quantities of crops grain and salt observed in the study area was also described in the central highlands (Goe,1987) and in the eastern highlands (Fekadu Abate and Alemu Yami, 2000). Feed shortage during the dry season was a major constraint in Boji district as described for other highland areas (Gryseels *et al.*, 1989 ; Legesse Dadi *et al.*, 1992), which is attributed to overstocking and overgrazing (Mohamed-Saleem and Mwendera, 1996) and lack of appropriate feeding management. Though population growth lead to a shift of grazing lands to crop cultivation in Boji, more pasture is still available to cattle as compared to the intensively cultivated areas of the central highlands where the ever declining in use of grazing lands availability forced livestock owners to heavily depend on purchased feed and crop residues (Hailu Beyene and Chilot Yirga, 1992 ; Benin *et al.*, 2002).

Despite the prevalence of cattle diseases, on-farm veterinary inputs were generally low in Boji district (0.48 Birr per head of cattle per year).

Contrasting to this scenario, Baars (1998) reported an average yearly expenditure of 800 Birr per herd (average of 43 TLU/herd) in pastoral areas in eastern Ethiopia. The use of Public veterinary services was low in the study area, mainly due to their distant location away from localities where major segments of the beneficiaries live. Because of this constraint farmers usually buy veterinary products indirectly and administer by themselves to sick animals.

The genetic potential of Horro breed for milk production was reported to be poor (Alberro and Haile-Mariam, 1982). The average total lactation milk off-take obtained in the present study (369.1 litres) however was higher than the figures (<300 litres) seen in former reports based on-farm investigations or other zebu breeds in the traditional highland systems in Ethiopia (Gryseels *et al*., 1989; Mukasa-Mugerwa *et al*., 1989). On the other hand higher lactation period (10.5 months) was recorded during the study when compared with other reports (7 months around Bako (Legesse Dadi *et al*., 1992), 7 and 8 months in the central highlands (Gryseels *et al*., 1989; Mukasa-Mugerwa *et al*., 1989)). The finding from the present study is in full disagreement with the assertions of Alberro and Haile-Mariam (1982) who mentioned a short lactation period of 6 months as a specific feature of the Horro breed. Figure 1 shows clearly the effect of season on milk production and off-take. Milk off-take during the end of the dry season (March-April-May) was lower, approximately 1.0 litre/day, than during the wet season (above 1.3 litres/day). The figures obtained in the study are relatively higher than those reported for Bako (Legesse Dadi *et al*., 1992) and in 5 other traditional livestock systems in Africa (De Leeuw and Wilson, 1987). Milk performances reported for Horro breed on station, 2.4 litres/day, were higher with a lactation length of 229.8 days (Mulugeta Kebede *et al*., 1993) than the current findings from on-farm study. The difference is a reflect of the potential of Horro cattle, which is under-utilised on-farm conditions due mainly to poor management. As in many other regions of Ethiopia butter is a substantial source of cash income for households in Boji district (Duteurtre, 1998). The greatest proportion of the butter was often sold at the expense of household consumption, signifying the importance of the cash generated from this commodity to the producers.

The findings from studies on traditional cattle husbandry in sub-Saharan Africa (De Leeuw and Wilson, 1987) showed daily weight gains in the first year varying between 150 and 220 g, with greater figures in the first six-month period. The figures found in the current study were much lower (110 g, from birth to 6 months). The body weight at one week of Horro cattle from Boji was 15.2 kg, which is lower than the birth weight reported by Mukasa-Mugerwa *et al*. (1989) (21.6 kg) in the central Ethiopian highlands but comparable to that of Wilson (1985) (16.6 kg) in the agro-pastoral system in

Mali. Mulugeta Kebede (1991) in his on-station research at Bako estimated the birth weight of Horro calves to be 18.6 kg and an average daily gain of 305g from birth to 6 months of age. Poor calves' management such as low milk supply at early ages (first months) and inappropriate weaning management may explain the growth deficiency of Horro calves in Boji district. The relatively stunted growth may also be explained by the high prevalence of parasitic diseases. Low growth rates in African livestock are a major cause of low productivity, affecting the age at which reproduction commences or oxen become available for ploughing, and the weight (and age) at which animals are slaughtered (ILCA, 1990).

Few quantitative data are available concerning the work of oxen under traditional husbandry in the Ethiopian highlands. Goe (1987) reported that oxen were employed less than 50 days/year for ploughing in the central Ethiopian highlands (North Shoa), which was by far less than the 90 days observed in our study. Estimates of daily work periods were higher (5 to 6 hours in average) in North Shoa. The difference may partly be attributed to the lapse (20 years) of time between the two studies. It appeared logical that nowadays, due to farm sizes decline, farmers face a decrease in draught power availability (Benin *et al*., 2002) ; they may tend to optimise the use of animals by sharing or loan arrangement such as *goubo* contracts described in Boji (Laval *et al*., 2002). In addition, cultural and religion differences between the study sites may be regarded as a contributory factor. Goe's study was located in a Copt Christian area where there are religious holidays, between 150 and 200 days per year (Gryseels and Anderson, 1983) that farmers can not carry out field activities, which limited the yearly use of oxen. It was not the case in Boji where the protestant religion did not impose such restrictions.

The average producers' price of butter in Boji in year 2001 (14.10 Birr/kg) was lower than the price reported by CSA (1999b) in year 1999 in the same Zone (16.90 Birr/kg). Due to international coffee market fluctuations and relatively good crop harvest in high potential areas, market prices of agricultural products have shown drastic decline during the year 2001-2002 in Ethiopia.

Figure 3 clearly indicates that butter prices varied seasonally in Boji, which was similar to the figures of CSA (1999a; 1999b; 2000) in the year 1999. Prices were higher during the dry season (January to May) and decreased during the rainy season (June to October). It is merely a question of availability as a function of the seasonal milk production pattern (Figure 1). Seasonal variation in demand also exert its effect (higher in April and May because of religious ceremonies / Easter). Gryseels and Goe (1984) mentioned that oxen could be rented on a cash basis, at US$ 1.50/day/pair without manpower. Prices of live animals in Boji district were similar to those reported by CSA for West Wellega in year 1999. They were higher than East Wellega and comparable to the national average (CSA, 1999a, 1999b, 2000).

To sum up, the demographic pressure in Ethiopian highlands and the severe reduction of available grazing lands and livestock per capita show the urgency to identify and implement policies compatible to the environment that enhance livestock productivity. This paper revealed that knowledge of local livestock practices and productivity is a preliminary necessity for addressing adequate recommendations at local level and that herd monitoring is an appropriate tool to achieve this objective.

The solution to prevailing productivity constraints must essentially encompass animal feeding during the dry season, calves and reproduction management, and animal health. Extension services could be useful means to implement envisaged recommendations. Farmers must be educated and sensitised on the availability of alternative feed resource basis, better livestock management and health care practices. Diversification of animal productions (especially sheep and chicken) may be considered as a potential option.

Recommendations that require higher investment include research on on-farm feeding and alternative feeding practices in highly populated and degraded areas and rationalisation of the veterinary services.

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# The effect of non-genetic factors on preweaning survival rate in the Tygerhoek Merino lambs

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## Abstract

*The aim of the study was to investigate the effects of non-genetic factors on preweaning survival rate of Merino lambs maintained at the Tygerhoek Experimental Farm. A total of 8823 lambs born from 1970 to 1994 were used. Average survival rate from birth to 100 days of age was 0.79 and was influenced by lamb birth weight, year of birth, age of dam at lambing, type of birth (single, multiple) and sex of lambs. Lambs with a liveweight between 4.0 to 4.9 kg at birth showed the highest survival rate while lambs with a liveweight of ≤ 2.0 kg showed the lowest survival rate.*

*Keywords*: Non-genetic factors; preweaning survival; Tygerhoek Merino lambs;

## Introduction

Lamb mortality results in serious financial losses in sheep production (Petersson and Danell, 1985). It is a major factor affecting the number of lambs weaned per ewe (Fogarty *et al*., 1985; Haughey *et al*., 1985). Efficiency of lamb production can thus in many situations be improved more readily by increasing the preweaning survival rate than by improved growth and body composition (Dickerson, 1978). In terms of reproductive wastage, lamb losses represent a serious problem because all investments made for ewes to conceive and maintain pregnancy are wasted (Mukasa-Mugerwa and Lahlou-Kassi, 1995). Land *et al.* (1983) indicated that no discussion of increasing lambing rates would be complete without mention of lamb survival after birth.

Preweaning lamb survival is a complex trait influenced by the lamb's ability to survive and by its dam's rearing ability (Burfening, 1993). Various studies have reported that birth weight, age of dam, year of birth, sex of lamb and type of birth affect preweaning lamb survival (Meyer and Clarke, 1978; Dalton *et al*., 1980; Schoeman, 1990; Yapi *et al*., 1992a; Burfening, 1993; Mukasa-Mugerwa and Lahlou-Kassi, 1995). Birth weight plays an important role in lamb survival, and an intermediate optimum has been shown to exist

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for birth weight (Al-Shorepy, 2001), with very large lambs which are more likely subjected to dystocia losses while very small lambs are at risk of death from hypothermia, starvation, respiratory diseases and other causes (Meyer and Clarke, 1978; Petersson and Danell, 1985; Al-Shorepy, 2001).

Environmental conditions and management practices are also expected to make a considerable impact on lamb survival. Nevertheless, unless it is practiced along with some selection against high death losses, improved management alone may not resolve the problem of high lamb mortality rates (Yapi *et al.*, 1992b). Except for the work of Heydenrych (1975), there is no information on the non-genetic factors affecting preweaning lamb survival rate in Merinos maintained at the Tygerhoek Experimental Farm. The purpose of the present study was to investigate the effects of various non-genetic factors influencing preweaning lamb survival rate of this flock.

## Materials and Methods

The experimental animals originated from a selection experiment on the Tygerhoek Experimental Farm of the Department of Agricultural Development that was started in 1969. The farm is situated in the southern coastal area of the Western Cape province, about 150 km east of Stellenbosch at an altitude of approximately 168 m above sea level (34° 08′ S, 19° 54′ E). The area has an average annual rainfall of 429 mm, 60 % of which is recorded in winter (April – September). The average maximum (minimum) summer and winter temperatures are approximately 22°C (15°C) and 12°C (5°C), respectively.

Data of 8823 Merino lambs born from 1970 through 1994 at the Tygerhoek Experimental Farm were used in this study. These lambs were the progeny of 2422 dams and 629 sires. Details regarding the origin, history and management of the flock are described else where by Heydenrych *et al.* (1984) and by Cloete *et al.* (1992). Lamb survival is defined in this study as the number of lambs weaned (LW) per 100 lambs born (LB), i.e. (LW/LB) x 100. Data on dead lambs were obtained from lambs that were born alive and died subsequently. The dependent variable was lamb survival rate from birth to weaning and was coded as '1' if the lamb survived to weaning and as '0' if the lamb died prior to weaning. Information on cause of death was not available.

Significant fixed effects were identified using the CATMOD procedure of the Statistical Analysis Systems (SAS, 1996). Parameters measured to determine their effect on preweaning death losses included age of dam (2- to 6-year of age), type of birth (single, multiple), sex of lambs (male, female), year of birth (1970 to 1995) and birth weight. Birth weight was categorised into discrete classes as CATMOD is not modelled optimally for continuous variables (SAS, 1996). Birth weight was categorised as follows: 1 = ≤ 2.0 kg; 2 = 2.1 – 2.9 kg; 3 = 3.0 – 3.9 kg; 4 = 4.0 – 4.9 kg; 5 = ≥ 5.0 kg. Simple t-test statistics indicated significant ($p < 0.05$) differences between the birth weight categories in mean preweaning survival rates. Crosstabulation in the Statistical Package for Social Sciences (SPSS, 1996) was used to estimate the percentage survival rate of lambs.

## Results

Sources of variation considered and the associated probability levels are presented in Table 1. Maximum-likelihood analysis of variance for preweaning survival showed significant ($p<0.001$) effects of all fixed effects considered. The average survival rate from birth to 100 days was 0.79. Estimated number of lambs survived to weaning are indicated in Table 2.

**Table 1.** Maximum-likelihood analysis of variance of preweaning survival rate.

| Source | df | Chi-square |
|---|---|---|
| Intercept | 1 | 138.27*** |
| Birth weight | 4 | 315.72*** |
| Year of birth | 24 | 549.90*** |
| Type of birth | 1 | 223.55*** |
| Age of dam | 4 | 53.55*** |
| Sex of lamb | 1 | 34.76*** |
| Likelihood ratio | 2000 | 3031.93*** |

***= p< 0.001

Survival rate was significantly ($p<0.001$) affected by birth weight of lambs. The lightest lambs generally had the highest mortality rate. There was also a reduction in the survival rate of lambs as they became heavier than 4 kg at birth. Losses were particularly high in lambs of 2.0 kg or less at birth (0.63). Increased birth weight showed an increased survival rate of lambs' (Figure 1). Maximum survival rate of 0.87 was obtained for lambs weighed 4.0 to 4.9 kg of liveweight at birth.

Age of dam had a highly significant ($p<0.001$) influence on preweaning lamb survival. Survival of lambs from 2-year-old ewes was the lowest, whilst it was highest in lambs from 4-year old ewes. The general trend was for preweaning survival to increase as ewes increased in age from 2- to 4-years, whereafter it decreased (Figure 2).

**Table 2.** Estimated preweaning survival rate of lambs as affected by birth weight, sex of lambs and type of birth.

| Source | N | lambs survived to weaning | |
|---|---|---|---|
| | | in number | in percentage (%) |
| Birth weight category | | | |
| 1 (≤ 2.0 kg) | 284 | 104 | 37 |
| 2 (2.1-2.9 kg) | 1653 | 1127 | 68 |
| 3 (3.0-3.9 kg) | 3902 | 3133 | 80 |
| 4 (4.0-4.9 kg) | 2486 | 2175 | 87 |
| 5 (≥ 5.0 kg) | 498 | 403 | 81 |
| Sex of lambs | | | |
| Male | 4335 | 3343 | 77 |
| Female | 4488 | 3599 | 80 |
| Type of birth | | | |
| Single | 5022 | 4274 | 85 |
| Multiple | 3801 | 2668 | 70 |

Type of birth also had a significant ($p<0.001$) influence on preweaning survival rate of lambs. Single born lambs had a higher survival rate than multiples (0.85 and 0.70, respectively).

Year of birth of lambs had also a significant ($p<0.001$) influence on preweaning lamb survival, with no distinct trend. In general, survival rate was better in earlier years than in later years of the study period (not shown).

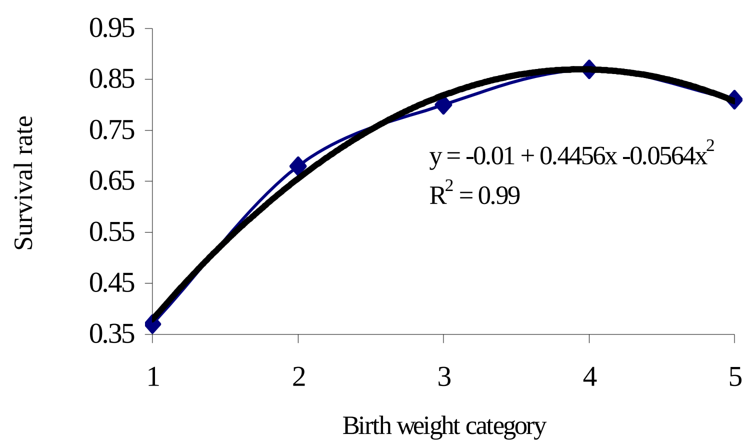


**Figure 1.** Thre regression of lamb survival on birth weight category.

Survival rate was also significantly ($p<0.001$) influenced by sex of lambs. Male lambs showed a higher pre-weaning mortality incidence than female lambs (0.23 and 0.20, respectively). The sex ratio (male/female) for surviving lambs was about 0.48:0.52.

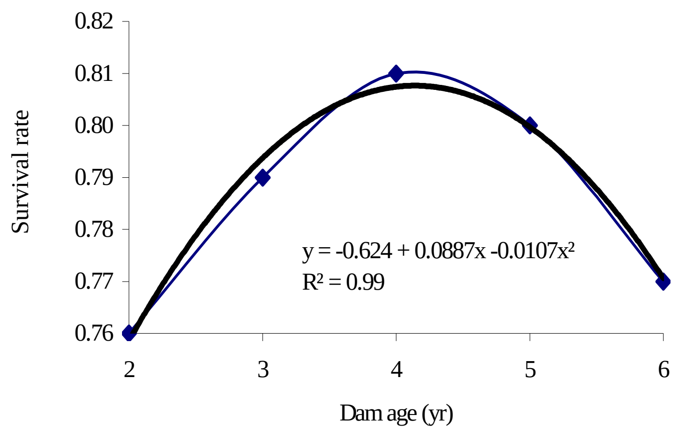


**Figure 2.** The regression of lamb survival rate on dam age.

## Discussion

Average survival rate from birth to 100 days obtained in the present study was within the range of 0.74 to 0.85 reported in the literature for other sheep breeds (Dalton *et al*., 1980; Wiener *et al*., 1983; Schoeman, 1990; Mukasa-Mugerwa and Lahlou-Kassi, 1995; Cloete and Scholtz, 1998; Solomon and Gemeda, 2000). Low birth weight, poor mothering ability, environmental stress (chilly, windy, wet and harsh temperature conditions) on the newborn, starvation and respiratory diseases were reported as the major causes of death of lambs (Heydenrych, 1975; Dalton *et al*., 1980; McCutcheon *et al*., 1981; Mukasa-Mugerwa and Lahlou-Kassi, 1995; Solomon and Gemeda, 2000). According to McCutcheon *et al*. (1981), about one-third of preweaning lamb mortality is considered to be due to starvation and exposure losses.

Birth weight was one of the factors affecting preweaning lamb survival in this study. Heydenrych (1975), who used part of the same data set, indicated that low body weight at birth and a concomitant rapid exhaustion of energy reserves appeared to be the most significant cause of perinatal deaths in twin lambs while excessive body mass and consequent dystocia seemed to cause most deaths amongst single born lambs. In the present study, lambs that survived to weaning weighed 0.5 kg more at birth than lambs that died prior to weaning (3.7 and 3.2 kg, respectively). Losses were particularly high in lambs that weigh 2.0 kg or less at birth. These results agree with those of Solomon and Gemeda (2000) and Mukasa-Mugerwa *et al.* (2000). These authors indicated that those lambs that were born with less than 2.0 kg birth weight, when the mean birth weights were 2.1 to 2.7 kg, had a greater risk of dying before weaning in two indigenous Ethiopian sheep breeds. In the present study, the maximum survival rate obtained from lambs with medium liveweight at birth of about 4.0 to 4.9 kg was within the weight range reported by Heydenrych (1975). In his study, lambs with a body weight at birth between 3.8 and 5.2 kg showed the highest survival rate. According to Peterson and Danell (1985), optimal birth weight seems to be higher than the mean birth weight. Likewise, in the present study, a maximum survival rate of 0.87 was obtained from lambs with 4.0 to 4.9 kg of liveweight at birth (Figure 1), which was above the 3.7 kg mean birth weight reported for this flock (Gemeda, 2001). Thus, since the relationship between birth weight and preweaning lamb survival is causative, it would be advisable to introduce farm management routines, which can help to increase birth weight. One option is to supplement ewes in the last trimester (Scales *et al.*, 1986; Yohannes *et al.*, 1998), especially to animals in poor body condition and to those carrying twins since both the foetus and the udder undergo rapid development during this period (Mukasa-Mugerwa *et al.*, 2000). According to these latter authors, cross-foster of weak or orphan or abandoned lambs shortly after parturition are the other options. They also indicated that the rotation of twins during nursing can also help to ensure that each twin mate gets enough milk.

Cloete *et al.* (2000) indicated that shearing of ewes prior to lambing might be advantageous under certain conditions, particularly when lamb survival is likely to be low. Nevertheless, in their study, lambs born to ewes that were shorn prior to lambing tended to be lighter than those from ewes shorn prior to joining.

Unlike the observations in the present study on the effect of age dam, Schoeman (1990) and Cloete and Scholtz (1998) reported that there were no significant differences in survival rate between lambs born to ewes of different ages. The difference might be due to management practices. It was, however, in general agreement with most results reported in the literature (Wiener *et al.*, 1983; Petersson and Danell, 1985; Atkins, 1986; Gama *et al.*, 1991; Solomon and Gemeda, 2000; Morris *et al.*, 2000; Mukasa-Mugerwa *et al.*, 2000) where preweaning lamb survival increased with ewe age, reached its peak by about 4 to 5 years of age and then decreased. This was partly accounted for by birth weight that was significantly lower for lambs born to 2-year-old ewes. It might also be attributed to poorer rearing ability for older ewes, which may result from udder damage and poor body condition. Lambs born to 6-years-old ewes were lighter at weaning than those born to 3- to 5-year-old ewes (Gemeda, 2001). In general, maiden ewes require better management than older age groups of ewes to enhance lamb survival rate.

The non-significant effect of sex on lamb survival rate reported by Yapi *et al.* (1992a) and Malik *et al.* (1998) was incontrast to the current results. The sex effect observed in the present study was, nevertheless, in general agreement with most other results reported in the literature (Petersson and Danell, 1985; Wiener *et al.*, 1983; Schoeman, 1990; Gama *et al.*, 1991). Schoeman (1990) reported that survival rate was significantly ($p<0.001$) affected by type of birth, with a higher survival rate in singles (0.88) than those of twins (0.78). Notter & Copenhaver, (1980), Wiener *et al.* (1983), Schoeman (1990), Solomon *et al.* (2000) and Mukasa-Mugerwa *et al.* (2000) suggested that the differences in mortality rates between singles and twins were primarily determined by differences in birth weight *per se*.

Differences between years may be a reflection of differences in feed availability between years, caused by differences in rainfall if feeding is pasture based. Severe weather conditions that were occasionally experienced at lambing can contribute to high environmental variance for lamb survival (Brash *et al.*, 1994). The Southern Cape area is subjected to dry years with limited feed availability. The significance of year effects may also be attributed to changes in general management of the flock. According to Ducker and Fraser (1973), a "low level of husbandry" at the time of lambing may increase lamb mortality. Nevertheless, in a South African study, Cloete and Scholtz (1998), referring to the work of Brand *et al.* (1985), pointed out that very intensive management failed to reduce lamb mortality to levels below 15%. Other South African studies by Schoeman (1990) and Cloete and Scholtz (1998) reported that survival rate was significantly influenced by year and season of birth. In general, to improve lamb survival the constraints imposed by genetics, nutrition, husbandry, disease and weather should be addressed (Haughey, 1991).

Male lambs showed a higher incidence of preweaning death losses than female lambs. This finding was in contrast to results reported by Schoeman (1990), Cloete and Scholtz (1998), Malik *et al.* (1998) and Solomon *et al.* (2000). They reported that survival rate was not influenced by sex of lambs. Generally, the current results were in agreement with several results reported in the literature (Meyer and Clarke, 1978; Schwulst and Martin, 1993; Peterson and Danell, 1985). Meyer and Clarke (1978) and Gama *et al.* (1991) found a higher mortality rate amongst males than amongst females.

## Conclusions

The results of this study indicated that several non-genetic fixed factors have a significant influence on preweaning lamb survival. Of these, birth weight was one of the factors affecting preweaning lamb survival. Thus, improving birth weight of lambs by using different management practices such as improving prepartum feeding of breeding ewes may partially solve the problem. Preferential treatments of maiden ewes as a separate management group and providing preferential treatment to ewes lambing multiples are also suggested.

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# The influence of non-genetic factors on early growth traits in the Tygerhoek Merino lambs

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## Abstract

*Records of 8310 lambs born from 2538 ewes and sired by 681 rams covering the period 1970 to 1998 were used in the analysis of birth weight (BW), weaning weight (WW) and pre-weaning average daily gain (ADG). All three traits were affected ($p<0.001$) by type of birth of lambs (single, multiple), sex, year of birth of lambs, group of animals (selection, control) and age of dam at lambing (2-to 6-year old). Male lambs and singles were heavier both at birth and weaning and grew faster ($p<0.001$) than females and multiples, respectively. Non-selected animals were lighter than selected animals at birth and weaning with an inferior growth rate. BW increased with increasing dam age at lambing until a maximum of 3.7 kg was reached at 6-year of age. However, both WW and ADG reached a maximum at about 4-year of age of the dam.*

*Keywords*: Non-genetic factors; early growth traits; Tygerhoek Merino lambs.

## Introduction

A large number of non-genetic factors influence lamb weights and preweaning weight gains. The effects of year of birth, sex, type of birth and dam age on early growth traits of lambs have been well documented (Heydenrych, 1975; Fourie and Heydenrych, 1982; Fahmy, 1989; Boujenane and Kerfal, 1990; Bunge *et al*., 1990; Schoeman, 1990; Sinha and Singh, 1997). Milk production also has a direct effect on weight gain of lambs (Hanrahan, 1976; Njwe and Manjeli, 1992). Post-natal factors account for 75 % of the maternal influence on weaning weight and are largely mediated through milk production (Bradford, 1972). Schoeman (2000) also reported that variation in pre-weaning weight might be due to poor milk production and composition or the environmental conditions under which the animal is maintained. The effect of dam age on early growth of lambs is also well documented (Heydenrych, 1975; Fourie and Heydenrych, 1982; Fahmy, 1989; Van Wyk *et al*., 1993). The effect of dam age on post-natal growth of lambs may be indirect

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through milk production in that mature ewes may produce more milk than younger ewes.

Selection of genetically superior individuals to be parents of the next generation is complicated by non-genetic factors that tend to mask the actual breeding values of the individuals being selected (Eltawil *et al.*, 1970). Identifying those non-genetic factors could help to look for appropriate ways to eliminate biases caused by them and hence more accurate estimation of breeding values would be possible. Van Wyk *et al.* (1993) indicated that the specification of a model that influence the specific trait requires the study of non-genetic sources of variation, so that a model can be found which (according to the available data) best describes the biological processes concerned. Most estimates of genetic variances in any livestock species are probably biased because of missing pedigree information jointly affected by non-genetic factors in the model and non-random selection of parents (Schenkel and Schaeffer, 2000). Knowledge of the non-genetic factors on production traits allows a more accurate assessment of breeding values and increases the rate of response to selection (Napier and Jones, 1982).

The purpose of the present study was to investigate some non-genetic factors influencing early growth traits in a Merino flock maintained at the Tygerhoek Experimental Farm. This was done to fit the appropriate operational model for the estimation of genetic parameters in a follow-up investigation.

# Materials and Methods

## Location of the study area

The experimental animals originated from a selection experiment on the Tygerhoek Experimental Farm of the Department of Agricultural Development that was started in 1969. The farm is situated in the southern coastal area of the Western Cape province, about 150 km east of Stellenbosch at an altitude of approximately 168 m above sea level (34° 08′ S, 19° 54′ E). The area has an average annual rainfall of 429 mm, 60 % of which is recorded in winter (April – September). The average maximum (minimum) summer and winter temperatures are approximately 22°C (15°C) and 12°C (5°C), respectively.

## Animals and management

Originally, 800 ewes of 1.5 to 5.5 years of age were stratified according to wool production at 18 months of age, and randomly allotted to five equal groups of 160 breeding ewes. Twenty-six randomly chosen rams sired the progeny born in 1969. During the 1969 mating season, 20 available rams were allocated at random to each experimental group in sets of four rams per group.

Selection of breeding rams in groups 1 and 3 was based on the highest uncorrected clean fleece mass at 18 months, provided that they had a fibre diameter lower than the average of their contemporaries. Replacement ewes were selected on clean fleece mass at 18 months of age in group 1 and corrected 42-day body mass in group 3 (Heydenrych *et al*., 1984). Both groups consisted of 160 breeding ewes and 6 rams up to 1976, when they were pooled and reduced to 150 breeding ewes and 6 rams. This decision was based mainly on preliminary findings (Heydenrych, 1977; as cited by Cloete *et al*., 1992). Later selection of this group was predominantly based on uncorrected clean fleece mass at 18 months in both sexes but with a restriction on fibre diameter in rams. The size of the breeding flock ranged from 150 to 160 breeding ewes and 6 to 8 breeding rams. For the progeny groups born during the period 1986 to 1989, the prerequisite for breeding rams to grow wool with a lower fibre diameter than the mean of their contemporaries was relaxed to include individuals up to 2 μm stronger than their contemporaries. Group 5 (hereafter called control group for the purpose of this study) served as a genetically stable Control Group for the assessment of selection progress in the selected lines. It originally consisted of 160 breeding ewes and 16 rams, but was allowed to increase to 200 breeding ewes and 20 breeding rams from 1976. Rams for the Control Group were chosen at random in such a way that each ram was replaced by a son and was used for one season only. Ewes were normally replaced by a second daughter reaching joining age, thereby retaining the same age structure as in the selection groups (Heydenrych *et al*., 1984). Selection Group and Control Group individuals were maintained in one flock with males and females kept separately. These flocks grazed on mainly dryland lucerne pastures and occasionally on small grain pastures or crop residues, when available (Cloete *et al*., 1992).

## Statistical Analysis

Records of 8310, 7997 and 7997 lambs born from 1970 to 1998 were used in the analysis for birth weight (BW), weaning weight (WW) and preweaning average daily gain (ADG), respectively. The lambs were the progeny of 2538 ewes and 681 sires. Total number of records used and means for all traits are presented in Table 1. Records with missing or incomplete information, those found suspect due to duplicate animal identifications and other irreconcilable inconsistencies were eliminated from the data. Those lambs deviating more than three standard deviations from the mean weight for BW and WW were excluded. Lambs were weaned at approximately 120 days of age from 1970 to 1982, and at about 100 days of age thereafter, and before fitting the models WW was adjusted accordingly for all lambs. The few triplets (12 records) were pooled with twin lambs. After running a preliminary analysis, ewes above 6-year-old age were pooled with 6-year-old ewes due to their small numbers and no differences ($p>0.05$) between the two sub-classes for any of the traits.

Fixed effects fitted were lambing year (1970 to 1998), sex (male, female), birth type (single, multiple), dam age (2 to 6-year old age), group of animals (group of animals selected for increased clean fleece weight and unselected control group), lambing year by group interaction and lambing year by type of birth interaction. The analyses were first carried out fitting a full model including all main effects and interactions using the General Linear Model (GLM) procedures of the Statistical Analysis System (SAS, 1996) to determine whether any of the effects or their interactions have an influence on the traits ($p<0.05$). Those having no effect ($p>0.05$) were subsequently omitted using a step-down procedure. The reduced models were then refitted for each variable.

**Table 1.** Number of records, means and standard deviations for BW, WW and ADG.

| | BW (kg) | WW (kg) | ADG (g) |
|---|---|---|---|
| No. records | 8310 | 7997 | 7997 |
| No. dams | 2538 | 2538 | 2538 |
| No. sires | 681 | 681 | 681 |
| Weight | | | |
| Mean | 3.6 | 22.9 | 192 |
| s.d. | 0.8 | 4.8 | 46.4 |
| Dam age (yr) | | | |
| 2 | 1527 | 1460 | 1460 |
| 3 | 1851 | 1782 | 1782 |
| 4 | 1900 | 1835 | 1835 |
| 5 | 1662 | 1607 | 1607 |
| 6 | 1370 | 1313 | 1313 |
| Sex | | | |
| Males | 4031 | 3862 | 3862 |
| Females | 4279 | 4135 | 4135 |
| Type of birth | | | |
| Single births | 4946 | 4860 | 4860 |
| Multiple births | 3361 | 3137 | 3137 |
| Group of animals | | | |
| Selection | 4238 | 4096 | 4096 |
| Control | 4072 | 3901 | 3901 |

The following model was fitted:

$$Y_{ijklmn} = \mu + Y_i + S_j + T_k + G_l + A_m + (YG)_{il} + (YT)_{ik} + e_{ijklmn}$$

where:

$Y_{ijklmn}$ = record of the n $^{th}$ animal

$\mu$ = the overall mean

$Y_i$ = the fixed effect of the i $^{th}$ birth year (i = 1970, 1971, …, 1998)

$S_j$ = the fixed effect of the j $^{th}$ sex (j = 1 or 2; 1 = male, 2 = female)

$T_k$ = the fixed effect of the k $^{th}$ type of birth (k = 1 or 2; 1 = single, 2 = multiple)

$G_l$ = the fixed effect of the l $^{th}$ group of animals (l = 1 or 2; 1= selection group, 2 = unselected control)

$A_m$ = the fixed effect of m $^{th}$ ewe age (m = 2, 3, 4, 5 or 6-yr-old)

$(YG)_{il}$ = interaction effect between i $^{th}$ birth year and l $^{th}$ group

$(YT)_{ik}$ = interaction effect between i $^{th}$ birth year and k $^{th}$ type of birth

$\mathbf{e}_{ijklmn}$ = the residual effect

## Results

Analysis of variance for BW, WW and ADG is presented in Table 2, while least-squares means for the same traits are shown in Table 3. All the fixed main effects had significant ($p<0.001$) effect on all three traits. But the birth year by type of birth interaction was only significantly related to BW. The analyses of variance showed that the fixed effect models accounted for 39.8, 38.2 and 38.4 % of the variances for BW, WW and ADG, respectively. Of these, type of birth had the highest contribution to variation in BW, and year of birth to variation both in WW and ADG.

The effect of sex of lambs was significant ($p<0.001$) for BW, WW and ADG. Male lambs were by 6.3 % (0.2 kg) and 8.2 % (1.9 kg) heavier at birth and weaning than females, respectively. They also grew approximately 9 % (17 g/day) faster from birth to weaning than female lambs. The effect of sex accounted for about 1.9 and 3.8 % of the variation in BW and WW, respectively.

**Table 2.** Analysis of variance for BW, WW and ADG.

| Fixed effects | df | Mean Square and significance level | | |
|---|---|---|---|---|
| | | BW | WW | ADG |
| Year | 27 | 28.928*** | 1428.583*** | 161941.943*** |
| Sex | 1 | 102.828*** | 6991.854*** | 543823.467*** |
| Type of birth | 1 | 971.439*** | 15233.934*** | 856388.743*** |
| Group of animals | 1 | 85.369*** | 7782.480*** | 622206.758*** |
| Ewe age | 4 | 39.490*** | 190.818*** | 8069.298*** |
| BY*GR | 27 | 1.205*** | 86.056*** | 7149.017*** |
| BY*TB | 27 | 0.702** | | |
| Error degrees of freedom | | 8218 | 7935 | 7935 |
| Error mean square | | 0.403 | 14.42 | 1337.07 |
| $R^2$ | | 39.82 | 38.24 | 38.42 |
| C.V. | | 17.46 | 16.61 | 19.05 |

** p<0.01; *** p<0.001; BY*GR=birth year by selection group interaction; BY*TB=birth year by type of birth interaction

**Table 3.** Least squares means (±S.E.) for BW, WW and ADG

| Fixed effects | BW (kg) | WW (kg) | ADG (g) |
|---|---|---|---|
| Overall mean | 3.6 | 22.9 | 192 |
| Sex | | | |
| Male | 3.7±0.01[a] | 23.8±0.06[a] | 202±0.60[a] |
| Female | 3.5±0.01[b] | 21.9±0.06[b] | 184±0.60[b] |
| Type of birth | | | |
| Single | 3.9±0.01[a] | 24.4±0.06[a] | 204±0.55[a] |
| Multiple | 3.2±0.01[b] | 21.4±0.07[b] | 182±0.68[b] |
| Group of animals | | | |
| Selection | 3.7±0.01[a] | 23.9±0.06[a] | 202±0.62[a] |
| Control | 3.5±0.01[b] | 21.8±0.06[b] | 184±0.61[b] |

[a,b] Within effects, values with different superscripts in the same column are significantly different (p < 0.001).

Year of birth had a very significant (p<0.001) effect on live weights and growth rates up to weaning. Year of birth of lamb had greater effect on WW than on BW (Figure 1). BW was relatively stable throughout the study period except for the sudden increase in 1983. It increased by 1.0 kg in this particular year. The WW performance of this flock was, however, decreasing in the early years of the study from 1970 to 1986, whereafter it increased. About 14.2 and 20.8 % of the weight differences for BW and WW were due to year of birth, respectively.

Type of birth also had significant effect (p<0.001) on early growth traits of lambs. Single born lambs were heavier by 20.6 % (0.8 kg) and 13.0 % (3.0 kg) at birth and weaning than those born as multiples, respectively. They also grew faster at approximately 22 g/day than multiple born lambs. The effect of type of birth decreased with increase in age of the lamb. Type of birth accounted for 17.7 and 8.2 % of the liveweight variation at birth and at weaning, respectively.

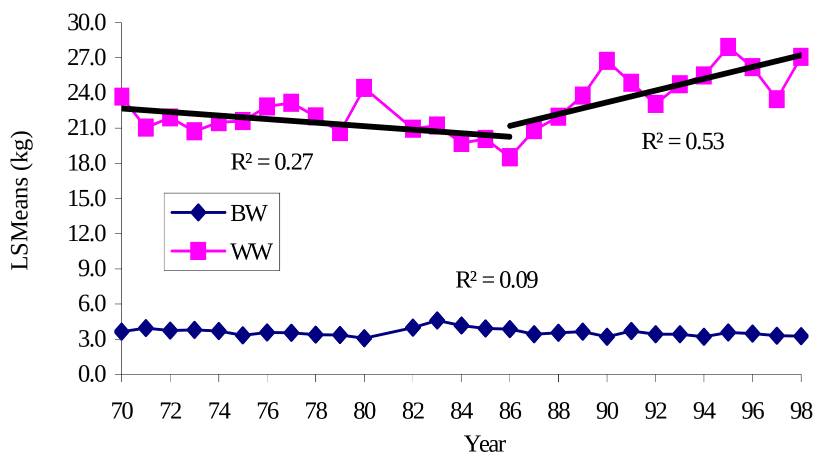


**Figure 1.** The relationship of year of birth with BW and WW.

Selection group also had significant effect (p<0.001) on BW, WW and ADG. Animals from the group selected for clean fleece weight were by 5.8 % (0.2 kg) and 9.0 % (2.1 kg) heavier at birth and weaning than the unselected control, respectively. They also grew faster than the unselected control group. A difference of about 18 g/day was observed between the selected and the unselected control groups.

The effect of age of dam was significant (p<0.001) for all three traits. Its effect followed the expected patterns for BW (Figure 2), where it increased with increasing dam age until the maximum of 3.7 kg was reached at 6-year of age of dam. However, the lack of adequate number of records on ewes older than 6-year of age in the present data set did not alow the estimation of age effects at older ages. Unlike BW, maximum WW and ADG were obtained for those lambs born to 4-year-old ewes (Figures 3 and 4), whereafter it declined. Quadratic regressions of both WW and ADG on age of dam reached maximum at about 4-year of age. Lambs born from maiden and older ewes grew slower and had lower liveweights at weaning as compared to lambs from middle-aged ewes (3 to 5-year-old ewes). The effect of dam age decreased with increasing age of lambs. Dam age accounted for about 2.9 and 0.4 % of liveweight variation at birth and at weaning, respectively.

For all three traits, the lambing year by group interaction was also significant (p<0.001). Nevertheless, it accounted only for about 0.6 to 1.3 % variation in the three traits. The lambing year by birth type interaction was only significantly (p<0.001) related to BW.

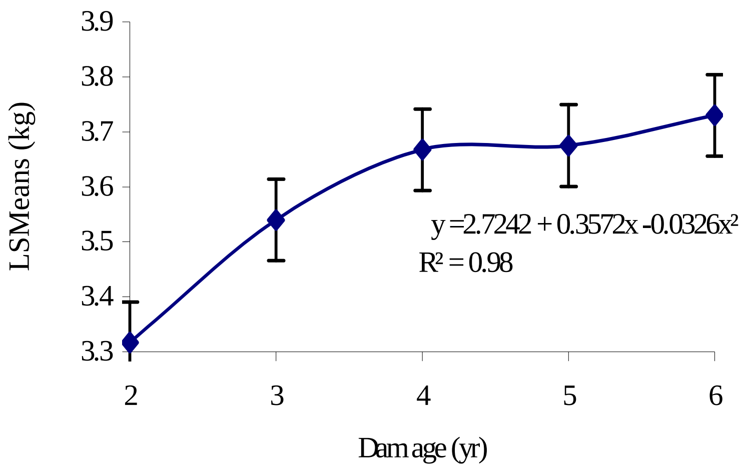


**Figure 2.** The regression of BW on dam age.

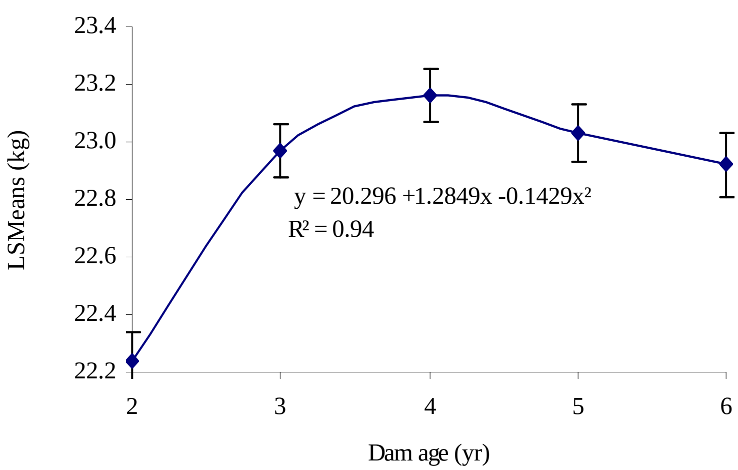


**Figure 3.** The regression of WW on dam age.

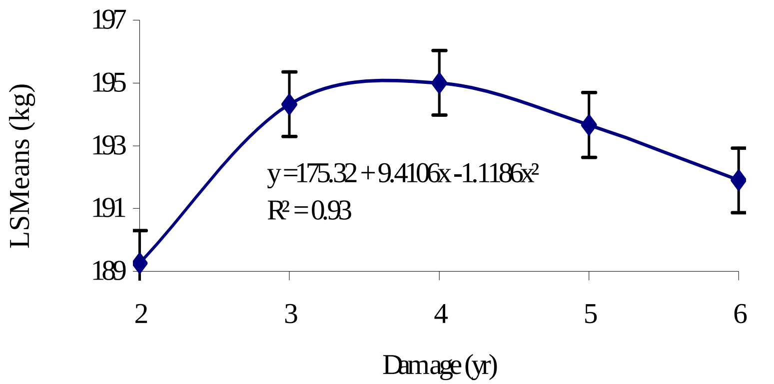


**Figure 4.** The regression of ADG on dam age.

## Discussion

The effect of environmental factors such as year, sex, type of birth and ewe age observed in the current study is in general agreement with those reported in the literature (Heydenrych, 1975; Fourie and Heydenrych, 1982; Boujenane and Kerfal, 1990; Schoeman, 1990; Van Wyk *et al.*, 1993). Under arid conditions, the above-mentioned environmental fixed factors are known to predominate in determining sheep productivity (Eltawil *et al.*, 1970).

Very few studies have been reported for BW in Merino sheep of South Africa. It was only analysed in a previous study conducted with this flock (Heydenrych, 1975) and one recently reported by Cloete *et al.* (2000) with a Merino flock in the Swartland region. It is, however, a trait of potential economic importance through its effect on lamb survival rate in the flock, in that very large and small lambs were at risk of preweaning death (Gemeda, 2001). Mean BW found in the present study was lower than those reported by Heydenrych (1975) based on part of the same data. This might be due to the smaller data set used in the previous study. It was, however, in accordance with that reported by Cloete *et al.* (2000). The mean WW obtained was also in agreement with these authors, but higher than those reported in the Carnarvon Merino flock (Snyman *et al.*, 1996). It was, nevertheless, lower than results reported for several other breeds by Schoeman (2000). The mean ADG found in the current study was in good agreement with those reported for Baluchi sheep (Yazdi *et al.*, 1998).

Male lambs were heavier at birth and at weaning than female lambs. They also grew faster than female lambs. This is in general agreement with reports in the literature (Heydenrych, 1975; Fourie and Heydenrych, 1982: Schoeman, 1990; Van Wyk *et al.*, 1993; Mavrogenis, 1996; Yohannes *et al.*, 1998; Solomon and Gemeda, 2000). The heavier WW of ram lambs than their female contemporaries may be due to heavier birth weights and faster growth rate of male lambs. According to Eltawil *et al*. (1970), lambs with a heavier BW, which might be due to being males, singles and/or from mature ewes, tend to achieve higher weights at weaning, partly because of the positive correlations between the traits. The influence of sex on liveweight increased with age, which agreed with results reported by Fourie and Heydenrych (1982) and Nagy *et al*. (1999). Such differences might be attributed to different physiological processes in the two sexes (Rajab *et al*., 1992).

In the current study, year had an important effect ($p<0.001$) on weights and growth rate up to weaning. Differences observed in weights between years may be a reflection of differences in feed availability between years, caused by variation in total annual precipitation and the distribution of rainfall. The southern Cape area is subjected to dry years with limited feed availability. Similar results of the effects of year on production traits are well documented (Eltawil *et al*., 1970; Blackburn and Cartwright, 1987; Rajab *et al*., 1992; Mavrogenis, 1996).

Differences in early growth traits were observed between the selected group and the unselected control. This could possibly be explained through the positive genetic correlation between liveweight and fleece weight. Heydenrych (1975), Heydenrych *et al.* (1984) and Cloete *et al.* (1992; 1998) reported that selection for clean fleece weight resulted in a correlated increase in liveweight due to this positive genetic correlation between fleece weight and body weight.

Type of birth also affected liveweight and growth rates of this flock. Single born lambs were heavier and grew faster than multiple born lambs. This is similar to results reported by Heydenrych (1975) for the same flock, Fourie and Heydenrych (1982) in Döhne Merino and several other breeds (Galal and Kassahun, 1981; Boujenane *et al*., 1991; Rajab *et al*., 1992; Solomon *et al*., 2000). Part of the type of birth differences on WW might be due to the carry-over of the heavier weight of singles at birth. Differences due to type of birth may be more important under arid conditions than under intensive sheep production systems (Eltawil *et al*., 1970). The difference of 0.8 kg found in the present study for BW corresponds to the 0.7 kg reported by Yazdi *et al*. (1998) for Baluchi sheep. However, a 1.8 kg heavier WW for singles than multiples reported by Yazdi *et al*. (1998) for the Baluchi breed was slightly less than the current result. Generally, in the current study, the effect of type of birth decreased as lambs became older. Fourie and Heydenrych (1982) reported similar results. According to Bradford (1985), environments with scarce forage, variable among seasons and years, and where supplemental feed is scarce and uneconomic, would only support sheep with single births. However, if such environments permit supplementation at critical times, twinning from mature ewes could be tolerated. The Tygerhoek Merino sheep grazed mainly on dryland lucerne pastures unless occasionally supplied with grain pastures or crop residues when available (Cloete *et al*., 1992).

The average weight of lambs at birth increased with increasing ewe age up to the maximum age (6-year) considered in this study. Three other South African studies observed an increase in BW up to 5- to 7-years of age in both Döhne Merino and Dormer sheep (Fourie and Heydenrych, 1982; Van Wyk *et al*., 1993; Schoeman, 1990). An increase in BW was observed up to an age of five years (fourth parity) in Horro sheep of western Oromia, Ethiopia (Solomon and Gemeda, 2000), seven years of age in Baluchi sheep of northeast Iran (Yazdi *et al*., 1998) and in Romanov sheep of Canada (Fahmy, 1989). The reasons for the differences may be attributed to differences in production environments and management levels (Schoeman, 2000). It might also be due to breed effects, in that earlier maturing breeds may reach their peak earlier than the late maturing breeds.

The influence of age of dam on growth traits of offspring was greatest at birth and decreased as the animal grew older to weaning. Lambs out of 2-year-old ewes were lighter ($p<0.001$) at birth and weaning than were lambs out of older ewes. This might be explained by the fact that young dams that had not reached adult size continued to grow during pregnancy and thus competed with the fetus for available nutrients. Moreover, maiden ewes as first-time lambers may produce less milk than average. Solomon and Gemeda (2000) indicated that maiden ewes may put their lambs at disadvantage in two possible ways. They produce lambs with lower body weight and their mothering ability is poor as a result of lack of experience and poorly developed udder. According to Snyman *et al*. (1996), problems related to young ewes may be carried over to the second and perhaps even to the third parities. Although 6-year-old ewes had lambs that were heavier at birth than all other age groups, their lambs were lighter at weaning than those reared by 3- to 5-year-old ewes. The general trend for the effect of age of ewe on WW and ADG was curvilinear. Maximum WW and growth rate of lambs were obtained from ewes of intermediate age groups, and lower WW and inferior growth rate performance from lambs of very young and old aged ewes. Therefore, the dam age effect observed on BW of lambs from 6-year-old ewes might be a manifestation of an age effect on pre-natal environment and that of WW and ADG of lambs from middle-aged ewes could be brought about by a higher milk production in the middle-aged ewes. An animal's WW is mostly a function of the milk production and mothering ability of its dam (Ercanbrack and Knight, 1998; Bourdon, 2000). It is also interesting to note that maximum WW and ADG were attained approximately at an age at which ewes of this flock attain their mature liveweight. In an earlier report, the Tygerhoek Merino flock breeding ewes reached their maximum liveweight at their fourth mating when they were 4.5-years old (Heydenrych, 1975). The superiority of lambs born to middle aged ewes in WW obtained in the current study agreed with the findings of Rajab *et al*. (1992), Van Wyk *et al*. (1993) and Solomon and Gemeda (2000). In contrast, Schoeman (1990) found non-significant ewe age effect on 100-day body weight in Döhne Merino (which is the same age as the current weaning age). The difference might be due to management practices.

## Conclusions

In this study, several non-genetic fixed factors were observed with significant influence on early growth traits. Male lambs and singles were heavier both at birth and weaning and grew faster up to weaning than females and multiples, respectively. Non-selected animals were lighter than selected animals at birth and weaning, and had inferior growth rates. BW increased with age of dam up to 6-year of age. However, the age of dam effects on WW and ADG were curvilinear. The heaviest lambs were from 3-to 5-year-old dams and the lightest from 2- and 6-year-old dams. Therefore, the heavier BW of lambs from 6-year-old ewes may be due to a better pre-natal environment, but these old ewes appeared to have produced lesser preweaning growth level. Thus, it becomes more profitable to keep a larger proportion of the middle-aged ewes (between 3-to 5-years-old ewes) to improve productivity of this flock.

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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 7$^{th}$ 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.

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***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.

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*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.

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*Photographs*: Should be original prints and suitable for reproduction. They should be unmounted with lettering clearly indicated on overlays or photocopies. For composites, photographs should be unmounted and a photocopy enclosed to indicate the required measurement. Magnification should be given in the legend or indicated by a scale or bar. They should be numbered as part of the sequence of Figures. If several plates or coloured photographs are submitted, the authors may be asked to the cost of reproducing them.

***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.

***Acknowledgements:*** Should be briefly stated following the conclusion.

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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)
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**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 | % |
| | | Gram per kilogram | g $kg^{-1}$ |
| | | International unites per kilogram | IU $kg^{-1}$ |
| | Blood | 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 $bodyweight^{0.75}$ | 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 $^oC$ |
| 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).

# Membership to the Ethiopian Society of Animal Production (ESAP)

## Membership advantages

Some of the personal benefits afforded to active members of the Ethiopian Society of Animal Production (ESAP) include the following:

- A convenient means of keeping up-to-date on current scientific and production developments.
- An avenue for personal involvement in fostering high standards and professional developments in Animal Science
- To receive a printed copy of the Ethiopian Journal of Animal Production (EJAP).
- Receiving copies of the Society's newsletter, Membership Directory, and advanced registration information for national meetings.
- Eligibility to present abstracts at national meetings and to submit manuscripts for publication in the Ethiopian Journal of Animal Production (EJAP).
- Eligibility to provide personal leadership to the field of animal science by serving on the Executive Committee of the society or by accepting other society assignments
- Eligibility to be selected for prestigious society-sponsored awards

## Eligibility for membership

Membership is open to individuals interested in research, instruction or extension in Animal Science or associated with the production, processing, marketing and distribution of livestock and livestock products.

## Application form for Membership

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## Erratum:

Corrected table in previous volume, Eth. J. Anim. Prod. Volume 1 Number 1-
Eshetu Y. *et al*. 2001: 63-66

**Table 1**. Distribution of *D. species* in fish of the different lakes, Ethiopia.

| Name of Lake | Type of parasite | Species of fish | Site of localization | No. of fish sampled | No. of fish affected | Percentage (%) |
|---|---|---|---|---|---|---|
| Ziway | *D. species* | *O. niloticus* | Eye lens | 193 | 81 | 41.97 |
| Chamo | *D. species* | *O. niloticus* | Eye lens | 131 | 34 | 25.95 |
| Tana | *D. species* | *O. niloticus* | Eye lens | 87 | 20 | 22.98 |
| Haik | *D. species* | *O. niloticus* | Eye lens | 64 | 38 | 59.38 |
| Ziway | *D. species* | *Barbus pp* | Eye lens | 11 | 2 | 18.18 |
| Total | | | | 486 | 173 | 36.42 |