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Status of Ethiopian indigenous Sheko cattle breed and the need for participatory breed management plan

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Abstract

Sheko is the only surviving taurine of the Abyssinian region, and is in danger of extinction mainly due to interbreeding with neighboring Zebu breeds and scarcity of pure Sheko breeding bulls. This study was undertaken to study current status of Sheko cattle breed and husbandry practices in southwestern Ethiopia between August 2004 and February 2005. The survey revealed that farmers do recognize special characteristics and desirable qualities of the breed, notably its tolerance to endemic diseases, the relative high milk yield, long lactation period, stamina for traction, less selective feeding behavior and maintaining good body condition at times of feed scarcity. The breed's voracious feeding habit and aggressive temperament, however, are noted by farmers as undesirable traits. To reverse the declining population trend and to lay the elements of sustainable use, a breed management plan consisting of establishing *in situ* breeding station, organizing a Sheko cattle owners' society, establishing breed studs in its breeding tract, promoting niche market and improving the husbandry practices, were proposed.

Keywords: Breed management plan, breed status, Ethiopia, desirable qualities, Sheko cattle

Introduction

Sheko cattle breed is the only surviving indigenous taurine breed of the Abyssinian region (Hanotte *et al*., 2000), and is one of the 23 recognized cattle breeds in Ethiopia. Recent genetic studies on some Ethiopian cattle breeds revealed that the Sheko is distantly related to Sanga cattle breeds in Ethiopia (Dadi *et*

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al., 2008) The breed is known to have evolved in the tsetse belt of southwestern Ethiopia under natural selection and patronage of the Sheko people and other ethnic groups that inhabited its breeding tract (Takele, 2005). Although the breed has been referred to in the literature as Sheko (Epstein, 1971; Alberro and Haile-Mariam, 1982; Mason, 1988), the various ethnic groups maintaining the breed use different names that are now considered as synonyms (Takele, 2005; Takele *et al*., 2007).

Sheko's unique evolutionary history, status and trypanotolerance have attracted research attention (Hanotte *et al*., 2000; Lemecha *et al*., 2006; ILRI, 2006; Dadi *et al*., 2008). The long held view that the breed is endangered by extinction (Epstein, 1971; Alberro and Haile-Mariam, 1982) was corroborated by molecular genetic evidence that showed about 90 percent of the sampled Sheko bulls have had their specific *taurine* allele replaced by *indicine* allele confirming an alarming introgression of Zebu genes (Hanotte *et al*., 2000). A more recent breed survey (Takele, 2005) confirmed that pure Sheko bulls are rare in the home area of the breed and the Sheko cattle keepers have either chose to or been forced to use Zebu bulls to mate Sheko cows. Moreover, the heterozyogocity level observed in Sheko cattle was lower than expected; indicating problem of inbreeding, and the total number of alleles found in Sheko cattle was the least compared to other contemporary Ethiopian breeds (Dadi *et al*., 2008). In recognition of this current scenario on status of the breed, this study was undertaken to outline a participatory breed management strategy to rescue the breed and promote its sustainable utilization in its home area and beyond.

Materials and Methods

The study area and population

This study canvassed the known current geographical distribution of Sheko breed of cattle in Bench Maji Zone of southwestern Ethiopia, as identified through consultation with local administration and agricultural extension officers, key informants (cattle traders, village chiefs, elders) and researchers. The breeding tract covers a total of 23,000 km^2 divided into nine districts and two major agro-ecological zones (lowland and mid-highland). The existing true–to–type Sheko cattle were also identified, located and enumerated through extensive consultation with Sheko cattle owners.

Methods of data collection and analysis

The breed survey was conducted between August 2004 and February 2005. Sets of open-ended questions were used to guide focus group discussions with key informants, local agricultural extension staffs and knowledgeable elders. The discussions covered origin and evolution of cattle in the area; existing cattle breed types, special attributes of cattle breeds and trait preferences. A semi–structured questionnaire was also administered on 129 Sheko owning farmers in 35 villages identified by the focus group discussions to collect data on cattle husbandry practices and desirable and undesirable traits of Sheko cattle. This was also supported by extensive field observations by the lead author. Further details about study methods were described in Takele *et al*. (2007). Descriptive statics of SAS (1999) was applied to analyze the data and generate summary statistics.

Results

Population trend and breed status

The total population of true Sheko cattle were enumerated to be about 4000 heads (Takele, 2005), which accounted for only two percent of the total cattle population in the known breeding tract of Sheko. Even this number was noted to be on decline in recent years which confirmed the widely held notion that Sheko breed is indeed endangered. Focus group discussions also revealed that Sheko cattle have grown smaller in body size, with narrower belly and hind-quarters. Key informants reported that elite Sheko cows used to be milked up to 15 litres per day when feed supplies were abundant, although such figures are difficult to verify. What is certain is the relatively high milk producing capacity of the Sheko in the hot and humid climate of the home area.

Desirable and undesirable traits of Sheko cattle

Desirable and undesirable traits of Sheko cattle as identified by the respondents are summarized in Table 1. In addition, the focus group discussion suggested better feed conversion efficiency, longevity, fertility, and good mothering ability of the Sheko compared to other cattle breeds in adjacent areas. Faster growth rate, larger body size and larger teats than the comparators were also noted as useful traits to improve milk production of the Sheko breed. Some key informants also reported that unlike their horned zebu counterparts the polled Sheko do not have difficulty to move around in dense forest for grazing. On the other hand, their occasional aggressive temperament and voracious feed-

ing habits, particularly during the dry season, were mentioned as undesirable traits.

Sheko cattle owners also identified special desirable adaptive attributes of the Sheko cattle against common stressor variables (Table 2). Most of the Sheko cattle owners had rated the Sheko cattle within high to moderate adaptation categories to these stressors compared to the zebu cattle in the region, although such preliminary indicators need to be substantiated through further studies.

Table 1. Frequency of desirable and undesirable traits of Sheko cattle

Traits	Frequency	Percent
Desirable traits		
Relatively high milk yield	74	46.2
Disease tolerance	15	9.4
Draught stamina	12	7.5
Less selective feeding behavior	11	6.9
Attractive look	10	6.2
Ability to maintaining good body condition	7	4.4
Short inter-calving period	5	3.1
Long lactation period	4	2.5
Undesirable traits		
Aggressive temperament	15	9.4
Voracious feeding habit	7	4.4

Table 2. Sheko cattle owners' perception on relative adaptive attributes of Sheko cattle compared to zebu type cattle

Stressor variable	N	Relative adaptation (%)		
		High	Medium	Low
Heat load	129	61.3	27.1	11.6
Feed scarcity	129	45.7	24.8	29.5
Tick infestation	129	41.1	48.8	10.1
Internal parasite infestation	129	40.3	49.6	10.1
Annoyance by biting flies	124	39.5	52.4	8.1

Constraints to Sheko cattle management

Sheko cattle keepers identified major constraints that contributed to the decline of Sheko cattle. These were later considered along with those reported by other stakeholders in developing a suitable breed management plan.

Shrinkage of grazing land: Focus group discussions and key informants reported that communal pastures that supply the bulk of feed resource are on decline due to expansion of crop fields in the face of rapid human population growth. Consequently, Sheko cattle keepers increasingly resort to tethered feeding. Average cattle herd size is therefore declining, which also discouraged maintenance of Sheko breeding bulls and encouraged communal use of available (non-descript) breeding bulls.

Polledness and aggressive behavior of the breed: Nearly 90 percent of the sampled Sheko cows and 85 percent of bulls were found to be polled. Normally farmers tether their cattle by the horns; polled cattle are tethered either by the neck or leg, which are less preferred to horn tethering as they do not provide secure tethering. In fact such animals often break the tether and damage crop fields to the detriment of communities' social relations. Some of the respondents also mentioned that polled animals have less attractive look as they lack the preferred grace that cattle have with their horns. Large size and strong physique of the breed also make tethering difficult especially by children and women. Some respondents, however, reported that Sheko cattle can better identify their owners and better respond to good care than the zebu type cattle or their crosses.

Scarcity of Sheko breeding bulls: Interviews, focus group discussions and observations on sampled cattle herds indicated that true Sheko breeding bulls are indeed scarce in the study area. The majority of small cattle herds do not keep breeding bulls, and the remaining few farmers mostly keep non-Sheko bulls. This is being exacerbated by the declining availability of grazing pastures. As young Sheko bulls are either disposed of or castrated at early age owing to their aggressive temperament, the smaller and more versatile zebu bulls and their derivative have become more prevalent in the breeding tract. Farmers that do not keep bulls are, therefore, forced to use any breeding bulls from their neighbourhood irrespective of the breed identity.

Misapprehension of importance and status of the Sheko cattle: Local, regional and national stakeholders have lagged behind to appreciate the relative importance of the breed and current breed status. Even the gradual recognition of these challenges did not lead to active interventions. There has also been lack of empirical evidence on population size and structure to invoke further research.

Lack of active intervention on the breed: The only significant effort made was the set up of Sheko cattle genetic improvement program at Bege breeding ranch outside of the breeding tract of Sheko cattle. Unfortunately, the ranch did not have functional link with the surrounding communities. That perhaps led to complete demolition of the ranch and its breeding stock during the political instability that ensued following the violent change of government in Ethiopia in 1991. No significant effort was made to re-establish the ranch, and even the recovered breeding animals were not put back into any breeding scheme. However, a collaborative research and development project has been undertaken by the International Livestock Research Institute (ILRI) and the Ethiopian Institute of Agricultural Research (EIAR) to evaluate trypanotolerance attributes of the Sheko cattle along with three other cattle breeds in the Ghibe valley. Similarly ILRI and the Southern Ethiopia Agricultural Research Institute (SARI) are considering a participatory breed improvement plan in the home area of the breed.

Proposed breed management plan

Based on findings of this study, an active breed management plan is suggested to rescue this unique breed and promote its sustainable utilization. The plan has the following eight elements:

Census and monitoring of Sheko cattle population: This is essential to precisely monitor population size and herd age structure to provide vital information for breed improvement. The unique attributes and current status of the Sheko breed justify a specific breed census in its current breeding tract. If specific breed census is not realistic, the regular agricultural censuses conducted by the Central Statistical Authority (CSA) can be adapted to generate breed level data on the Sheko cattle, with budget provisions to meet incremental costs. The minimum task needed is to identify enumerated cattle by breed type, such as Sheko, non-Sheko and cross so that census tabulations can be done by breed type. This is consistent with the Global Plan of Action for Animal Genetic Resources adopted by the community of nations with the Interlaken Declaration (FAO, 2007).

Targeted publicity of Sheko breed: The general public in and outside the natural habitat of the breed (where the breed can have potential market niche) should be targeted to publicize special merits of the breed, such as its trypanotolerance, adaptation to warm and humid environments and its desirable

dairy qualities. Components of the breed management plan should also be widely communicated to relevant stakeholders using appropriate media.

Improving husbandry practices: Tools such as nose rings could be used to tame aggressive Sheko bulls and oxen in the area. Traditionally farmers use ear rings for the same purpose and this practice needs to be closely examined for its effectiveness. One of the major problems is the tie ropes do not last long, thus rope made of high quality material can be considered as an option and provided at subsidized cost until the status of the breed improves. Breaking and training of animals at younger age and alternating herding with tethering can soften aggressive behavior of the breed. Specific interventions are needed to improve feed supplies and sustain existing grazing lands to increase average herd sizes. Larger herd sizes increase the likelihood of selection and maintenance of breeding studs in the villages. Some communities need more accessible watering points and natural mineral licks to fully utilize potential of the Sheko breed.

Creating market opportunities for the breed outside of its home tract: The breed has potential for high marketability in large parts of south-western Ethiopia constrained by medium to high tsetse and trypanosomosis challenges. Government-sponsored schemes of resettling smallholder farmers from densely populated highlands into underutilized fertile and sparsely populated valleys of south-western Ethiopia have recently created demand for adapted breeding cattle for which the Sheko cattle is the best alternative. Dairy and draught qualities of the breed may be worth investigating even for other agro-ecologies. The extension services and the national research systems need to support this effort until market interests gain momentum. Given the threat the breed is facing an incentive system whereby an owner who manages to get a Sheko calf (sired by a Sheko bull) can be rewarded needs to be put in place. This would make the use of proposed studs efficient and make owners to work against indiscriminate mating (Zander *et al*., 2008).

Establishing *in situ* breeding station: The provincial administration has had plans to set up *in situ* pure breeding station either in the Sheko or Bench district. This plan should be supported and incorporated as part of this breed management plan with active participation of local stakeholders. The station can then supply elite breeding bulls and heifers to interested Sheko breeders initially in the home area and eventually to others as well. However, this plan may be constrained by shortage of budget as such a plan naturally should have a long timeframe. Such public institutions may also need support from other

stakeholders to sustain operations of the station. Therefore this plan needs to be supported by satellite breeding schemes run by smallholder breeders.

Establishing smallholder stud breeders: To urgently overcome the prevailing scarcity of Sheko bulls, selected villages can be supported to establish voluntary stud breeders' groups. Use of the stud bull will be based on a commonly agreed payment mainly to cover bull management costs. This decentralized breeding scheme can also alleviate occasional problems of cattle theft. This scheme therefore can be managed together with the planned *in-situ* Sheko breeding station.

Address indiscriminate use of non–descript and zebu bulls: Through provision of Sheko bulls, indiscriminate use of non–descript and zebu bulls can be discouraged. Castration of young Sheko bulls should also be discouraged through active publicity. Farmers should be provided with better market opportunities to sell young Sheko breeding bulls. This can be also supported through provision of semen using the functioning network of artificial insemination service.

Organization of Sheko cattle breeders' society: A small group of interested Sheko cattle owners can initiate such an organization to provide the social platform for promoting the breed. Technical guidance can then be provided on setting standards to register the true Sheko cattle and to create opportunities for marketing of breeding stock in and outside of the breeding tract. The society together with concerned bodies can develop incentives for farmers participating in genetic improvement of the Sheko cattle.

Developing artificial insemination program for Sheko

Enhanced use of cryopreserved Sheko bull semen at the National Artificial Insemination Center (NAIC) particularly in the Sheko home area as part of the ongoing artificial insemination service can help alleviate the limitations in pure breeding of Sheko cattle. At the same time, semen can be collected from known Sheko bulls in same area for cryopreservation and further use. However, care has to be taken to minimize the rate of inbreeding which might result from excessive use of few bulls.

Discussions

Superior trypanotolerance attributes and better fertility of the Shoko cattle (Lemecha *et al.*, 2006) coupled with desirable dairy and traction qualities

(Takele, 2005; Takele *et al*., 2007) can be used to selectively promote the breed and avert further decline of the breed population. However, Sheko cattle keepers are neither well aware of these opportunities nor the precarious status of the breed.

Mwacharo and Drucker (2005) and Zewdu *et al*. (2006) have shown the challenges associated with small herd sizes and suggested that group-breeding schemes can overcome structural limitations of institutionalizing selective breeding. It is therefore suggested that implementation of the suggested management plan should be initiated sooner to avert further declines in the surviving Sheko cattle population and when many communities can clearly identify true-to-type Sheko cows and bulls.

As Wollny (2003) and Scarpa *et al*. (2003) have pointed out, any breed conservation plan should be based on validated superior economic benefits of the breed. Direct and indirect incentives to breed maintenance should also be based on expected economic benefits to society. According to Lund (2002) incentives can encourage the owners to keep breeding stock under good management which enhances maintenance of the breed. This may, therefore, require establishment of Sheko breed conservation fund.

Köhler–Rollefson (2003) recommended active publicity as a vehicle to disseminate knowledge on special qualities and value of the breed. This is a useful strategy to harness the community support and to sensitize the public sector.

Formation of breeders' society for Sheko cattle will ensure farmers' participation to identify elite animals, create market opportunities, initiate herd registration, and to take the lead in conservation activities (Hegde, 2005). To achieve this, the society has to be an independent and legally recognized organization with executive powers. This requires mobilization of resources and leadership development through capacity building (Köhler–Rollefson, 2003).

Artificial insemination can be used to support conservation measures for the maintenance of threatened breeds (William and Amanda, 1999). This can be therefore adopted to conserve and increase the population size of the Sheko breed.

Conclusion

The endangered Sheko breed can be rescued and developed through active breed management plan with full participation of a range of stakeholders in-

cluding Sheko cattle owners, agricultural extension staff, administration officials, conservationists and researchers. The plan should primarily address commonly identified constraints to Sheko cattle maintenance while harnessing breed promotion opportunities based on special qualities of the breed. The emerging large market opportunity for trypanotolerant cattle can be targeted to promote Sheko breed outside its natural habitat in parts of southwestern Ethiopia.

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Growth and Reproductive performance of Ogaden cattle at Haramaya University, Ethiopia

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Abstract

The Ogaden Zebu in Ethiopia is also known in the literature as a Lowland Zebu. It is range-adapted and has good potential for beef production from the semi-arid rangelands. This study characterized growth and reproductive performance of the breeding herd maintained at Haramaya University. The mean birth weight was 21.0±0.31 kg for females and 22.0±0.33 kg for males, and the average weaning weight at six months was 87.9±1.95 kg for females and 95.4±1.92 kg for males. Males had average yearling weight of 145.±2.86 kg and it was 127.65±2.87 kg for females, and the 24-month weight was 214.80±4.30 kg for males and 186.59±4.08 kg for females. Average weight at first service was 245.7 kg which reached 269.1 kg at first calving at an average age of 49.2±4.43 months. The mean annual calving rate was 74.2±16.03 % with average lifetime calving of 2.17±0.12 per cow. The average breeding efficiency was 69.6%. Cows measured 150.11±8.20 cm on chest girth, 121.09 ± 7.18 cm on body length, 115.54 ± 5.17 cm on height at withers and 57.49 ± 4.33 cm on distance from ground to the abdomen. Qualitative characteristics were also described. The result indicated promising growth and reproductive performances of Ogaden breed, which is favourably comparable to other zebu cattle breeds of Ethiopia. Some of the physical traits of Ogaden cattle are similar to those of the Ethiopian Boran, but both cattle breeds are different in some other traits.

Keywords: Ogaden zebu cattle, Ethiopia, Phenotypic characterization, Growth, Reproduction.

Introduction

The indigenous cattle breeds of Ethiopia constitute an important asset for the present as well as future economic and social development of the country. However, characterization and inventory work on these resources is still at its early stage of development. Most of the 27 recognized indigenous cattle breeds only have a basic description of their typical features and their distribution (Aleber-

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ro and Haile-Mariam, 1982; Sisay Gezahegn, 1996; DAGRIS, 2007), but very limited comparative information is available on productive and reproductive performance, let alone specific adaptive attributes, viability and within-breed genetic diversity. Detailed on-station performance evaluation of indigenous cattle breeds have been carried out in relation to national smallholder dairy improvement programmes. Some of them are the Ethiopian Boran cattle and their crosses at Abernosa ranch (Azage Tegegn, 1981 and Mekonnen Haile-Mariam, 1987), Fogera cattle and their crosses at Andassa cattle breeding station (Asheber Sewalem 1992), and Arsi cattle at Assela livestock farm (Enyew Nigussie, 1992). Moreover, several new distinct indigenous cattle breed types have been reported recently. These are the Wollo Highland zebu, Raya Sanga and Afar Sanga (Dereje Tadesse et al., 2008) and Mahibere-Silassie (Zewdu Wuletaw et al., 2008). The present report is part of a bigger study which was targeted to characterize Ogaden cattle in terms of morphological traits as well as reproductive and growth performances at specific ages (Getinet Mekuriaw, 2005).

The Ogaden cattle are maintained by Somali pastoralists and agro-pastorals and inhabit most of the warm and arid rangelands of the Ogaden region in south-eastern Ethiopia (Figure 1). In this area mid-day temperature readings can soar to more than 40°C (CE, 2005). There are no official population estimates the breed. Alberro and Haile-Mariam (1982) classified the Ogaden zebu as similar to the Ethiopian Boran; however, Sisay Gezahegn (1996) provided genetic evidence based on protein polymorphism data that the Ogaden and Ethiopian Boran both have relatively very high heterozygosity values indicating separate and divergent long-term within-breed natural selection for adaptation to harsh environmental conditions towards formation of separate breed lines.

The breed is mainly used for meat and milk and they are considered to be drought-tolerant. The breed is regarded as suitable for profitable beef production from arid and semi-arid rangelands of south-eastern Ethiopia, and is being extensively used for both domestic and export markets. Thus they can effectively be used to generate more incomes for the large pastoral and agro-pastoral community in the Ogaden rangelands. Some typical features of the Ogaden cattle are the white to grey hair coat color, compact body conformation and short horns (Sisay Gezahegn, 1996). No attempt has been made to characterize performance of this breed. The present study provides the first *ex situ* on-station performance characterization of the breed using the experimental beef herd that has been maintained at the Beef Cattle Farm of the Haramaya

University since 1990 (Figure 1). Hence, the objectives of this report are to evaluate morphological characteristics of Ogaden cattle breed and to estimate average reproductive and growth performances of the herd.

Materials and Methods

The study area

Haramaya University (formerly known as Alemaya University of Agriculture) is situated at an altitude of 9º 20´ North of the Equator and 42º 03´ East of Meridian and at an altitude of 1980 m.a.s.l. in eastern Ethiopia, about 521 km on the easterly road from Addis Ababa. It lies within high potential agricultural plateau of the Hararghe highlands. It enjoys a moderate average temperature of 16ºC, with mean minimum temperature of 9.73ºC and mean maximum temperature of 24.02ºC. The annual rainfall ranges between 507 and 995 mm (Mengistu and Asnakech, 1986).

The foundation stock of this breeding herd was purchased from different places of Dagahabur Awraja of the previous Hararghe Administrative region which is the natural habitat of the breed, about 200 km south of the University in 1990. Ninety females and ten bulls were selected as foundation stock. From establishment up to August 2004, a total of 495 animals were born on the farm and a further 148 animals were purchased into the herd. All of these 743 animals were included in this study. The herd is kept on pasture without supplementary feeding. The pasture predominantly consists of *hyparrhenia* species, *Cynodon dactylon*, *Sporobolus Africanus* and *Pennisetun* species (Mengistu and Asnakech, 1986). Natural seasonal block mating was practiced, with an average mating ratio of one bull to twenty-five cows. Cows were not milked and calves were allowed to run with dams till weaning age of 180 days. Breeding bulls have been selected based on birth, weaning and yearling weights, good body conformation and size and condition of the testis, and they were allowed to graze with the cows during the breeding season which is usually 75-90 days.

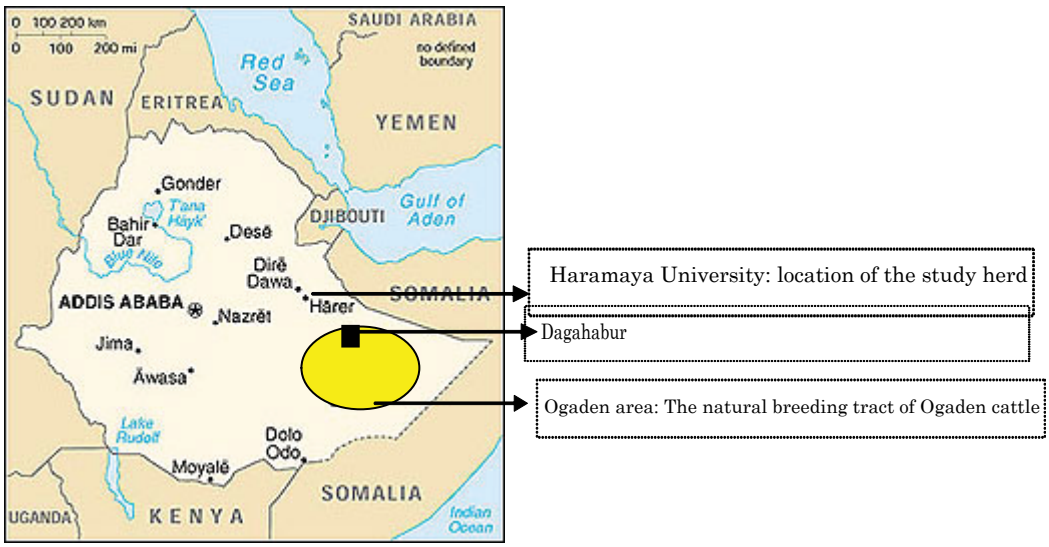

Figure 1. Natural habitat of the Ogaden breed

Data collection and management

Data on the growth and reproduction of the herd between 1990 and August 2004 were collected from individual and herd record cards of the farm for the purposes of this study. Substantial data cleanup and checking was made before transcription into computer. Morphometric data were collected from randomly selected adult animals, whose age is greater than or equal to three years, on site by the researcher.

Cows were identified by origin, as some belonged to the foundation stock (or brought in recently as replacements) and others were born in the farm. Birth, weaning (at six months) as well as bi-monthly live body weights were used to evaluate growth and weight gains. Weight records were checked through calculated fortnightly weight gains and records suggesting average daily gains (ADG) or losses above one kilogram were considered unrealistic and hence excluded from the analysis. Because body weight records were not taken on exactly 15 days intervals, only those records within ±6 days to the weaning, yearling and other fixed age weights were included in the analysis. Using the average daily weight gain which the animal achieved within the interval of consecutive fixed ages, data were projected through linear interpolation to the required fixed age of each individual animal. .

Based on the breeding plan of the farm, Ogaden heifers were made available for mating for the first time when they re ach 24 months of age and have attained a body weight of around 200-250 kg. Annual calving rate (CR) was calculated as percent annualized calving interval (Wilson, 1986), i.e.: $CR(\%) = (\frac{S}{CI} x 365) x 100$, where, S=Litter size, and CI = Calving interval. Similarly, the breeding efficiency (BE) was calculated as the average number of calves born per annum during reproductive life of the cow (Wilcox *et al*., 1957), i.e. $BE = \frac{365(N-1)}{Days\ from\ first\ to\ last\ calving}$, where N = the number of calvings during the reproductive life of the cow. For morphological and morphometeric descriptions, both qualitative and quantitative variables were recorded from existing adult male and female stock (FAO, 1986), and cows and heifers above three years of age were used. But for males the relatively very small number of males in the herd meant that all the available males, including young bulls less than four years of age had to be used.

Statistical Analysis

Quantitative data were subjected to the General Linear Model (GLM) procedure of SAS (SAS, 1999). Descriptive statistics was used to analyze qualitative variables. Missing body weight and age data limited options for analyzing interactions between variables. Depending on the trait, fixed effects such as birth year, birth season, birth weight, origin of dam, sex of the calf and parity of the dam were used in the statistical models. These factors were included on the basis of their direct influence on the coefficient of determination (R^2) and the overall number of observations per trait.

The following statistical models were used:

Growth performance traits:

$$Y_{amdjsl} = \mu + B_a + H_m + P_d + S_j + X_s + e_{amdjsl}$$

Reproductive performance traits:

1. Age at first calving: $Y_{ajl} = \mu + B_a + S_j + e_{ajl}$
2. Gestation length: $Y_{abjsl} = \mu + B_a + W_{b(Cov)} + S_j + X_s + e_{abjsl}$
3. Calving interval: $Y_{mdinl} = \mu + H_m + P_d + R_i + Z_n + e_{mdinl}$

Where; Y_{amdjsl} = the dependent variable

B_a= effect of a^{th} birth year

H_m = effect of m^{th} source of dam herd
P_d = effect of d^{th} parity of the dam
R_i = effect of i^{th} calving year
S_j = effect of j^{th} birth season
W_b = effect of b^{th} birth weight of the calf
X_s = effect of s^{th} sex of the calf
W_b (birth weight) was considered as a covariate for gestation length. For morphological traits, breeding efficiency and weight at first service, only descriptive statistics was be applied.

Results

Growth Performance

The overall least squares means of birth weight was 21.50±0.29 kg, with 20.98±0.31 kg for females and 22.03±0.33 kg for males (Table 1). The calves had adjusted mean 3 months weight of 62.85±0.46 kg and ADG from birth to 3 months of age of 462 g with coefficient of variation 31.05% (Table 2).

Table 1. Least square means and standard errors (LSM±SE) of birth weight

Factors	N	LSM±SE (kg)
Overall	378	21.50±0.29
Dams herd		*
Farm born dam	167	21.91±0.37^{a}
Purchased dams	211	21.10±0.33^{b}
Parity of dam		**
1	189	20.29±0.34^{d}
2	67	21.53±0.39^{abc}
3	41	21.79±0.50^{abc}
4	35	21.94±0.54^{ab}
5	46	21.98±0.53^{a}
Year of birth		**
1991	77	24.68±0.54^{b}
1993	18	20.65±0.80^{cdefgh}
1994	16	20.26±0.81^{efghijk}
1995	24	20.26±0.64^{efghij}
1996	21	20.89±0.66^{cdefgh}
1997	15	22.43±0.79^{c}
1998	19	19.70±0.70^{efghijkl}

Factors	N	LSM±SE (kg)
1999	34	21.43±0.62^{cdef}
2000	1	20.58^{cdefghi}
2001	38	25.09±0.55^{a}
2002	41	21.66±0.48^{cde}
2003	41	19.67±0.59^{efghijkl}
2004	33	22.24±0.53^{cd}
Season of birth		NS
Kiremt	165	21.01±0.37
Meher	130	22.35±0.49
Belg	83	21.15±0.49
Sex of calf		**
Male	176	22.03±0.33^{a}
Female	202	20.98±0.31^{b}

LSM with different letters within a factor differ significantly, ** = P<0.01, * = P<0.05 and NS = Non-significant

Table 2. Least square means and standard errors (LSM±SE) of adjusted weight at three months of age and average daily weight gain from birth to three months.

Factors		LSM±SE (kg)	
	N	ADJ3Wt	ADG0-3
Overall	159	62.85±0.46	0.462±0.02
Dams herd		NS	NS
Farm born dams	104	66.72±1.37	0.495±0.02
Purchased dams	55	63.66±1.77	0.472±0.02
Parity of dam		*	*
1	61	63.29±1.66^{abcd}	0.478±0.02^{abc}
2	33	67.30±2.07^{abc}	0.521±0.03^{a}
3	17	69.11±2.92^{a}	0.513±0.04^{ab}
4	20	67.32±2.73^{ab}	0.494±0.03^{abc}
5	28	58.93±2.36^{d}	0.408±0.03^{d}
Season of birth		**	*
Kiremt	39	66.50±2.03^{a}	0.472±0.03^{a}
Meher	95	61.07±1.28^{b}	0.445±0.02^{b}
Belg	25	68.00±2.49^{a}	0.533±0.03^{a}
Sex of calf		**	**
Female	88	61.42±1.40^{b}	0.440±0.02^{b}
Male	71	68.95±1.69^{a}	0.520±0.02^{a}

LSM with different letters within a factor differ significantly, ** = P<0.01, * = P<0.05 and NS = Non-significant, ADJ3Wt = adjusted weight at three months age and ADG0-3 = average daily weight gain from birth to three months

The least squares means of live weights of calves at weaning and 9 months were 91.65±1.67 kg and 111.1±2.16 kg, respectively, with 95.42±1.92 kg and 116.64±2.49 kg for males and 87.88±1.95 kg and 105.50±2.37 kg for females. The estimated ADG from 3 months to weaning age was 0.389 kg with 0.407±0.01 kg for males and 0.370±0.01 kg for females and it was 0.336 kg for the period from weaning to 9 months of ages with 0.355±0.01 kg for males and 0.317±0.01 kg for females (Tables 3&4).

Table 3. Least square means and standard errors (LSM±SE) of adjusted weight at six months of age and average daily weight gain from 3-6 months.

Factors	**N**	**LSM±SE (kg)**	
		ADJ6Wt	**ADG3-6**
Overall	210	91.65±1.67	0.389±0.01
Dams herd		NS	NS
Farm born dam	133	93.48±2.11	0.395±0.01
Purchased dam	77	89.82±1.91	0.383±0.01
Parity of dam		*	*
1	79	91.44 ± 2.02^{abc}	0.397 ± 0.01^{abc}
2	39	93.66 ± 2.50^{ab}	0.400 ± 0.01^{ab}
3	28	95.69 ± 2.92^{a}	0.411 ± 0.02^{a}
4	26	92.33 ± 3.09^{abc}	0.388 ± 0.02^{abc}
5	38	85.13 ± 2.87^{d}	0.348 ± 0.02^{d}
Year of birth		**	**
1991	3	96.46 ± 8.52^{b}	0.390 ± 0.05^{bcd}
1992	-	-	-
1993	-	-	-
1994	12	93.19 ± 4.77^{bcd}	0.407 ± 0.03^{bc}
1995	5	124.36 ± 6.19^{a}	0.574 ± 0.03^{a}
1996	16	88.07 ± 3.89^{bcdefg}	0.368 ± 0.02^{bcdefgh}
1997	10	93.37 ± 5.13^{bc}	0.389 ± 0.03^{bcde}
1998	12	81.03 ± 4.71^{bcdefghij}	0.338 ± 0.03^{cdefghij}
1999	24	92.27 ± 3.72^{bcde}	0.409 ± 0.02^{b}
2000	-	-	-
2001	35	92.18 ± 3.54^{bcdef}	0.369 ± 0.02^{bcdefg}
2002	38	76.55 ± 2.92^{jk}	0.304 ± 0.02^{defghijk}
2003	39	84.73 ± 3.35^{bcdefghi}	0.370 ± 0.02^{bcdef}
2004	16	85.94 ± 3.93^{bcdefgh}	0.358 ± 0.02^{bcdefghi}
Season of birth		NS	NS
Kiremt	94	95.49±2.44	0.418±0.01

Factors	N	LSM±SE (kg)	
		ADJ6Wt	ADG3-6
Meher	97	90.19±2.66	0.370±0.02
Belg	19	89.27±4.27	0.378±0.02
Sex of calf		**	**
Males	105	95.42±1.92a	0.407±0.01a
Females	105	87.88±1.95b	0.370±0.01b

LSM with different letters within a factor differ significantly. ** = P<0.01, * = P<0.05 and NS = Non-significant

ADJ6Wt = Adjusted weight gain at six months ADG3-6 = Average daily weight gain from three to six months

Table 4. Least square means and standard errors (LSM±SE) of adjusted weight at nine months of age and average daily weight gain from 6-9 months.

Factors	N	LSM±SE (kg)	
		ADJ9Wt	ADG6-9
Overall	240	111.07±2.16	0.336±0.01
Parity of dam		*	*
1	93	109.05 ± 2.63^{bcd}	0.334 ± 0.01^{abcd}
2	48	112.36 ± 2.86^{abc}	0.341 ± 0.01^{ab}
3	33	116.85 ± 3.44^{a}	0.357 ± 0.01^{a}
4	26	112.65 ± 3.89^{ab}	0.339 ± 0.01^{abc}
5	40	104.43 ± 3.43^{de}	0.309 ± 0.01^{cde}
Year of birth		**	**
1991	19	118.84 ± 5.19^{bc}	0.347 ± 0.02^{bcde}
1992	-	-	-
1993	4	124.36 ± 8.99^{ab}	0.384 ± 0.03^{ab}
1994	12	116.53 ± 6.01^{bcde}	0.369 ± 0.02^{bcd}
1995	18	134.50 ± 4.67^{a}	0.432 ± 0.02^{a}
1996	19	101.40 ± 4.69^{efghi}	0.286 ± 0.02^{fghi}
1997	12	108.12 ± 5.93^{bcdef}	0.317 ± 0.02^{bcdefg}
1998	14	90.21 ± 5.56^{ijk}	0.262 ± 0.02^{ijk}
1999	36	118.13 ± 4.05^{bcd}	0.380 ± 0.01^{bc}
2000	-	-	-
2001	35	98.09 ± 4.36^{fghi}	0.269 ± 0.02^{ij}
2002	35	104.25 ± 3.74^{efgh}	0.307 ± 0.01^{fgh}
2003	36	107.33 ± 4.34^{bcdefg}	0.341 ± 0.02^{bcdef}
2004	-	-	-
Season of birth		NS	*
Kiremt	119	114.94±2.64	0.353 ± 0.01^{a}

Factors	N	LSM±SE (kg)	
		ADJ9Wt	ADG6-9
Meher	103	107.45±3.43	0.306±0.01^{bc}
Belg	18	110.81±5.83	0.349±0.02^{ab}
Sex of calf		**	**
Males	119	116.64±2.49^{a}	0.355±0.01^{a}
Females	121	105.50±2.37^{b}	0.317±0.01^{b}

LSM with different letters within a factor differ significantly, ** = P<0.01, * = P<0.05 and NS = Non-significant
ADJ9Wt = Adjusted weight at nine months of age, ADG6-9 = Average daily weight gain from six to nine months of age

The overall least squares means yearling and 18 months weights were 136.30±2.36 kg and 163.32±2.51 kg, respectively with 144.96±2.86 kg and 171.92±3.1 kg for males and 127.65±2.87 kg and 154.72 kg for females. The difference was highly significant between males and females at the specified ages (Table 5). The ADG from 9 months to yearling age was 322 g with coefficient of variation 21.52%, and that from yearling to 18 months of age was 226g. The overall least square means weight at 24 and 30 months of ages were 200.7±3.43, and 234.79±3.67 kg, respectively, which meet the minimum weight for the age of export beef animals (Table 6). ADG from 18 to 24 months of age was 227.0 g and from 24 to 30 months of age was 222 g per day. The Ogaden cattle reached 267.63± 4.44 kg and 298.7±5.48 kg of overall mean adjusted weight at 36 and 42 months of age, respectively, with 217g and 212 g ADG from 30 to 36 and from 36 to 42 months of age, respectively (Table 7).

Table 5. Least square means and standard errors (LSM±SE) of adjusted weight at yearling age and 18 months age, and average daily weight gain from 9 to 12 months and from 12 to 18 months.

Factors	N	LSM±SE (kg)		N	LSM±SE (kg)	
		ADJ12Wt	ADG9-12		ADJ18Wt	ADG12-18
Overall	240	136.30±2.36	0.322±0.01	237	163.32±2.51	0.226±0.00
Dams herd		*	**		**	**
Farm born dam	130	132.08±2.90^{b}	0.309±0.01^{b}	91	157.85±3.41^{b}	0.218±0.01^{b}
Purchased dam	110	140.53±2.84^{a}	0.334±0.01^{a}	146	168.79±2.73^{a}	0.234±0.00^{a}
Parity of dam		**	**		*	**
1	93	140.19±3.06^{abc}	0.337±0.01^{ab}	134	166.55±2.37^{abcd}	0.233±0.00^{abc}
2	48	142.29±3.74^{a}	0.339±0.01^{a}	44	167.82±3.91^{abc}	0.234±0.01^{a}
3	33	142.03±4.49^{ab}	0.336±0.01^{abc}	26	168.53±5.01^{a}	0.234±0.01^{ab}
4	26	136.81±5.16^{abc}	0.322±0.01^{abc}	13	167.85±7.20^{ab}	233±0.01^{abcd}
5	40	120.21±4.45^{d}	0.275±0.01^{d}	20	145.85±5.94^{e}	0.197±0.01^{e}

Factors	N	LSM±SE (kg)		N	LSM±SE (kg)	
		ADJ12Wt	ADG9-12		ADJ18Wt	ADG12-18
Season of birth		NS	NS		NS	NS
Kiremt	119	136.54±2.44	0.318±0.01	131	159.71±2.61	0.220±0.00
Meher	103	140.72±2.51	0.333±0.01	49	160.62±3.83	0.222±0.01
Belg	18	131.65±5.97	0.314±0.02	57	169.63±4.33	0.235±0.01
Sex of calf		**	**		**	**
Male	119	144.96±2.86[a]	0.345±0.01[a]	111	171.92±3.10[a]	0.239±0.01[a]
Female	121	127.65±2.87[b]	0.298±0.01[b]	126	154.72±2.92[b]	0.213±0.00[b]

LSM with different letters within a factor differ significantly, ** = P<0.01, * = P<0.05 and NS = Non-significant, ADG12Wt = Adjusted weight at 12 months of age, ADG9-12 = Average daily weight gain from nine to 12 months of age, ADJ18Wt = Adjusted weight at 18 months of age, ADG12-18 = Average daily weight gain from 12 to 18 months of age.

Table 6. Least square means and standard errors (LSM±SE) of adjusted weight at 24 and 30 months of age, and average daily weight gain from 18 to 24 and from 24 to30 months.

Factors	N	LSM±SE (kg)		N	LSM±SE (kg)	
		ADJ24Wt	ADG18-24		ADJ30Wt	ADG24-30
Overall	195	200.68±3.43	0.227±0.00	174	234.79±3.67	0.222±0.00
Dams herd		**	**		**	**
Farm born dam	72	192.04±4.72b	0.216±0.01b	64	225.43±5.27b	0.213±0.01b
Purchased dam	123	209.32±3.75a	0.238±0.00a	110	244.16±3.88a	0.232±0.00a
Parity of dam		*	**		**	**
1	109	200.32±3.30bcd	0.229±0.00abc	92	240.47±3.62ab	0.230±0.00ab
2	36	213.93±5.55a	0.245±0.01a	32	247.38±5.97a	0.237±0.01a
3	16	203.14±8.22ab	0.230±0.01ab	15	241.54±8.66abc	0.229±0.01abc
4	13	202.84±9.21abc	0.228±0.01abcd	11	235.63±10.18abc	0.222±0.01abc
5	21	183.18±7.59d	0.203±0.01d	24	208.94±7.50d	0.194±0.01d
Season of birth		**	**		NS	NS
Kiremt	104	193.87±3.80b	0.218±0.00b	91	238.94±4.21	0.226±0.00
Meher	49	221.13±4.96a	0.254±0.01a	46	229.23±5.12	0.217±0.01
Belg	42	187.04±6.16b	0.209±0.01b	37	236.21±6.73	0.224±0.01
Sex of calf		**	**		**	**
Male	87	214.80±4.30a	0.245±0.01a	70	253.36±4.68a	0.242±0.00a
Female	108	186.59±4.08b	0.210±0.01b	104	216.22±4.41b	0.203±0.00b

LSM with different letters within a factor differ significantly, ** = P<0.01, * = P<0.05 and NS = Non-significant, ADJ24Wt = Adjusted weight at 24 months of age, ADG18-24 = Average daily weight gain from 18 to 24 months of age, ADJ30Wt = Adjusted weight at 30 months of age, ADG24-30 = Average daily weight gain from 24 to 30 months of age

Table 7. Least square means and standard errors (LSM±SE) of adjusted weight at 36 and 42 months age, and average daily weight gain from 30 to 36 and from 36 to 42 months.

Factors	N	LSM±SE (kg)		N	LSM±SE (kg)	
		ADJ36Wt	ADG30-36		ADJ42Wt	ADG36-42
Overall	137	267.63± 4.44	0.2165±0.0040	109	298.70±5.48	0.212±0.0041
Dam herd		**	**		*	*
Farm born dam	47	255.58±6.12^{b}	0.206±0.01^{b}	30	288.25±8.39^{b}	0.204±0.01^{b}
Introduced dam	90	279.69±4.57^{a}	0.227±0.00^{a}	79	309.15±4.99^{a}	0.219±0.00^{a}
Dam parity		NS	NS		*	*
1	78	270.51±4.06	0.221±0.00	62	308.69±5.05^{ab}	0.219±0.00^{ab}
2	28	281.98±6.34	0.231±0.01	18	313.64±8.94^{a}	0.224±0.01^{a}
3	11	264.37±10.23	0.213±0.01	11	302.66±10.91^{abcd}	0.215±0.01^{abcd}
4	10	263.28±10.92	0.212±0.01	10	307.29±11.74^{abc}	0.217±0.01^{abc}
5	10	258.04±10.96	0.206±0.01	8	261.20±13.54^{e}	0.184±0.01^{e}
Birth season		*	NS		*	*
Kiremt	64	273.88±5.61^{a}	0.221±0.01	59	303.26±6.07^{a}	0.213±0.00a
Meher	44	273.46±5.49^{a}	0.222±0.00	29	283.00±6.95^{b}	0.200±0.01^{b}
Belg	29	255.57±7.47 ^{b}	0.206±0.01	21	309.83±9.77^{a}	0.220±0.01^{a}
Calf sex		**	**		**	**
Male	44	306.53±6.18^{a}	0.251±0.00^{a}	37	341.94±6.99^{a}	0.245±0.00^{a}
Female	93	228.74±4.68^{b}	0.182±0.01^{b}	72	255.46±6.26^{b}	0.179±0.01^{b}

Note: LSM with different letters within a factor differ significantly, ** = P<0.01, * = P<0.05 and NS = Non-significant, ADJ36Wt = Adjusted weight at 36 months of age, ADG30-36 = Average daily weight gain from 30 to 36 months of age, ADJ42Wt = Adjusted weight at 42 months of age, ADG36-42 = Average daily weight gain from 36 to 42 months of age

The overall adjusted mean body weight at 48 months age and ADG from 42 to 48 months were estimated 295.11±12.59 kg and 0.184±0.01 kg, respectively (Table 8). Even though calves born to farm-born dams had significantly higher birth weight than those born to purchased dams (Tables 1), their weight at three and, six months of age and rate of gain during these periods were similar (Tables 2&3). However, from one year of age to 42 months of age progeny of the purchased dams performed significantly better than calves born to farm-born cows (Tables 5, 6&7). As expected males calves always had significantly higher body weight than their counterpart females, especially more so as the animals approached maturity.

Table 8. Least square means and standard errors (LSM±SE) of adjusted weight at 48 months of age, and average daily weight gain from 42 to 48 months.

Factors	N	LSM±SE (kg)	
		ADJ48Wt	ADG42-48
Overall	118	295.11±12.59	0.184±0.01
Dams herd		NS	NS
Farm born dam	27	294.63±19.32	0.184±0.01
Introduced dam	91	295.59±11.12	0.184±0.01
Dam parity		NS	NS
1	71	278.34±10.28	0.173±0.01
2	22	313.64±18.84	0.198±0.01
3	10	300.12±24.98	0.187±0.01
4	7	307.17±30.43	0.191±0.02
5	8	276.29±29.01	0.172±0.01
Birth season		**	**
Kiremt	58	299.94±14.53^{b}	0.188±0.01^{b}
Meher	34	337.19±14.46^{a}	0.212±0.01^{a}
Belg	26	248.21±21.66^{c}	0.152±0.01^{c}
Calf sex		**	**
Male	50	316.27±15.38^{a}	0.198±0.01^{a}
Female	68	273.95±13.65^{b}	0.170±0.01^{b}

LSM with different letters within a factor differ significantly, ** = P<0.01, * = P<0.05 and NS = Non-significant, ADJ48Wt = Adjusted weight at 48 months of age, ADG42-48 = Average daily weight gain from 42 to 48 months of age

Birth weights were significantly affected by parity, with calves belonging to the first parity being lighter (20.29±0.34 kg) at birth than those born at later parities (Table 1). The heaviest average birth weight (21.98 kg) was recorded for the fifth and later parities. However, the growth rates of calves were less affected by parity. Season of birth did not affect birth weight, but weight at three months of age was significantly ($P < 0.01$) influenced whereby calves born during the wet season had heavier weights at three months of age.

The average observed weight at first service at the age of about 34 months was 245.7 kg (N=73). As stated above, heifers are considered ready for mating from about 24 months of age or about 200kg body weight. Similarly the average postpartum weight after first calving was 266.0 kg with coefficient of variation 12.9 %.

Reproductve Performance

The average age at first service was 34.4±2.28 months (N=52), with minimum and maximum values of 22.6 and 51.5 months, respectively. About 26% of them had service age of below 24 months. The overall mean age at first calving was 49.2±4.43 months (Table 9).

Table 9. Least square means and standard errors (LSM±SE) of age at first calving

Effects	N	LSM±SE (Months)
Overall	81	49.18±4.43
Birth year		**
1994	9	$37.18±4.23^{gh}$
1995	5	$50.17±4.59^{bcdef}$
1996	11	$48.21±3.30^{bcdefg}$
1997	4	$57.15±5.53^{ab}$
1998	4	$52.33±5.53^{abcde}$
1999	9	$44.43±4.23^{bcdefgh}$
2001	9	$56.75±4.16^{abc}$
2002	11	$61.96±3.52^{a}$
2003	3	$54.63±6.25^{abcd}$
2004	16	$42.15±2.84^{defgh}$
Birth season		NS
Kiremt	33	46.65±2.51
Meher	30	55.26±2.79
Belg	18	49.57±3.67

LSM with different letters within a factor differ significantly, * = P<0.05 and NS = Non-significant

The mean gestation length was 284.9±1.07 days with coefficient of variation of 2.20% (Table 10). Calf birth weight had highly significant effect (P<0.01) on gestation length. As the calf birth weight increased the gestation length was decreased. The average calving interval was 492.9±13.23 days with coefficient of variation of 23.5%. Parity of the dam and calving year had significant influences on calving interval; it was not affected by origin of dam and calving season (Table 11).

Table 10. Least square means and standard errors (LSM±SE) of gestation length in days.

Factors	**N**	**LSM±SE (days)**
Overall	318	284.89±1.07
Birth year		**
1991	74	286.35 ± 1.42^{bcd}
1993	14	290.73 ± 2.22^{a}
1994	17	282.39 ± 2.21^{dcghij}
1995	15	280.33 ± 2.10^{efghijk}
1996	25	284.76 ± 1.69^{cdef}
1997	15	284.10 ± 2.06^{cdefg}
1998	12	290.25 ± 2.24^{ab}
1999	25	282.60 ± 2.03^{defghi}
2001	26	284.78 ± 1.74^{cde}
2002	30	288.06 ± 1.56^{abc}
2003	38	280.26 ± 1.90^{efghijk}
2004	27	283.18 ± 1.49^{defgh}
Birth season		NS
Kiremt	132	282.67±1.19
Meher	102	287.28±1.43
Belg	84	284.67±1.50
Calf sex		*
Female	165	284.01 ± 0.95^{a}
Male	153	285.62 ± 0.98^{b}
Birth weight	380	**

LSM with different letters within a factor differ significantly, ** = P<0.01, * = P<0.05 and NS = Non-significant

Table 11. Least squares means and standard errors (LSM±SE) of calving interval in days

Factors	N	LSM±SE
Overall	176	492.86±13.23
Dam herd		NS
Farm born dam	83	503.41±18.50
Introduced dam	93	482.32±16.71
Dam parity		*
1	57	554.42±18.27^{a}
2	41	533.06±20.88^{ab}
3	33	476.07±23.69^{bc}
4	19	445.62±30.50^{cd}
5	26	455.13±28.58^{cd}
Calving year		**
1991	26	570.14±29.73^{a}
1992	3	429.47±73.06^{cdefghijk}
1993	10	516.87±44.56^{abcdef}
1994	5	498.36±60.67^{abcdefgh}
1995	6	557.49±51.04^{abc}
1996	10	535.28±41.03^{abcd}
1997	17	566.30±36.12^{ab}
1998	14	529.89±37.99^{abcde}
1999	7	356.41±54.25^{hijkl}
2000	-	-
2001	12	450.07±40.20^{cdefghij}
2002	25	504.20±28.37^{abcdefg}
2003	22	452.71±37.77^{bcdefghi}
2004	19	440.01±31.42^{cdefghijk}
Calving season		NS
Kiremt	89	474.98±21.06
Meher	52	520.75±25.58
Belg	35	482.85±29.81

LSM with different letters within a factor differ significantly, ** = P<0.01, * = P<0.05 and NS = Non-significant

The average annual calving rate for this herd was calculated to be 74.2±16.03 % (N=78).

The overall mean lifetime calving obtained per cow was 2.17± 0.12 (N=114). The breeding efficiency was calculated to be 69.6% with very high coefficient of variation of 42.36%.

Morphometric characteristics

On chest girth females measured 150.1±8.20 cm compared to 148.2±14.31 cm for males (Table 12). The average chest depth was 57.8 and 57.20 cm for females and males. The average distance from the ground to the abdomen was 57.5 cm and 58.4 cm for females and males. The average body length was 121.1 cm for females and 120.4 cm for males. The average height at wither was 115.5 cm for both females and males. Females and males have average horn lengths of 8.0 cm and 5.9 cm, ear lengths of 19.7 cm and 19.6 cm, and tail lengths of 71.6 cm and 71.9 cm, respectively. However, the results obtained for males were lower than that of females which seem contrary to the reality. The reason was, since more number of male animals were not allowed to stay in the farm, relatively very small number of males in the herd meant that all the available males, including young bulls under four years of age had to be used (Table 12).

Table 12. Linear measurements of male and female Ogaden cattle

Variable (cm)	Sex	N	Mean ±SD	Minimum	Maximum
Chest girth	Female	107	150.1± 8.20	131.0	170.0
	Male	20	148.2 ± 14.31	134.0	180.0
Chest depth	Female	107	57.8 ± 4.01	47.0	69.0
	Male	20	57.2 ± 4.79	51.0	73.0
Body length	Female	107	121.1 ± 7.18	120.0	147.0
	Male	20	120.4 ±7.27	110.0	140.0
Height at wither	Female	106	115.5 ± 5.17	104.0	131.0
	Male	19	115.5 ± 7.71	102.0	138.0
DGA	Female	106	57.5 ± 4.33	50.0	80.0
	Male	20	58.4 ± 2.16	55.0	63.0
Horn length	Female	91	8.0 ± 4.83	1.0	22.0
	Male	19	5.9 ± 3.26	1.0	12.0
Ear length	Female	107	19.7 ± 1.69	12.0	23.0
	Male	20	19.6 ± 1.05	17.0	22.0
Tail length	Female	107	71.6 ± 5.04	55.0	80.0
	Male	20	71.9± 5.15	62.0	85.0

DGA = Distance from the ground to the abdomen

Qualitative characteristics

Majority of females have short glossy hair, but not very shiny, with some females and all males having dull course hair. Over 80% of Ogaden cattle have white grey coat color with straight top line of same color (Figures 2 and 3). The facial profile is straight with flat forehead and level head. The eyelid and eyelashes are grey to white grey. The horns are grey and straight firm at base, and not thick. The ears are medium in size and horizontal in orientation. The muzzle color is grey for most of the animals. They have pyramidal hump, which is small in females and large in males. The dewlap is either small or medium. The naval flap is absent. The tail and switch are long and the black switch ends at pastern region (Figures 2&3). The hooves are medium sized, oval in shape and grey in color. The udder is small with cylindrical teats, which are pointed at tip.

Source: Getinet Mekuriaw, 2005

Figure 2. Herd of Ogaden cows

Source: Workneh Ayalew and Rowlands, 2004
Figure 3. Ogaden Bulls

Source: Workneh Ayalew and Rowlands, 2004
Figure 4. Ethiopian Boran bull

Discussion

Growth Performance

The birth weight recorded in the present study is less than those reported for various Boran calves in Ethiopia: 23.3 kg by Beyene Kebede and Galal (1982), 23.9±0.08 kg by Kassa Mersha and Arnason (1986), 25.2 kg by Mekonnen Haile-Mariam (1987), 26.6 kg by Yohannes Gojjam *et al.* (2001b) and 23.7 kg by Amsalu Sisay (2003). The cooler and wetter agro-ecology of the study area is markedly different from the arid to semi-arid agro-pastoral characteristics

of the natural habitat of the Ogaden zebu breed, and this is expected to affect growth performance of the breed.

The live weights at weaning and 9 months of age are comparable to earlier reports for Boran calves (Amsalu Sisay, 2003), much better than similar reports on Boran calves by Yohannes Gojjam *et al*. (2001b), but less than those reported by Beyene Kebede and Galal (1982) for Barka, Boran and Horro breeds. The estimated ADG from 3 months to weaning age (389 g) was comparable with 382.3 g reported by Addisu Bitew (1999) for Fogera cattle and 390.0±21 g for Boran breed reported by Amsalu Sisay (2003).

The overall least squares mean yearling live weight (136.30±2.36 kg) was higher than 130.1± 4.9 kg for Boran reported by Amsalu Sisay (2003), but lower than the 179±5 kg for Boran reported by Mekonnen Haile-Mariam (1987) at Abernossa ranch, and 145.2±0.9 kg for Fogera cattle by Giday Yifter (2001). The rate of gain from 9 months to yearling age (322g) is very much higher than the reported 199±16 g rate of gain from 6 to 12 months for Boran cattle by Amsalu Sisay (2003), but lower than 424.8±13 g for Boran at Abernosa reported by Mekonnen Haile-Mariam (1987). Like other indigenous cattle breeds mentioned above, the Ogaden cattle has also comparative and encouraging live weight and rate of gain and realize as the breed can have better weight if the management practice is improved.

The overall least squares mean weight at 24 months (200.7±3.43 kg) is comparable to 201.5±4.26 kg for Fogera cattle reported by Addisu Bitew (1999) at this age, but lower than 269 kg of Boran cattle reported by Mekonnen Haile-Mariam (1987). Addisu Bitew (1999) reported 177.84 g per day for Fogera cattle from 18 to 24 months of age, which was very much lower than results (227.0 g) of this study. The overall adjusted mean body weight at 48 months of age (289.6 kg) is better than 267.0 kg of White Gudali at Shika station in Nigeria (Oni *et al.,* 1988) but less than the 300.0 kg of White Fulani cattle in Nigeria (Tawah and Rege, 1996). The better performance of the calves born from purchased cows than those from farm-born might be due to differences in genotype of the dam groups as they were not selected from the same original herd.

Calves born during the wet season had heavier weights at three months of age, perhaps due to the better quality and quantity of pasture and hence milk yield of dams during later parts of the wet season.

The average weight at first service (245.7 kg) and the average postpartum weight after first calving (266.0 kg) are considered too low to support reproduc-

tion of the animals. Low weights at calving are closely related to calving difficulties and subsequent reproductive disorders (Ugarte, 1986).

Reproductve Performance

The age at first calving of Oganden cattle (49.2±4.43 months), is considered too late compared to reports of 45.2 months (Kassa Mersha and Arnason, 1986) and 45 months (Mukasa-Mugerwa, 1989) for Ethiopian Boran cattle. The study herd has been under seasonal mating, and those heifers which failed to come to heat during the breeding season had their next mating delayed until the next mating season, and this is expected to have contributed to the late average age at first calving. The mean gestation length (284.9±1.07 days) is close to 281.0 (Azage Tegegn, 1981) and 281.4 days (Ababu Dekeba, 2002) observed for other Ethiopian Boran herds at Abernossa ranch and 280 days for Barka cattle(Azage Tegegn, 1981) but higher than 276.2 days estimated for Arsi cattle (Enyew Negussie, 1992). The earliest as well as late gestation length is highly associated with the birth weight of the calves. It is biologically true that calves which are carried for longer time are higher in birth weight. It might be due to this fact that Ogaden has relatively higher gestation length and birth weight than Arsi cattle.

The average calving interval (492.9±13.23 days) is much lower than 780 days of traditionally managed Ethiopian highland zebu (Mukasa-Mugerwa *et al.,* 1989) and 534.3±17.64 days of the other Ethiopian Boran herd maintained at Abernossa ranch (Ababu Dekeba, 2002). But, the present estimate is higher than 479.9 days for Boran cows at Abernosa ranch (Azage Tegegn, 1981), 477±0.3 days for Boran cows at Mkwaja ranch of Tanzania (ILCA, 1985), and 465± 4 days for Boran cows in Abernosa ranch (Mekonnen Haile-Mariam, 1987).

The average annual calving rate for this herd (74.2±16.03%) is much lower than 97 and 91% reported for Horro cattle and their crosses at Bako station in Ethiopia (Gebre-Egziabher Gebre-yohannes and Mulugeta Kebede, 1996). However, it is better than the estimated 46% for Ethiopian Highland Zebu cattle (Mukasa-Mugerwa, 1989), 40% for Boran cows at Abernosa ranch (Million Tadesse and Alemayehu Reda, 2002). Environments like nutritional requirement and other management practices which are provided for the animals are determinant factors in affecting the performance of reproductive traits like calving rate, gestation length, calving interval and others than the genotypic influence. Therefore, the above mentioned figures at the respective traits are

good indicatives to revisit how the overall management practices were going on at farm level.

The overall mean lifetime calving obtained per cow (2.17± 0.12) is a lot less than 4.8 observed for Boran cows at Abernossa ranch (Mekonnen Haile-Mariam, 1987) and 3.34± 0.1 for Fogera cattle at Metekel ranch (Giday Yifter, 2001). The prolonged age at first calving and longer calving intervals can partly explain the low calf production. The low breeding efficiency (69.6%) indicates limitations of the routine husbandry practices of the study herd and that significant improvements in reproductive management can be achieved at the farm.

Morphometric characteristics

The average chest depth (57.8 and 57.20 cm) for females and males are similar to those of the Ethiopian Boran known for their deep chest (Rege *et al*., 2001). The relatively long height from the ground to the abdomen (57.5 cm and 58.4 cm for females and males) is explained by the relatively long legs, which are useful to improve walkability and keep the body far above the ground to adapt to hot tropical environment of the Ogaden lowlands. The horn length is similar to those of the Ethiopian Boran cattle and the Somali Short-horned Boran (Rege *et al.,* 2001).

Qualitative characteristics

The white grey coat color which constitutes over 80% of the body is suitable to adapt to the hot climate by reflecting sunrays and the large dewlap size increases surface area for body heat dissipation (Maule, 1990). Similarly, the long tail and switch size are used to protect them from biting flies (Figure 3). Though some of the physical traits of Ogaden cattle are similar to the Ethiopian Boran, they differ from Ethiopian Boran in other traits which would indicate that Boran and Ogaden cattle are distinct breeds. Such performance differences have also been observed in growth as well as reproductive traits which strengthen their distinctiveness. The Ogaden have white grey to white coat color whereas the Ethiopian Boran coat color is light grey or fawn and some of them have patches. Horns of Ethiopian Boran are thick at base whereas horns of the Ogaden cattle have narrower base. The hump of Ogaden bulls is pyramidal in shape where as Ethiopian Boran bulls have humps hanging over one side. Ethiopian Borans have more pendulous sheath whereas the Ogaden breed has tied up sheath (Figure 4).

Conclusion

The result of this study indicated the promising growth (birth weight, weaning weight, yearling weight and later age weights) and reproductive (gestation length and calving rate) performances of the Ogaden breed as a beef type breed, which is comparable and even better to other zebu cattle of Ethiopia. Though some of the physical traits of Ogaden cattle are similar to those of the Ethiopian Boran, they differ in other traits. It was interesting to note that those dams procured from outside mostly performed better than those born in the farm, which is contrary to the breeding objective of improving herd performance in the station. Obviously, the herd is maintained outside its natural habitat; yet under station research management it is generally expected that the herd performs better than on-farm condition. This is an indication that the level of care provided to the breeding herd is unsatisfactory.

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Traditional Backyard Cattle Fattening in Wolayta: Systems of Operation and the Routine Husbandry Practices

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Abstract

Traditional backyard cattle fattening is a deep-rooted and widely practiced cattle enterprise in Wolayta, although it is by and large a seasonal undertaking. This practice is synchronized with the existing farming system as it almost entirely relies upon locally available resources to minimize finishing costs. This study was conducted to characterize traditional backyard cattle fattening system in Wolayta. Semi-structured questionnaire, focus group discussions and key informant contact were used to generate the data set. According to our findings selection of fattening cattle mainly depend on the physical appearance of the animal. The average length of fattening period was 3.88±1.18 month with a range of 2 to12 months. The average number of fattening cycle per year was 1.55±0.55 with a range of 1 to 3. The reported average number of stall-fed cattle per cycle was 1.27±0.52 with a range of 1 to 4. Our studies showed that cut grass is used as basal feed whereas green cereal grains, root and tuber crops, household leftovers, agro-industrial by-products and others make 43.62, 35.29, 10.20, 5.98 and 4.92% of the supplementary feed, respectively. However, the use of agro-industrial by-products is a very recent practice. Respondents' categorization of the feed based on level of abundance indicates that sweet potato and green maize ranked high. However, the reverse is true for nutritional quality ranking. Feeding regime evolved in Wolayta uses different types of treatments making the feed more palatable and day-night feeding is a common practice. Average daily water intake during dry and wet seasons was 12.52±6.51 and 5.21±3.42 liters, respectively. A mineral lick called *adua* is used as mineral supplement by all the respondents. The fattening practice usually reaches its peak from June to September. Fattening cattle are kept in a compartment as part of the farmer's residence to protect from theft, adverse weather and predators. Since cattle fattening is solely based on stall-feeding a significant amount of labor is invested by adult family members to maximize the profit of the fattening operation. Results showed that the use of locally available feed is a growing practice in Wolayta, however, further work is needed to develop a cost effective feeding strategy, and a ration formulation for finishing cattle.

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Keywords: Feeds and feeding; fattening cycles; husbandry practices; fattening period; seasonality.

Introduction

Even though it is by and large a seasonal undertaking, traditional backyard cattle fattening is a deep–rooted and widely practiced cattle enterprise in Wolayta. Such types of cattle fattening practices which are synchronized with seasonal feed availability are reported in literature (Thomas and Addy, 1977; Thomas–Peterhans, 1982; Fekadu and Alemu, 2000). This is because feed undoubtedly constitutes the principal component of total cost of fattening (Cordiez *et al*., 1977; Fourie *et al*., 2006) and therefore feed costs and the level of use are considered as key components of profitable cattle fattening (Hadi *et al*., 2002).

In view of the prevailing feed price, much effort needs to be made to develop the ways of using locally available and relatively cheaper feed sources. Cattle fattening in Wolayta is largely based on non-conventional feed resources and uses locally-innovated feeding strategies. This strategy is useful to optimize the use of locally available feed resources and a comparable type of feeding system was reported by Fekadu and Alemu (2000) for smallholder farmers in east Ethiopia. Therefore, much needs to be learnt to promote the expansion, improvement, adoption of this type of feeding strategy for a much wider use across the country.

Type and amount of feed, condition of the fattening cattle prior to stall-feeding and day to day management of the animal determine the length of fattening period. Therefore, scarcity of feed, animal in poor condition before fattening and improper management prolong the finishing period. Longer fattening periods tie up capital, which in turn significantly reduces profit realized from cattle finishing (Ebrahim *et al*., 2004). For example, purchasing healthy cattle which is in good body condition ties up capital for relatively short period of time and reduces operation costs (Ebrahim *et al*., 2004). This in turn requires the knowledge of selecting the appropriate animal.

All these conditions require generating information on appropriate feeding and management strategies for backyard cattle fattening. Therefore, scaling out and scaling up of the already adopted traditional stall-fed cattle fattening systems by the rural poor is a way for poverty reduction by increasing the productivity of the cattle industry (UNDP, 2003). In response to this concern,

study was conducted to document peculiar characteristics of Wolayta cattle fattening system.

Materials and Methods

The study area

Wolayta Zone is located in south Ethiopia between geographical coordinates of 6.4^0–7.1^0 N latitude and 37.4^0–38.2^0 E longitude (WZFEDD, 2005). It has a total area of 3982km^2 (Tesfaye, 2003). Its altitude ranges from 1200 to 2950 meters above sea level and is subdivided into three ecological zones: kolla or lowland (35%), woina dega or intermediate highland (56%) and dega or highland (9%). Wolayta has a bimodal rainfall pattern with major and minor rainy seasons mostly lasting from July to October and March to May, respectively. Average total annual rainfall is 1014mm and the mean daily temperature is 19.5 ^{0}c (WZFEDD, 2005). According to Westphal (1975) Wolayta has *enset*–based mixed crop-livestock farming system, where *enset* is the co–staple food together with cereals, root and tuber crops (Tesfaye, 2003). Like other mixed crop livestock production systems in Ethiopia, livestock production is an integral part of the farming system. According to WZFEDD (2005) report Wolayta Zone has 682178 head of cattle.

Sampling procedures and methods of data collection

A reconnaissance tour was made in advance to familiarize with the existing farming system. Field observation, 12 focus group discussions, 8 key informant contacts, wayside informal talks and secondary data sources were used to collect basic information. A single–visit survey was then carried out from January to July 2006 in four districts of Wolayta Zone–Damot Gale, Soddo Zuria, Humbo and Offa representing dega, woina dega and kolla agro–ecological zones. The 12 focus group discussions (3 for each study district) were guided by the following sets of questions: the historical development of cattle fattening practice; trends of the fattening practice *i.e* is it increasing, decreasing or static? Constraints and opportunities of cattle fattening; the unique practices of Wolayta cattle fattening, and the type of feed resources used for fattening.

Further stratification of the study districts was made based on agro–ecology and cattle fattening practices such as highland and lowland fattening systems that mainly differ in the type of the principal feeds used. Random sampling frame was developed to select representative villages and households from each stratum. A semi–structured questionnaire pre–tested in 3 sites was then

administered on 164 study households' selected using systematic sampling from Peasant Associations' farmers list record book (Table1).

Table1. Respondents' summary by district and agro-ecological zone and number of sampled villages in each district.

District	Agro-ecological zone			Sampled villages
	Kolla	Woina Dega	Dega	
Damot Gale	-	40	10	10
Soddo Zuria	-	31	11	8
Humbo	24	12	-	6
Offa	12	18	6	6

Data management and analysis

SAS (2002) software was used to analyze quantitative and qualitative data using descriptive statistics and GLM procedures and graphic presentation was made by using Microsoft Office Excel 2003.

The proc GLM was used for the analysis of three dependent variables: the length of fattening period, number of fattening cycles per year and number of fattened cattle per cycle as indicated in the following model:

$$y_{ijk} + = \mu + d_i + a_j + s_k + e_{ijk}$$

Where the response variable y_{ijk} is length of fattening period, number of fattening cycles per year or number of animal fattened per cycle; μ is the overall mean; d_i refers to study districts (4 levels), a_j refers to agro-ecological zones (3 levels), s_k refers to sex of the respondent (2 levels) and e_{ijk} refers to residual term.

Age of the respondents and district by agro-ecological zone interaction are found statistically insignificant for all dependent variables and hence they were dropped from the model. Moreover, agro-ecological zone and sex were found significant for length of fattening period only, however for the sake of comparison agro-ecological zone was kept in the model during analysis of number of fattening cycles per year and number of animal fattened per cycle.

Results

Selection of cattle

Cattle fatteners in Wolayta select cattle those have better body condition for fattening and have attractive look that would get market demand (*e.g* coat color). The reported selection criteria are mainly based on physical appearance of the animal (Table2). However, it was reported that cattle with different age and body condition are purchased for fattening and this would result in a considerable variation in the level of fattening.

Table 2. Reported selection criteria of fattening cattle

Selection criteria	Freq	%	Selection criteria	Freq	%
Wide & deep body	255	32.94	Thick neck	29	3.75
Big & stand-high hump	127	16.41	Long tail	14	1.81
Height	114	14.73	Lean but healthy	11	1.43
Good body condition	74	9.56	Well matured	10	1.29
Length	55	7.10	Thin skin	6	0.78
Glossy coat	38	4.91	Others*	9	1.16
Medium, thick and up-right horn	32	4.13			

*Intact tail, low cost, animal that was reared in comparable agro-ecological zone, animal staying on draft work for 2 to 3 years (mimics the idea of compensatory growth).

The fattening system

It was reported that the length of fattening period varies according to the type of principal feed ingredients used and market demand. Wolayta cattle feeders averagely (±s.d) fed cattle for 3.88±1.18 months with a range of 2-12 months (Table 3). However, if there is enough feed, farmers usually sell fattened cattle earlier. If the animal is not well fattened in one fattening cycle farmers usually extend the feeding period until the animal attains good finishing.

Animals are fattened turn by turn; therefore, new animals are purchased after selling the finished ones. Among the respondents 50.61, 46.95 and 2.44 percent fatten 2, 1 and 3 times per year, respectively. The reported average (±s.d) fattening cycle per year was 1.55±0.55 with a range of 1-3 (Table 3).

According to focus group discussants and key informants number of cattle finished per cycle varies based on capital stand, feed availability and market demand. The reported number of fattening cattle per individual feeder per fattening cycle was 1, 2, 3 and 4 for 75, 23.2, 1.2 and 0.6 percent of the respondents, respectively. The reported number of animals finished per cycle was 1.27±0.51

with a range of 1-4 (Table3). Fattening cattle mainly constitute draught oxen as they are usually used for draught work before fattening commence, even though; very few instances of purchasing cattle directly for fattening were reported. Besides draught oxen, sterile females and cows with poor production and reproduction performances are fed for finishing.

Table 3. Reported length of fattening periods (month), and number of fattening cycles per year and fattening animal per cycle.

Category	N	Least square means±s.e		
		Length	# Cycles/year	# Animals/cycle
District				
Damot Gale	50	4.03±0.17[a]	1.23±0.08[a]	1.01±0.07[a]
Soddo Zuria	42	3.45±0.18[b]	1.65±0.09[b]	1.10±0.08[a]
Humbo	36	3.20±0.20[c]	1.71±0.10[b]	1.61±0.09[b]
Offa	36	4.19±0.17[a]	1.79±0.09[b]	1.49±0.08[b]
Agro–ecological zone				
Lowland	27	3.28±0.21[a]	1.63±0.10[a]	1.26±0.09[a]
Mid–highland	101	4.04±0.11[b]	1.57±0.05[a]	1.31±0.05[a]
Highland	36	3.84±0.21[ab]	1.58±0.10[a]	1.34±0.09[a]

LS Means with different superscripts show statistically significant differences at $p \leq 0.05$.

Moreover, our results showed that the number of fattening animals per cycle has positive but low correlation (r) with number of fattening cycles per year ($r = 0.29$; $P \leq 0.001$), however it has weak and negative correlation with length of fattening period ($r = -0.069$; $P \geq 0.05$). Length of fattening period has negative and weak correlation with number of fattening cycles per year ($r = -0.142$; $P \geq 0.05$).

Seasonality of cattle fattening

Most of the time cattle fattening starts before the onset of the main rainy season (May to June). Therefore, cattle fattening is a seasonal operation with a peak from June to September (Figure1) and this is governed by seasonality pattern of feed availability and main holidays.

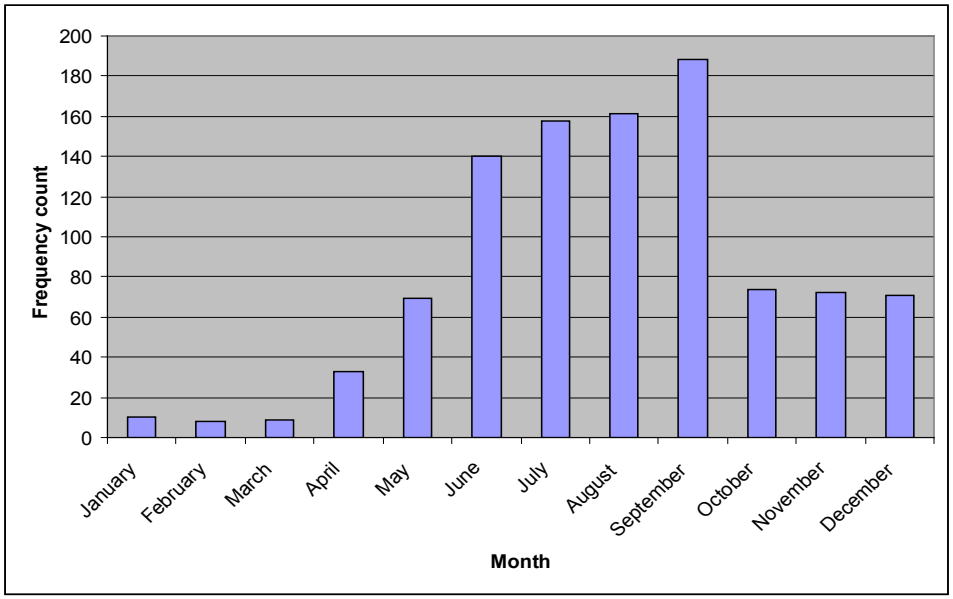

Fig.1. Reported months of cattle fattening

Feed resources

Grass is used as basal feed and proportion of supplementary feeds that are used for cattle fattening are described in Table 4.

Table 4. Reported supplementary feed types used for cattle fattening

Feed type	Freq.	%	Feed type	Freq.	%
Grains			Household leftovers		
Green and dry maize	169	19.81	Aitta tukeea	50	5.86
Green and dry haricot bean	92	10.79	Attelab	37	4.34
Green and dry sorghum	43	5.04	Agro–industrial byproducts		
Green teff	27	3.17	Wheat bran	42	4.92
Boiled maize & haricot bean	24	2.81	Noug cake	9	1.06
Green barley	9	1.06	Others		
Green faba bean	8	0.94	Sugarcane	32	3.75
Root and tuber crops			Bamboo leaf	10	1.17
Sweet potato	153	17.94			
Enset	83	9.73			
Pumpkin	60	7.03			
Cassava	5	0.59			

[a] leftover of hot drink made from coffee leaf and spices; [b] leftover of locally made beverages

Feed is sourced both from farm yard and through purchase and from farm yard only for 70.12 and 29.88% of the respondents, respectively. Relative availability of feeds in decreasing order of importance is presented in Table 5. Respondents have also listed available feed types according to decreasing order of their feeding value (Table 5).

Table 5. Reported mean ranks for availability and feeding value of main supplementary feeds that are common for study districts and agro–ecological zones

Category	Feed type					
	Level of abundance (mean rank)			Feeding value (mean rank)		
	Sweet potato	Green maize	Green haricot bean	Sweet potato	Green maize	Green haricot bean
District						
Damot Gale	1.15	2.05	3.00	2.24	1.13	2.28
Soddo Zuria	2.09	2.22	2.50	2.04	1.61	2.13
Humbo	2.35	1.22	2.35	2.35	1.23	2.56
Offa	2.07	2.39	2.50	1.38	1.78	2.40
Average rank	**1.92**	**1.97**	**2.59**	**2.00**	**1.45**	**2.34**
Agro–ecological zone						
Lowland	2.30	1.55	2.25	2.04	1.26	2.50
Mid–highland	1.77	1.93	2.48	2.11	1.45	2.26
Highland	1.55	2.14	3.00	2.07	1.30	2.38
Average rank	**1.87**	**1.87**	**2.58**	**2.07**	**1.34**	**2.38**

The lowest the mean rank, the most important is the feed type

Reported seasonal trend in feed availability is graphically presented in Figure 2. Accordingly, main rainy season (June to September) and dry season (December to March) were reported as seasons of better feed availability and feed shortage, respectively.

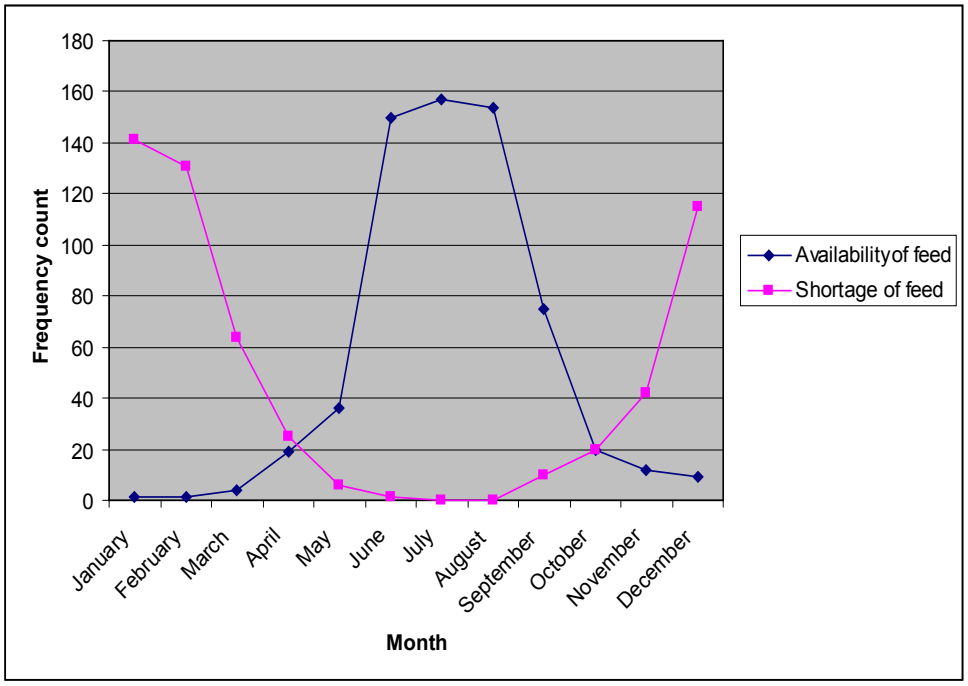

Fig.2. Reported months of feed availability and shortage

Feed scarcity and quality deterioration of the feed during dry season are the main challenges facing smallholder cattle feeders. The main reported combating mechanisms were feed conservation (hay making) and feeding practices including straw and stover feeding, feeding of enset, grain, sweet potato and sugar cane.

Respondents overcome scarcity of water during dry season (December to February) by collecting water from distant areas. During dry season 85.4, 8.2, 2.5, 1.9 and 1.9 percent of the respondents reported that they provide water once a day, twice a day, thrice a day, once in two days and once in three days, respectively. Whereas during wet season 59.0, 26.2, 12.1 and 2.7 percent of the respondents reported that they provide water once a day, once in three days, once in two days and once in four days, respectively. Reported average daily water intake during dry (N=146) and wet (N=141) seasons were 12.52±6.51 and 5.21±3.42 with a range of 2.50 to 30.00 and 0.57 to 12.50 liters, respectively. It was also noted that as the fattening period advanced water intake of the animal would reduce. Moreover, all the respondents fed the natural mineral

lick called "*adua*" by purchasing from local market. Average amount of *adua* daily offered to finishing cattle was reported at 493.42±40.19g with a range of 250 to 500g (N=114). It was also reported that *adua* is used to improve the feed intake of the animal and it is fed to make the beef tasty.

Feeding systems

To minimize fattening costs large proportion of the total feed intake at the start of the fattening period constitutes grass. Whereas as fattening period advances since the animals tend to show more preference for grains, root and tuber crops and household leftovers, it was noted that amount of grass offered gradually decrease. Moreover, it was reported that feed intake is reduced as the quality of feed offered gets poorer and as the finishing period advances. Therefore, to improve the palatability of roughage feeds, treatments like chopping and wilting, soaking within boiled water and *attela* and sprinkling of the mixture of *adua, aitta tukee* and salt are used, and grains are boiled before feeding. Farmers usually start feeding their cattle while they are on draught work. This condition put the animal in better condition when transferred to finishing. Fattening of cattle usually coincides with seasons of better feed availability. Usually farmer have a close look at their animals to provide fattening cattle with feeds on alternative basis according to preference of the animal.

It was found out that locally made materials like wooden bath and clay dish, and synthetic materials such as plastic bath and plastic pot are used as feeding and watering troughs by 74.33, 4.95, 18.02 and 2.70 percent of the respondents, respectively. Farmers mostly provide warm drinks (water and *aitta tukee*) to the animal by assuming that hot drinks can create a warm condition which enables the animal to finish earlier in better condition.

Housing systems

Fattening cattle are kept in a stall constructed as compartment of farmers' house (Table 6). Almost throughout the fattening period stall–fed cattle are enclosed in the stall in order to minimize energy loss by walking, with the exception of taking outside to refresh the animal every two weeks. Litter material is frequently changed and manure is frequently collected to keep the animal in a clean condition. Feeder cattle are well protected from adverse weather conditions, predators attack and theft. To keep the stall warm the wall is covered with leaves and grasses. Enough space is provided in the stall to reduce competition for feed among stall–fed cattle. It was reported that keeping fat-

tening animals in calm and comfortable stall improves voluntary feed intake and would result in more gain.

Table 6. Reported reasons for using in house compartment

Reported reason	Freq	%	Reported reason	Freq	%
It is our culture	71	42.52	Scarcity of resources	23	13.77
To create warm condition	26	15.57	For close supervision	22	13.17
Theft problem	25	14.97			

The routine husbandry practices

Routine husbandry practices are shared among family members and rarely with partner (Table 7). To use manure for crop production, farmers frequently remove cattle faeces and urine and feed refusals from the stall.

Table 7. The routine husbandry practices

Activities	N	Responsible family member (%)			
		Husband	Wife	Children	Partner
Cleaning of the stall	223	15.24	49.78	34.98	0.00
Marketing	175	92.00	2.29	3.42	2.29
Health care	218	71.10	26.61	2.29	0.00
Supplementary feed provision	315	47.94	28.25	23.81	0.00

Discussions

Consistent with FAO (2007) report, selection of fattening cattle for desirable size, conformation and body condition rely upon visual assessment. Besides the health condition of the animal is considered in the selection process, this is because, if the animal is healthy, as it was described by Auriol (1974) mortality and morbidity rates will be kept at lower level.

The length of fattening period for stall-fed cattle exhibits considerable variation. For example, Wardle (1979) reported 3 to 6 months and UNDP (2003) extended to 8 month whereas Nkhonjera *et al*. (1988) reported average of 188±53 days and 213±54 days in Blantyre and Lilongwe areas of Malawi, respectively. According to Habtemariam (2000) farmers in east Ethiopia fed oxen for more than one year, which exceeds the maximum length of fattening period reported in Wolayta. This indicates that, poor performing cattle are kept for a longer period to reach targeted fattening level (Jepsen and Creek, 1976).

Cattle fattening by smallholder farmers in Wolayta is strategically synchronized with seasonal feed availability and main holidays. Inconsistent to our findings cattle are, however, fattened throughout the year with a peak during dry season in Malawi (Agyemang *et al*., 1988). However, in Ethiopia dry season is typically characterized by shortage of feed (Nega *et al*., 2002; Ameha *et al*., 2007). Therefore, animals which fed well during better season of feed availability would gain more (Nkhonjera *et al*., 1988). Moreover, finished cattle are sold at attractive price due to maximum consumption of beef during main holidays (Belachew, 2004; Ebrahim *et al*., 2004). Therefore, supply, demand and consumption of beef exhibit a seasonal trend (Ebrahim *et al*., 2004).

Consistent to John (1987) cut green grass constitutes the bulk of the feed for stall-fed cattle in Wolayta. Maize grain was reported as feed of best feeding value and this might be due to maize starch which is known to be incompletely fermented in the rumen, therefore, likely pass with some degree into the duodenum (Ferreiro *et al*., 1977). However, the use of scarce resources like grain for cattle fattening is rarely practiced in developing countries (Richardson and Smith, 2006). Sweet potato is one of most widely cultivated crops and available feed in Wolayta. As it was described by Backer *et al*. (1980) after harvesting a large volume of forage consisting of stems and leaves and variable amount of non-commercial tuber is left, which can be fed to finishing cattle. It was also reported that sweet potato is the second valuable feed and this might be due to its high starch content (Lu and Sheng, 1990).

Similar to reports of John (1987) and Sanderine (2004) household leftovers such as *attela* and *aitta tukee* are fed to finishing cattle. The former is a traditional brewery and liquor residue, which contains high level of crude protein (20%) and organic matter (97%) (Yoseph *et al*., 2000) and it is a commonly used feed supplement in Ethiopia; whereas the later was prepared from green leaves of coffee boiled together with spices such as ginger, red pepper, garlic and salt as flavors. Similarly, leftover of *chemo*, a comparable type of hot drink used for human consumption is fed to cattle in southwest Ethiopia (Takele, 2005). Moreover, *Adua*, which is used as natural mineral lick supplement in Wolayta cattle fattening is comparable to *natron* (a hydrated sodium carbonate) reported by John (1987) for cattle fattening in Cameron and is rich for its sodium content (Adugna and Said, 1992).

Native pasture is characterized by having remarkable seasonal variation in quantity and quality (Ameha *et al*., 2007). During wet season, feed is more diversified whereas during dry season the feed resource mainly constitutes *en-*

set and cereal straws and stovers. Therefore, consistent to the reports of John (1987) and Marion (2000) purchase of conserved fodder and cut grass from the low-lying relatively wet areas increasingly becomes a common practice (Marion, 2000). However, there is variation in feed types among agro-ecological zones. For example, farmers in the highland have feed sources like *enset*, which is available year round. Especially, *gefetino* (a matured black-stemmed *enset*) is appreciated by the farmers for its feeding value and a similar type of finding was reported by Marion (2000). However, there are more open communal grazing areas in the lowlands (Marion, 2000).

A farmer group identified high losses in the delivery of feed in cattle finishing systems as a major constraint (CIAT, 2004). Our findings also indicated that adult family members are mainly involved in provision of supplementary feeds to minimize wastage of feed. Our study also showed that large proportion of labor input was provided by adult family members because cattle finishing practice requires care to ensure success (Fourie *et al*., 2006). However, children are also a valuable source of labor especially for cleaning of stall and for provision of supplementary feeds. Cleaning of the stall was largely done by the wife and children and the stall was frequently cleaned to create favorable condition.

In line with the report of Marion (2000), stall-fed cattle are kept in confinement for the entire finishing period. The stall is constructed as a compartment of farmer house (Marion, 2000) from locally available materials and a comparable type of housing system was reported by Nkhonjera *et al.* (1988). This confinement keeps the energy expenditure due to effect of walking at lower levels compared to grazing animals (Schlecht *et al*., 1999; Richardson and Smith, 2006). Farmers reported that the stall is constructed to provide comfortable condition for finishing animal and routine husbandry practices and a comparable reason was reported by Tesfaye *et al.* (2005). Proper housing minimizes stressful environmental conditions (Pusillo *et al*., 1990) as housing conditions are determinants of animal behavior and health (Jan Hultgren, 2001). Inconsistent with the findings of (Muhamad *et al*., 1983; Koknaroglu *et al*., 2000; 2005), the study communities reported that darkened stall covered with leaves and grasses would enable the animal to finish in better condition and gives a glossy coat.

Conclusions

Our studies indicate that the adopted management practices by smallholder traditional cattle feeders are useful to draw important lessons to adopt a com-

parable practice with some modifications elsewhere. Moreover, use of readily available local resources including non-conventional feed sources could be an attractive option for low-income rural poor farmers. Our results showed that the use of locally available feed is a growing practice in Wolayta, however, further work is needed to develop a cost effective feeding strategy, and a ration formulation for finishing cattle.

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Herd management, milk production and reproduction of Urban dairy farms in the Harar milkshed

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Abstract

A monitoring study on 26 urban and peri-urban dairy farms was undertaken to evaluate the production characteristics and identify the major constraints of the Harar milk shed in eastern Ethiopia. In this study, it was noted that important threats to productivity in the urban and per-urban dairies may be the constraints posed by irregulars calving distribution and irregulars milk production over the year. Reproductive performance of cows studied deviated negatively from the target values and these deviations were larger in farms of larger herd size compared to medium and small herds. Lower body weight and poor body condition scores before and after calving were found to be important in management of urban dairy farms influencing the productivity of the dairy farms in the milkshed. Reproductive and breeding problems were also identified as important problems in the urban and peri-urban dairy production systems. Although the artificial insemination (AI) service is used by a relatively large groups of the farms continuous interruption of the service seems to have forced the farmers to resort to the bulls of unknown pedigree. The access to AI services for dairy operation in urban area is mixed with apparently successful private entry into veterinary services, but no attempt is made so far in the private provision of AI services. However, these services are used mostly by the large and advanced dairy farmers in the urban areas. Thus, the reproductive and breeding problems and general management problems were identified, in this study, as important limiting factors for dairy production and will have to be looked into in the future dairy improvement strategies of the Harar milkshed.

Keywords: *Urban & Peri-Urban; Herd Management; Milk Production; Reproduction; Calving Distribution*

Introduction

Livestock production is rather poor in Ethiopia when compared to the rest of Africa. Milk production in tropical Africa in particular is limited by the quantity and quality of feed and animal genotype. Tropical pastures mature rapidly

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and are generally deficient in crude protein and phosphorus and low in energy (ILCA, 1978) which is major limiting factor for milk production (ILCA, 1978). Studies in the tropics have consistently shown that zebu breeds produce low milk yields per lactation period (which is usually also quite short), even under moderate to good feeding and management conditions. Especially zebu cows are considered poor milkers in comparison with the exotic breeds or crosses (Schaar *et al*., 1981; Kiwuwa *et al*., 1983; Mbah *et al*., 1987; Kurtu *et al*., 1999). Hence, the development of milk production systems in tropical conditions such as Ethiopia requires improvements, both in the genotype and in the feeding strategies.

Many countries in the tropics have attempted to replace their indigenous cattle breeds through breed substitution with exotic dairy types (Mbha *et al*., 1987) in order to meet the growing demand for dairy products. However, the imported dairy breeds have generally not achieved the same levels of production in the tropics as those in temperate environments. Some countries have resorted to upgrade the poor milk yielding indigenous breeds with imported semen (Brannang *et al*., 1980; Kurtu *et al*., 1999). This strategy was aimed at improving milk production by combining the adaptive traits such as efficient utilization of poor quality roughages, tolerance to diseases and high ambient temperatures and the general hardiness of the indigenous zebu breeds with the high milk production capacity and good temperament of the exotic *Bos taurus* (Syrstad, 1990).

Urban and peri-urban dairy production systems are among the many forms of dairy production systems in the tropics and sub-tropics. These systems involve the production, processing and marketing of dairy products that are channeled to consumers in urban centers (Rey *et al*., 1993; Staal & Shapiro, 1996). Urban and peri-urban dairy production systems have emerged to meet the increasing demand for milk in urban centers as a result of growing urbanization and increasing cost of imported dairy products. Peri-urban and urban dairy production systems contribute to the overall economic development through income and employment generation, food security, asset accumulation, poverty alleviation and improving human nutrition and health (Tegegne *et al*., 2000).

The development and sustainability of urban and peri-urban dairy production systems require a relatively large initial capital and long-term commitment. Furthermore, the major constraints related to these dairy production systems need to be addressed. Studies on characterization of the urban and peri-urban dairy production systems in and around Adiss Ababa have been carried out by

Yoseph and Azage (2003). However, little is known about the characteristics and the associated problems of the urban and peri-urban diary production systems of the Harar milk shed. However, this is required to know and have better understanding and adequate knowledge about the production systems and related problems. Subsequently, knowledge of the productions characteristic features and identifying problems limiting milk production of the Harar milkshed will assist to come up with appropriate interventions that will increase milk production and enhance dairy productivity in the Harar milkshed.

This study was therefore, undertaken to assess certain aspects of the herd management, milk production and reproduction performance of diary cattle and to identify the major constraints of the urban and peri-urban dairy production systems of the Harar milkshed.

Materials and methods

Study Site

This study was conducted on the dairy farms in and around the Harar town as a component of dairy productions systems in the Harar milkshed in eastern Ethiopia. In fact, this milkshed includes two adjacent areas, namely the Harari region and the Babile district from the Oromia region of Ethiopia. In this particular context, the milkshed refers to the geographical areas where milk is produced and marketed in a specific centre, in this case, the Harar town.

The Harar milkshed includes the whole Harari region and the Babile district (*warada*) from the bordering Oromia region to the east of Harar. Bisidimo is a small town in the Babile district and is located 18 km southeast of Harar town and 3km off the main road leading from Harar to the town of Jijiga.

The Harari region is one of nine administrative regions of Ethiopia. It supports a densely populated area located in eastern Ethiopia where crop- livestock, agro-pastoralist and pastoralist farming systems are predominant.

The Babile district and the area around Bisidimo are identified as important components of the Harar milkshed and supply milk to Harar town. The Harari region lies between latitude 9° 24'N and 9°42 03E and 42° 16'E longitude. The Harar town is situated about 500 km east of Addis Ababa. The Babile district lies between 8°9'N and 9°23'N latitude and 42°15'E and 42°53'E longitude and is about 35 km to the southeast of Harar town.

More than 99% of the population in the Harari region and the Babile district are Muslim and belong to the Harari, Oromo, Argoba and Somali ethnic groups (ECSA, 1999).

The Harari region has a wet tropical and receives an annual rainfall between 600 and 900 mm in a bimodal pattern. The bimodal pattern is characterized by a short rainy season that occurs between March and April and a long rainy season that occurs between July and September.

Data Collection

Fifty dairy farms were identified in the urban and peri-urban dairy production systems of the Harar milkshed. These farms were classified into three sub-systems or clusters on the basis of major variables that include: herd size, gender of the household head, education levels and off-farm businesses. The sub-systems were: Urban Resource Poor Dairy Subsystem (URPDSS) farms, Urban Medium Resource Dairy Subsystem (URMDSS) farms and Specialized Urban Dairy Subsystem (SUDSS) farms. In these 50 farms there were about 900 high grade crossbred cattle of Frisian exotic breed.

From these 50 farms a total of 26 farms, representing 16 URPDSS, 7 URMDSS and 3 SUDSS subsystems were purposively selected on the basis of easy accessibility and short distances between the farms. As the numbers of farms in SUDSS were only three, all were sampled while samples for the URPDSS and the URMDSS farms were taken on proportional basis. Data on herd composition, number of calving, mortalities, sales and purchases of animals, milk production performance, live weight of the cows before and after calving and body condition scores (BCS) were collected over a period of one year. For age at calving and calving intervals, data and information were obtained from the available records or by directly questioning the owners.

The reproductive performances of dairy cows were obtained from farm record books (where available), farmers were interviewed and information was gathered during the monitoring period of one year. From these data, the herd composition was calculated and compared with values that were suggested for optimum production in small-scale dairy farms (Radostits *et al*., 1994; Hoffman, 1999) (Table 1).

Table 1. Ideal target values for the distribution of cows in the different phases of the production cycle in urban dairy production systems

Variable	Lactating Cows		Dry Cows	
	Pregnant	**Not pregnant**	**Pregnant**	**Not pregnant**
Ideal Target Value	42%	41%	17%	0%

Source: Radostits *et al*., 1994; Hoffman, 1999

Determination of milk production

Milk produced at each of the 26 farms were measured using a graduated measuring cylinder and recorded for individual animals at both morning and evening milking; the sum of which was recorded as the daily individual yield per cow. The total daily milk production was also calculated for each herd. This was done once a month during the monitoring period by the resident enumerators.

Monitoring reproductive performance

Recently calved cows were considered from the herd at each site to monitor the reproductive performance of post partum dairy cows. Cows were monitored from the fourth day of lactation until the cows were confirmed pregnant by an AI technician by means of rectal palpation. During the one year observation period for the 26 herds the following parameters were monitored: number of services per conception and type of mating (natural or AI) practiced until the cows were confirmed pregnant. Pregnancy diagnoses were performed by an experienced operator 60 to 90 days after the last service by means of rectal examination.

Body weight and condition score fluctuations

Body weights were estimated with the aid of a heart girth measuring tape calibrated in cm and were applied to estimate body weight 30 days before and 30 days after calving. A Tropical Livestock Unit (TLU) is equivalent to a mature head of cattle of 250 kg live weight (ILCA, 1993). The number of TLU's was calculated for each herd. Body condition scores on a scale of 1-5 (Wildman et al., 1982) were determined concurrently with the live weight estimates of the cows.

Statistical Analysis

Data on herd management, milk production, reproduction, live weight changes and body condition score were analyzed using the General Linear Model (GLM) procedures of SAS (SAS, 2002). The model employed was as follows:

$y_{ij} = \mu + D_j + e_{ij}$

Where;

y_{ij}= Response variables (herd management, milk production, reproduction, body weight, body condition score)

μ= Overall mean
D_i= j^{th} Dairy Production Sub-System
e_{ij}= Residual

Chi-square test was used to compare number of calves born, died, slaughtered and retained across the different dairy production sub-systems.

Results and discussion

Herd composition and reproductive status of cows

The results in terms of herd composition of the urban dairy farms are summarized in Table 2. The dairy farms selected for the monitoring had a total population of 553 crossbred dairy animals that included cows, heifers, calves and bulls.

Table 2 Herd composition of the urban dairy farms in the Harar milk shed

Production Sub-System	No. of Dairy Farms	Cows		Heifers		Calves		Bulls		Total
		N	%	N	%	N	%	N	%	N
URPDSS	16	99	55	27	15	51	28	3	1.6	180
URMDSS	7	155	84	18	9	44	24	7	3.8	184
SUDSS	3	112	59	39	21	40	21	1	0.5	189
Total	26	323	58	84	15	135	25	11	2.0	553

There were changes in the herd dynamics during the study period of one year and the main sources of these changes included the birth or death of calves and slaughtering of animals (Table 3). No animals were sold or purchased in any farm across all the groups of farms (Subsystems) except one heifer and one bull sold from URPDSS farm. A total number of 246 calves were born from 323 cows in the three Subsystems. An overall calving rate of 76% was observed for

all the farms. This calving rate shows that under the existing management condition, the reproductive performance of the cow herd is not too poor. Vandeplassche (1982) and Diag (1985) reported calving rates in Mozambique ranging from 69.1 to 74.8% and from 51.2 to 76.4%, respectively for crossbred dairy cows on small-scale farmers. A large number of the calves that were born, died (8%) mainly because of calf scour and 37% of male calves were slaughtered at a young age before weaning and fed to either dogs or wild beasts with no apparent economic benefit to the farms (Table 3). This was mainly because of lack of alternative ways of disposal particularly for male calves and the shortage of feeds.

Overall calf mortality was 8%. Farms in SUDSS had the highest mortalities (13%) and farms in URPDSS had the lowest (4%) mortalities. The observed mortality rates indicate that the smaller the herd the lower the calf losses under small-scale farm conditions. Similar trends have been reported by Hoffman (1999) in the Addis Ababa milkshed.

Table 3. Number of calves born, died, slaughtered and retained on the farm in the urban dairy farms of the Harar milk shed

Dairy Production Sub- Systems	Calves Born		Calf Mortality		Calves Slaughtered (Male)		Calves Retained on the farm	
	N	%	N	%	N	%	N	%
URPDSS (no. of farms=16)	80	32.52	3	15.79	26	33.33	51	37.78
URMDSS (no. of farms=7)	88	35.77	6	31.58	36	46.15	44	32.59
SUDSS (no. of farms=3)	78	31.71	10	52.63	16	20.51	40	29.63
Significance	ns		ns		*		ns	

ns=not significant (P>0.05); *=P<0.05

The distribution of the cow herds in the different production and reproductive phases in the urban dairies by Subsystem is presented in Table 4. A total of 76% cows were lactating and 24% were dry in the three clusters. Of the total number of cows, 31% were pregnant and milked, 46% were milked and non-pregnant, 10% were dry and pregnant and 14% were dry and non-pregnant. It is interesting to note that the highest number of cows were non pregnant and lactating. A large deviation of about 11% from the target value of 42% as set in Table 1 was found in milking and pregnant cows. An even larger deviation from the target value was observed in dry pregnant cows. In this group, the number of cows was about 10% below the target value of 17%. A higher (14%)

percentage of cows were found to be dry and not pregnant, compared to the target value of zero. This means that the overall reproductive performance of the cows studied deviated negatively from the target values. However the 76% calving rate observed show that under the existing management condition, the overall reproductive performance of the crow herd is still acceptable.

The percentage of cows that were dry and not pregnant (14%) suggest reproductive management problems in the farms studied. These dry and non-pregnant cows will have to be culled from the farms for economic reasons. A large percentage of dry and non-pregnant cows were recorded in large and specialized farms, compared to the smaller urban dairy farms in URPDSS. Hoffman (1999) has reported similar findings in peri-urban and urban dairy areas around Addis Ababa. She reported values of 18% for pregnant and dry, 21% for milking and pregnant, 21% for milking and not pregnant and 9% for dry and non-pregnant cows. Compared to the current study, Hoffman (1999) found a lower number of dry and non-pregnant cows. This might be owing to the improved feeding conditions and better reproductive management provided for dairy cows around Addis Ababa compared to those in the Harar milkshed.

Table 4. Distribution of the dairy cow herds in different phases of the productive cycle in the urban dairy farms of the Harar milk shed

Production Sub-Systems	No. of Dairy Farms	Milking Cows				Dry Cows				Total (N)
		Pregnant		Non-pregnant		Pregnant		Non-pregnant		
		N	%	N	%	N	%	N	%	
URPDSS	16	33	33%	47	47%	14	14%	5	5%	99
URMDSS	7	34	30%	54	47%	11	10%	16	14%	115
SUDSS	3	32	29%	46	42%	6	6%	25	23%	109
Total	26	99	30%	147	46%	31	10%	46	14%	323

Monthly calving distribution

The monthly calving distribution of the urban dairy farms is shown in Figure 1. A total of 246 calvings were recorded during the study period of one year. The highest calving rate was recorded in March (17%), followed by September (12%). The lowest number of calvings occurred in November (1%) and December (4%). The highest number of calving was recorded during March to May which falls during the short rains (39%) and the lowest number of calving was during October to December which falls in the later part of the dry season (11%). Almost similar patterns of calving were observed in the three clusters.

These results agree well with those of Kiwuwa *et al.* (1983) and Kurtu *et al.* (1999), who reported an almost similar pattern of calving distribution, but with slightly higher values for the main rainy season followed by the short rainy season. These authors found that there were calving percentages of 56%, 43% and 41% in June to September, March to May and October to February, respectively. The difference between their findings and the present results could probably be as a result of the feeding and management systems because those reports were under open-grazing conditions which are more affected by the effects of the season. In addition, their data was obtained from research station conditions where the environments are better controlled.

The seasonal calving distribution observed in this study can partially be explained by the season's effect because the majority of the cows conceived during the main rainy season (June to September) and calved during the short rainy season (March to May). During this main rainy period, feedstuffs like green and succulent plant materials, including green grasses, green maize and weeds provide the cows with more protein and especially β-carotene, the precursor of vitamin A, mostly associated with cow fertility causing the cows to come in heat (Slater, 1991). On the other hand this pattern of calving tends to provide an irregular distribution of calving through the year and subsequently irregular supplies of milk. Milk production is highly dependent on the availability and quality of feedstuffs which are normally influenced by the season.

In addition, there were little attempts to meet the feed requirement of the cows over different lactation stages. Nutrient and energy requirements of a cow differ considerably at different stages of lactation, calling for appropriate feeding strategies (Slater, 1991). Apparently no appropriate feeding strategies seem to have been applied to meet the different cows' requirements over the production cycle. The urban dairy farms in the Harar milkshed seem to follow a calving distribution throughout the year, coupled with traditional feeding and management as well as milk production patterns. This would hardly enable the farms to ensure a continuous milk production and supply on a regular basis over different seasons of the year in order to meet the market demand and subsequently meet the desired profit expected by the producer on a sustainable and regular basis.

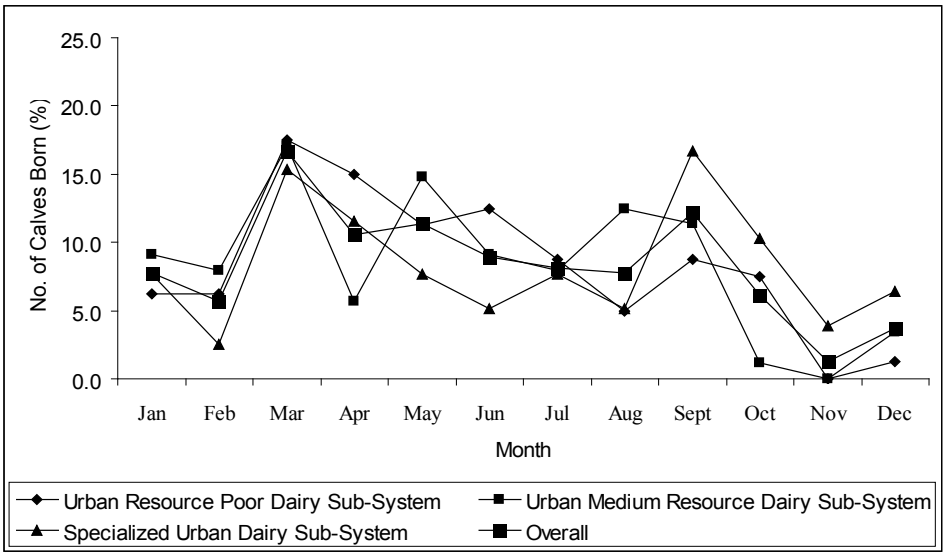


Figure 1. Calving distribution (%) in the Urban Dairy farms of the Harar Milk shed by month and production sub-system

Milk production

A total of 246 cows gave a total milk yield of 84312 liter during the study period of one year. The seasonal distribution of milk production in the urban dairy farms of the Harar milkshed is presented in Table 5.

Table 5. Seasonal distribution of milk production in the urban dairy farms of the Harar milkshed

Seasons	Months	Milk Production	
		Litre	%
Early dry season	October to December	16 171a	19
Late dry season	January to February	11 879b	14
Short rains season	March to May	28 014c	33
Long rains season	June to September	28 248c	34
Total		84 312	100

[a-c] Means with different superscripts within columns differ significantly (P<0.05)

The highest milk yield was obtained during the rainy seasons and the lowest during the dry season. More than 28000 liter (34%) of milk was produced during the long rainy season (June to September) and only about 12000 liter (14%) of milk was produced during the dry season. This difference was significant

(P<0.05) and may be explained by the irregular annual calving distribution, which is partly associated with the unbalanced feed conditions over the seasons. During the wet seasons the bulky feeds especially green plants including weeds, are available to the animals while during the dry season these feedstuffs were in most cases not available (Slater, 1991). In addition, the available literature indicates that tropical pastures tend to mature rapidly and are generally deficient in crude protein, phosphorus and energy during dry season of the year (ILCA, 1978).

The mean milk yield/cow/day seems to vary little over the 12 months of the year (Figure 2 a). However, during the rainy seasons, total milk tends to be higher. The highest total milk yield occurred during March and April, followed by July and September, while the lowest occurred during December and February (Figure 2 b). This was strongly influenced by the number of cows that calved (Figure 2 c). The same type of result was reported for crossbred cattle in Ethiopia (Kiwuwa *et al.,* 1983; Kurtu *et al.*, 1999). Apparently, the difference in total milk production seems to be more differentiated between Subsystems than between months (Table 6).

Table 6. Average daily milk yield per cow and total milk production per cluster of the urban dairy farms in the Harar milkshed

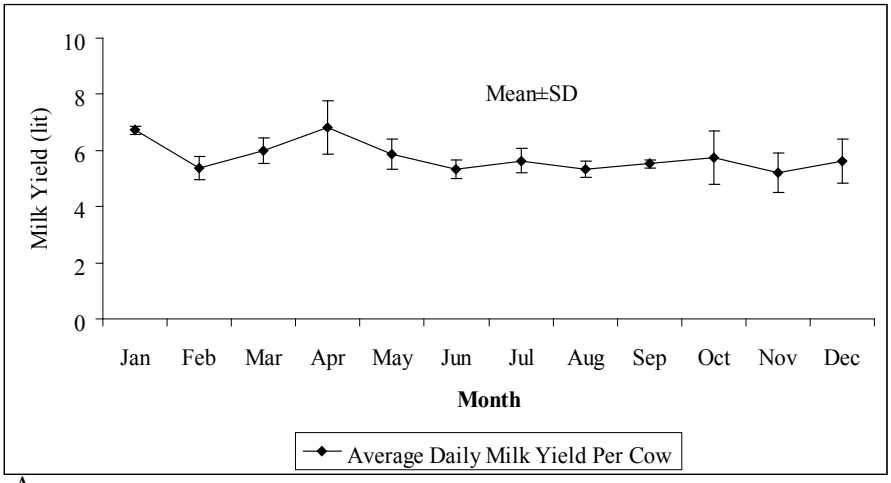
Production Sub-Systems	Milk/cow/day (liter)	Total milk (liter)
URPDSS	5.71±1.31	28611[a]
URMDSS	5.89±1.21	29508[a]
SUDSS	5.62±1.32	26193[b]

a, b Means with different superscripts within columns differ significantly (P<0.05)

Differences in milk production between Subsystems tend to reflect the discrepancy in management practices, particularly feeding, of the herds in the three Subsystems. Average milk yield per cow per day was almost the same in all three Subsystems. The total milk yield between the three Subsystems was significantly different (P<0.05). Farms in URMDSS produced 29508 liter per month, the highest yield, followed by URPDSS with 28611 liter and USDSS with 26193 liter (Table 6). Differences in milk yield between the Subsystems could probably be explained by differences in the herd size, feeds available and the commitment of the owners. The smaller the herd (URPDSS) the easier the management, but shortages in feeds results in lower milk production. The larger the herd size (USDSS) the more feeds and more commitment are required. However, the commitments for improved production seem to be lacking in this group as they are also engaged in other businesses. Tegegne *et al.*

(2000) indicated that as the dairy herd size increases, more feeds, better management and long-term commitment are required to get increased production.

In conclusion, the irregular calving distribution over the year, irregular milk production and a lack of strategic feeding systems were important management problems identified in the urban dairy production systems. It was also noted that these problems were more pronounced in USDSS compared to URPDSS and URMDSS and require intervention to improve dairy productivity in the Harar milkshed.



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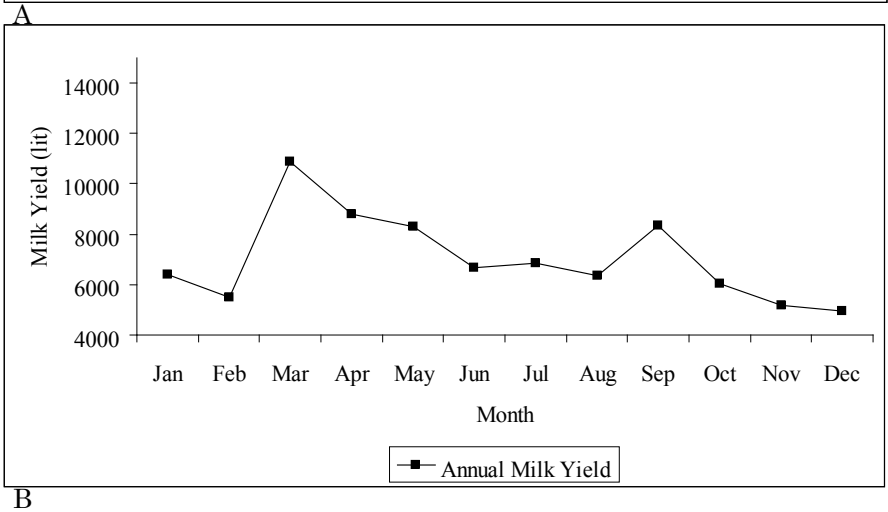

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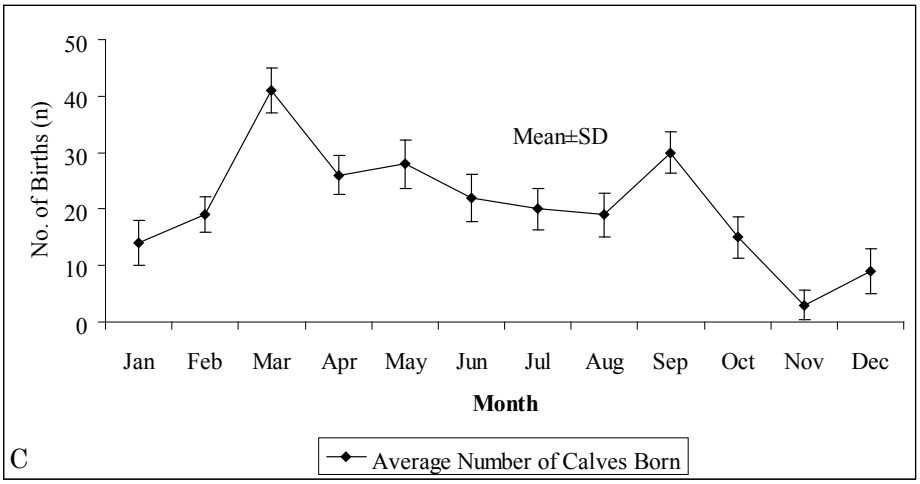

Figure 2. Average daily milk yield per cow (A), total milk yield (B) and number of calves born (C) in urban dairy farms in the Harar milk shed

Reproductive performance

Available data only allowed the analysis of age at first calving, lactation length, number of services per conception and calving intervals (Tables 7 and 8). The rest of the reproductive traits could not be addressed owing to a lack of data.

The overall mean age at first calving was 30.6 months, but differences between clusters were observed. Cows in URPDSS and URMDSS calved for the first time two months earlier than cows in SUDSS. The overall age at first calving is 6 months later than the target age of 24 months and requires attention because it is greater than the 28 months suggested by Radostits *et al.* (1994). However, these crossbred cows had their first calves much earlier compared to local pure breds, which normally do not give birth to their first calves before 4 years of age (Swenson *et al.*, 1981; Albero, 1983). This is supported by several reports on crossbred cattle in Ethiopia that have shown better reproductive performances than the indigenous cattle (Albero, 1983; Kiwuwa *et al.*, 1983). Differences among the clusters for age at first calving however, could be attributed to the different management levels provided to the crossbred cow. As indicated by Preston (1989) the relative advantages of crossbred cows depend on the level of management and adequate nutrition provided.

The overall mean calving interval observed in this study was very long (498 days) whereas the optimum is around 365 to 400 days as suggested by Kiwuwa *et al.* (1983). The calving interval observed, however, is in agreement with Bekele *et al*. (1991) who reported 15.8 months in Ethiopia.

Table 7. Average age at first calving, calving interval and lactation length of urban dairy cows in the Harar milk shed

Production Sub-Systems	Age at 1st calving (months)	Calving interval (months)	Lactation length (months)
URPDSS	30.97 [a]	16.8 [a]	310 [a]
URMDSS	29.72 [a]	15.5 [a]	322 [a]
SUDSS	32.50 [c]	17.5 [b]	332 [a]
Over all mean	30.06	16.6	321

[a-b] Means with different superscripts within columns differ significantly (P<0.05).

Table 8. Number (mean ± SD) of services per conception in urban dairy farms in the Harar milk shed

Production	Number of Services Per Conception	
Sub-systems	No. of cows	Mean ± SD
URPDSS	88	2.9 ±1.4 [b]
URMDSS	74	2.5 ±1.3 [a]
SUDSS	81	3.1 ±1.3 [b]
Overall		2.8±1.3

[a-b] Means with different superscripts within columns differ significantly (P<0.05)

Longer calving intervals are generally reflections of the problems associated with poor nutrition, health and reproductive managements (Kiwuwa *et al.,* 1983). The calving interval needs to be shortened for improved reproductive and productive performances (Kiwuwa *et al.,* 1983). Thus, the results of the present study regarding calving interval calls for an appropriate intervention.

The overall mean number of services per conception is 2.8±1.34, which is higher than that reported by Bekele *et al*. (1991) in Ethiopia as 1.83 ± 0.90. However, Tegegne (1997) in Ethiopia reported 2.6 services per conception, which is in agreement with the results of this study.

Cows in URMDSS required a smaller number of services (P<0.01) compared to those cows in URPDSS and especially SUDSS. Cows in SUDSS had slightly more services/conception than cows in URPDSS, but the difference was not significant (P>0.05). Higher number of service means longer calving interval

as cows in SUDSS had longer calving interval compared to cows in URPDSS and URMDSS.

However, all required more services than the target 1.5 recommended by Radostits *et al.* (1994). It is important to note that all the target values used are based on the North American and European dairy production systems, because there are no established standards either for Ethiopia or for tropical Africa as such. Larger numbers of services per conception are the result of a number of factors including poor management, feeding, heat detection, time of services, semen quality and skills of the inseminator (Branning & Person, 1990) and requires attention.

It was noted that majority of urban and peri-urban dairy are using Artificial Insemination (AI) service for breeding their cow herd. However, the AI service was very often noted to be irrupted causing reproductive problems on the dairy farms. Consequently, the dairy farms were forced to use bulls of unknown pedigree for breeding the dairy cows. There is no private AI service delivery system in the Harar milkshed which might have helped to mitigate the AI problem

It can be concluded that the overall reproductive performance of the cows in this study deviated negatively from the target values and these deviations were larger in SUDSS compared to Subsystems URPDSS and URMDSS. Therefore, reproductive problems were also important factors that reduce the productivity of urban dairy farms and need to be addressed to improve productivity in the urban sub-system of the Harar milkshed.

Pre-partum and post-partum body weight changes

The average body weight of the cows in all Subsystems was 446 and 419 kg before and after calving respectively (Table 9). Cows in URMDSS were the heaviest and cows in SUDSS the lightest before calving. Cows in SUDSS were significantly ($P<0.05$) lighter than those in URMDSS and URPDSS after calving. For URPDSS and URMDSS this difference was not significant ($P>0.05$). The weight differences before and after calving for URPDSS and URPDSS was almost the same (6%) whereas this weight difference for cows in URMDSS was a bit higher (7%). These small differences in the body weights noted for cows in URPDSS and URMDSS before and after calving compared to the cows in SUDSS could be attributed to the better feeding levels provided to the cows, especially before calving.

The overall mean BCS's of the cows were 3.15 and 3.00 before and after calving respectively. This means that cows in all clusters were not in good conditions after calving with body scores ≤ 3 BCS, which has been described as poor by Wildman *et al*. (1982). This might be the result of underfeeding particularly resulting from a lack of adequate feed supplies. There were differences among the dairy farms in the different Subsystems. The BCS of cows in UMRDSS had the highest score and cows in SUDSS the lowest score before and after calving (P<0.05). Differences in BCS before and after calving between cows in URPDSS and SUDSS were not significant (P>0.05 However, for cows in SUDSS the average BCS before and after calving was lower than the acceptable level of BCS suggested by Wildman *et al*. (1982) for optimum production. BCS changes before and after calving in the present study indicate that cows, particularly in URPDSS and SUDSS, were in sub-optimal condition probably because of a lack of proper feeding before calving. This would subsequently result in lower milk production. Poor BCS at or after calving (<3) often results in lower peak milk yield and lower total milk lactation yield.

Cows with high condition score URMDSS gave more yield (13%) total milk than cows with lower condition score in SUDSS (Table 6). Cows with high condition score URMDSS had heavier body weight (Table 9).

Table 9. Pre-partum and post-partum body weights and body condition score (mean ±SD) of cows in urban dairy farms in the Harar milk shed

Production Sub-Systems	N	Body weight (kg)		Body Condition Score(Scale 1-5)		
		Pre-partum	Post-partum	N	Pre-partum	Post-partum
URPDSS	88	454.1 ±11.6[b]	427.3 ± 14.6[b]	80	3.1 ±0.9 [b]	3.0 ±0.3 [b]
URMDSS	74	474.6 ±13.6[c]	448.6 ± 13.8[b]	88	3.3 ± 0.0 [a]	3.2 ± 0.0 [a]
SUDSS	81	411.3 ± 14.5[a]	382.3 ± 11.2[a]	78	2.9 ± 0.1 [b]	2.8 ± 0.7 [b]
Over all mean	81	466.6±13.2	419.4±13.2	82	3.15±0.5	3.0±0.3

[a-b] Means with different superscripts within columns differ significantly (P<0.05)

Dairy cows should not lose more than one point in BCS soon after calving because excessive loss of body condition in early lactation has been shown to reduce the reproductive efficiency (Wildman *et al*., 1982). The low body weights and body condition scores of cows before and after calving in this study appears to have resulted from the feeding systems employed.

Conclusions

Lower body weight and poor body condition scores of the cows before and after calving were found to be important factors in management of urban dairy, influencing productivity of the dairy herds in the milkshed. · The irregular calving distribution over year and related reproduction problems, irregular milk production distribution over the year were also known to constitute important problems limiting milk production in the dairy herd of the milkshed. These problems were noted to be more apparent in the dairy herds in large sized herd or specialized dairy farms than in resource medium and resource poor farms. It is thus, recommended to have high level of management that would require better skill, knowledge of husbandry of dairy cattle and commitment than the traditional knowledge to make the specialized dairy farms productive.

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The effect of weaning crossbred calves at different ages on growth performance

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Abstract

Small scale dairy farmers use extra amount of whole milk for rearing calves. However, this practice is not recommendable and is uneconomical for large-scale dairy farmers. A study was carried out at Holetta Agricultural Research Center to reduce calf milk consumption using early weaning system. Sixty Friesian x Boran and Jersey x Boran crossbred calves were randomly assigned to five age groups as treatments. Calves were bucket fed and weaned at the age of 6, 8, 10, 12 and 14 weeks consuming 118, 164, 210, 248 and 260 liters of milk, respectively. Milk was offered twice daily, in the morning and evening. Starting at two weeks of age, the calves were supplemented with concentrate and hay. Daily dry feed allowance was calculated based on 3% calf's body weight and offered once per day on dry matter basis. Calves were allowed to exercise for one hour every morning. There were no marked differences ($P > 0.05$) in concentrate and hay intake between treatments, calf sexes and breeds. Calves weaned at 6 and 8 weeks of age had significantly ($P < 0.05$) lower daily body weight gain than calves weaned at 12 and 14 weeks. Calves weaned at 10 weeks of age had similar growth rate with calves weaned at 12 and 14 weeks of age ($P > 0.05$). Weaning at 10 weeks of ages is recommended for both Friesian x and Jersey x Boran crossbred calves in relation to the reduced amount of milk consumed.

Keywords: calves; milk; weaning; crossbred; growth.

Introduction

Documented information (Etgen *et al.*, 1987; Beyene 1992) show that lifetime performances of dairy cows are influenced by the rearing practices at their calf hood, age at which they are weaned, post-weaning management practices, breed, and starter ration and rearing environments. Basically, two types of calf rearing practices are commonly known by a dairy farmer: partial suckling and artificial rearing systems. Partial suckling system is a practice in which calves are allowed to suckle their dams before and after milking while artificial rearing system is a practice in which calves are separated from their dams

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immediately after birth and bucket fed predetermined amount of milk until weaning. However, the choices of alternative rearing practices are determined by scale of the farm, rearing objectives (beef/dairy) and biological and economic considerations.

In Ethiopia, dairy production is dominated by smallholder farmers owing no or a few crossbred dairy cows. Consequently, partial suckling is well known and has been a long-standing tradition under smallholder systems in Ethiopia. Therefore, it is not practically feasible and economically sound to recommend artificial calf rearing practices under such system. On the other hand, artificial calf rearing practice is the rule of thumb, and is an alternative calf rearing options widely used in large-scale dairy farms.

Information on calf rearing practices is limited in Ethiopia. For instances, Little *et al.* (1991) carried out an experiment on the two types of calf rearing practices at the former ILCA, Debre Zeit station in Ethiopia. Both suckled and bucket fed calves were weaned at 94 days of age. But they didn't attempt to reduce weaning age below 94 days. Azage *et al.* (1994) also carried out similar experiment at the same station, but reduced weaning age for both suckled and bucket fed calves to 57 days of age. This experiment also focused on only comparing the influence of the two calf rearing practices on calf growth, but didn't considered ranges of weaning ages within a given calf rearing practices. Furthermore, Azage *et al.* (1990) conducted an experiment on Boran and Freisian x Boran crossbred bulls which were allowed to wean at six and eight months of age. The experiment was aimed at investigating the influence of different weaning ages on the performances of bull calves, but considered neither calf sex nor different weaning ages. However, results of all experiments unequivocally concluded that suckled calves grew faster than bucket fed calves and though differences in the weaning weights seemed to be noticeable at the beginning, these differences are gradually balanced by the mechanism of compensation growth. Therefore, results of these experiments are suggestive of the fact that weaning ages of calves could be further reduced without major effects in bucket fed calves.

Nowadays, interplays of many factors are contributing towards the establishment of large-scale dairy farms in Ethiopia. Favorable economic policy reforms directed towards a liberalized and market-oriented economic system and drivers of change such as rapidly growing urbanization, high population growth rate, changing consumer taste preferences towards safe and quality products are attracting investors into dairy business. Due to their scale of production,

commercial dairy producers are likely to practice artificial calf rearing systems. Therefore, improved and economically as well as biologically efficient calf rearing practices are needed. However, there is a paucity of information on growth performance of early weaned Friesian x Boran and Jersey x Boran crossbred calves. Therefore, this experiment was carried out to investigate growth performances of Friesian x Boran and Jersey x Boran crossbred calves subjected to different weaning ages.

Objective

To identify most appropriate and biologically as well as economically feasible weaning age in crossbred calves

Materials and methods

Location

This study was carried out at Holeta Agricultural Research Center, which is located at about 40 km west of the capital city, Addis Ababa. Holetta represents typical central highland areas of Ethiopia with an altitude of about 2400 masl. It receives an average annual rainfall of 1000 mm. It has an annual average temperature of about 18^0C.

Calves

Sixty F_1 crossbred calves were randomly grouped into five milk-feeding treatments, based on their sex (30 males and 30 females), and breed (30 Friesian x Borans and 30 Jersey x Boran crosses). The calves were randomly assigned to the experimental treatment groups at birth. Pre-experimental calf weights in different treatment groups were almost similar.

Milk feeding

All calves were bucket fed colostrums ad-lib per day, for the first 4 days. The daily amount was offered in equal parts at 7 am and 5 pm. After 4 days of age, all calves were offered whole milk until their respective weaning age (Table 1). Calves were weaned at 6, 8, 10, 12 and 14 weeks of age for treatments 1, 2, 3, 4 and 5, respectively (Table 2).

Table1. Classification of calves in the experiment

Treatments	Weaning ages (weeks)	Calf sex		Calf breed	
		Males	Females	FBO	JBO
1	6	6	6	6	6
2	8	6	6	6	6
3	10	6	6	6	6
4	12	6	6	6	6
5	14	6	6	6	6

FBO=Friesian x Boran
JBO= Jersey x Bora

Table 2. Liquid diet offered up to weaning

Treatments	Weaning Ages (weeks)	Colostrum (L)	Whole milk (L)
1	6	12	118
2	8	12	164
3	10	12	210
4	12	12	248
5	14	12	260

Dry feeds

A calf starter ration containing 15% wheat bran, 40% wheat middling, 30% noug cake (*Guizotia abyssinca*), 10% meat meal, 4% bone meal and 1% salt was used with natural pasture hay as roughage. Calves were trained to consume dry feeds from the 7th day to the 13th day of life. Concentrate was offered in plastic buckets, while hay was offered in troughs. Feed intake was measured starting from the 14th day of age and the amounts of concentrate and hay offered and refused each day was measured. Type of hay used was harvested from natural grass pasture. It was offered dry by weighing the daily allowance. Dry feed was offered once per day at 10 a.m. with a daily dry feed allowance of 3% of weekly body weight on DM basis, at a ratio of 40:60 for concentrate: hay. Feed allowance continued till 24 weeks post weaning.

Exercise

All calves were allowed to exercise outdoor every morning from 9 – 10 a.m. in the fenced calf exercise area, except during heavy rainy days and during cold weather. The calves could also make free movement within their individual pen.

Housing

The calves were reared in a calf house with corrugated iron for both roof and walls. There was free air movement with a partial opening between the roof and the wall. The floor was paved with concrete and slated with water drainage strips. The calves were housed in individual stall with two feed troughs, one for concentrate (concentrate was fed using pail kept in this trough) and the other for hay. The stalks were cleaned and the bedding changed twice per day. The floor was washed once per week. The calves were offered water *ad lib* twice per day with plastic buckets. A water trough was also used in the calves exercise area.

Measurements

Body weights were recorded at birth and every two-week thereafter until post weaning. Daily milk offered was also recorded. There was no milk refusal.

Statistical analysis

One calf, which refused dry feed after weaning at 42 days, was removed from the experiment and was replaced by another newborn calf. Ten calves that have died during pre-weaning periods were also replaced by other calves. Randomized Complete Block Design with a factorial arrangement was used. Main factors were treatments and breeds, which were blocked by calf sex. A regression equation was fitted to the bi-weekly live weight values to calculate the average live weight gain over the periods of 0 – 14 weeks. Daily body weight gain and final body weight attained at 6 months of age were subjected to analysis of covariance method, using the General Linear Models (GLM) procedures of SAS (SAS, 2002). Statistical model used to analyze the data is expressed as

$$Y_{ijke}=T_i+B_j+S_k+e$$

Where,

Y_{ijke} = An observation for i^{th} treatment, j^{th} breed, and k^{th} sex
T_i = Treatment effect
B_j = Breed effect
S_k = Calf Sex effect
e=random error

Results and Discussion

Early weaned calves had higher concentrate intake ($p < 0.05$) than late weaned calves during pre-weaning period, however, this difference diminished during post weaning period (Table 3). There were differences ($P < 0.05$) in concentrate intake between calf breeds during pre weaning periods. Friesian crossbred calves had higher daily concentrate intake than Jersey crosses. This may be due to size differences between the two. In agreement with the current result, Khalili *et al*. (1992) also reported that larger calves adapt to dry feeding at an earlier age than smaller sized calves. Concentrate intake was not influenced by calf sex ($p > 0.05$). All calves in each treatment had attained recommended levels of concentrate intake at their respective weaning age. This finding is in agreement with earlier studies by Leaver and Yarrow (1972) who suggested that weaning could be successfully undertaken when Friesian or other similar sized calves are consistently consuming 40 g dry feed per day. They also reported that calves were consuming about 400 g concentrates per day when they were about 7 to 8 weeks old. However, in our study

calves weaned at 6 and 8 weeks of age consumed 552 and 546 grams per day, respectively. Calves weaned at 10, 12 and 14 weeks of age consumed only 320, 341 and 372 grams /head/day, respectively, at 8 weeks of age. The low level of concentrate intake might be attributed to the relatively high level of milk offered to these groups, since they were not weaned early. This finding is in agreement with earlier reports of Khalili *et al*. (1992) who indicated that calves that consumed higher amount of milk had lowered concentrate intake. Similar results were also reported in Leaver and Yarrow (1972) and Fallon and Harte (1986).

Table 3. Least squares means (±SE) of calf starter intake

Variables	Number	Concentrate intake (Kg)	
		98 days	180 days
Overall mean	60	31.2	69.1
Treatments			
1	12	34.1±2.04[a]	61.4±4.17
2	12	32.7±2.04[ab]	62.2±4.17
3	12	32.3±2.04[ab]	74.6±4.17
4	12	29.5±2.04[ab]	74.5±4.17
5	12	27.3±2.04[b]	73.0±4.17
Calf sex			
Males	30	32.3±1.29	69.8±2.60
Females	30	30.1±1.29	68.5±2.68
Crosses			
Jersey	30	28.3±1.29[b]	63.8±2.64[b]
Friesian	30	34.1±1.29[a]	74.5±2.64[a]
R^2		0.31	0.26
C.V.%		22.7	20.9

Means with different superscripts are different (P<0.05)

Hay intake was relatively similar for all calves during pre-weaning period, however calves weaned at 6 weeks of age had numerically, but not statistically (P>0.05), the least hay intake during post weaning period (Table 4). Hay intake during early life didn't vary (P>0.05) between weaning groups. As for concentrate, hay intake was also higher for Friesian crosses than for Jersey crosses up to 98 days of age, probably attributed to size differences. Breed difference for hay intake was significant (P<0.05) during pre-weaning rearing period. Roy (1980) and Khalili *et al.* (1992) also suggested that size attributed for intake differences.

Table 4. Least squares means (±SE) of hay intake (Kg)

Variables	Number	Weaning days	
		98 days	180 days
Overall mean	60	30.6	64.0
Treatments			
1	12	31.7±2.86	56.2±4.50 [b]
2	12	31.3±2.86	58.2±4.50[ab]
3	12	27.8±2.86	65.0±4.50 [ab]
4	12	30.8±2.86	69.8±4.50 [ab]
5	12	31.4±2.86	71.3±4.50[a]
Calf sex			
Males	30	31.3±1.80	66.4±2.81
Females	30	29.9±1.80	61.8±2.81
Crosses			
Jersey	30	27.9±1.80[b]	61.2±2.86
Friesian	30	33.3±1.80[a]	67.0±2.86
R^2		0.11	0.19
C.V.%		32.4	24.5

Means with different superscripts are different (P<0.05)

Least square means of calves daily body weight gains during pre- and post-weaning periods are presented in Table 5. Calves weaned at 12 and 14 weeks of age showed higher ($P < 0.05$) growth performance than those weaned at six and eight weeks of age during both pre- and post-weaning periods. Calves weaned at 10 weeks of age had intermediate growth rate between the two extremes. They started to vary in body weight ($P < 0.05$) starting at 8 weeks of age. At 14 weeks of age, calves weaned at 10, 12 and 14 weeks of age had significantly higher body weight than calves weaned at 6 weeks of age. This finding is in agreement with Azage *et al*. (1981) and Khalili et al. (1992) who suggested the importance of giving higher level of milk to increase live weight gain of calves.

Table 5. Least squares means (±SE) of calf daily weight gains at different ages

Variables	Number	Body weight gains (g)		
		pre-weaning gain	Post-weaning gain	Birth to 6 months
Overall mean	60	306.62	311.02	308.95
Treatments				
1	12	255.08±24.49^{c}	268.33±32.2^{b}	250.17±22.81^{b}
2	12	301.25±24.49^{ab}	295.17±32.17^{ab}	289.33±22.81^{ab}
3	12	335.42±24.49^{ab}	269.7±32.17 ^{b}	304.50±22.81^{ab}
4	12	368.50±24.49^{a}	349.67±32.17^{ab}	355.33±22.81^{a}
5	12	332.50±24.49^{a}	372.17±32.17^{a}	331.30±22.81^{a}
Sex				
Males	30	341.2±24.49^{a}	313.53±20.35	312.36±14.44
Females	30	295.90±24.49^{b}	308.50±20.35	299.36±22.81
Crosses				
Jersey	30	277.67±15.49^{b}	268.43±20.35^{b}	263.76±15.08^{b}
Friesian	30	359.43±15.49^{a}	353.60±20.35^{a}	348.495±14.09^{a}
R2		0.50	0.25	0.40
C.V.%		24.94	36.01	25.41

Means with different superscripts are different (P<0.05)

There was no difference (P > 0.05) either in total weight gain or daily weight gain between calf sexes (Table 6). However, significant difference was observed between calf breeds at 6 months of age. Friesian crossbred calves had significantly higher growth rate than Jersey calves starting from 4 weeks of age, which is in agreement with Monteiro (1975), who indicated that Jerseys were less effective than Friesians in transferring feed into weight gain.

Table 6. Least squares means (±SE) of calf body weight attained at different ages

Variables	Number	Body weights attained (Kg)	
		pre-weaning (98 days)	Post-weaning (180 days)
Overall mean	60	57.7	81.7
Treatments			
1	12	50.3±2.4[b]	70.3±4.15[b]
2	12	55.6±2.4[ab]	78.2±4.15[ab]
3	12	59.0±2.4[a]	80.5±4.15[ab]
4	12	62.9±2.4[a]	90.8±4.15[a]
5	12	61.0±2.4[a]	88.5±4.15[a]
Sex			
Males	30	59.2±1.5	83.9±2.6
Females	30	56.4±1.5	79.4±2.7
Crosses			
Jersey	30	52.2±1.5[b]	72.0±2.62[b]
Friesian	30	63.3±1.5[a]	91.3±2.62[a]
R2		0.54	0.45
C.V.%		14.3	17.6

Means with different superscripts are different (P<0.05)

Conclusion

Calves weaned at 6 weeks of age had lower growth performance in all the early growth traits. However, weaning at 10 weeks of age didn't affect early growth traits and consequently had similar performances with calves weaned at 14 weeks of age. Therefore, taking into consideration both biological efficiencies as well as economic benefits gained from reduced milk consumptions by calves, weaning at 10 weeks of age is recommended. However, this experiment was carried out using conventional calf starter ration composed of hay from natural pasture and ingredients admixed from industrial by-products. Therefore, we further recommend that using more nutritious calf starter ration there is still a possibility of reducing weaning ages to below 10 weeks of age.

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Major Reproductive Health Problems of Dairy Cows in and around Bako, West Ethiopia

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Abstract

An investigation was made into major clinical reproductive health problems of 217 dairy cows (146 local and 71 crossbreds) on-station and on-farm in and around Bako in west Ethiopia. Prevalence and major risk factors of major clinical reproductive health problems were studied between October 2007 and May 2008. Questionnaire survey and clinical examinations were used to identify major reproductive health problems and risk factors. Of a total of 217 dairy cows assessed, 30.4% (n=66) were found to be affected either with one or more of the clinical reproductive problems. Major reproductive problems found were repeat breeding 8.72%, retention of placenta 6.88%, abortion 5.96%, dystocia 2.75%, anoestrus 2.29% and prolapses 0.92%. The prevalence of clinical reproductive problems showed significant differences ($p<0.05$) with respect to parity, production system and body condition of dairy cows. Breed had no significant effect ($p>0.05$) on the prevalence of these problems. Repeat breeding, retention of placenta, and abortion, were among the major factors responsible for the low reproductive performance of the dairy cows in and around Bako town, eastern Wollega and western Shoa zone of Oromiya, Ethiopia. The results showed that reproductive health problems, coupled with management system and poor body condition, are important factors that contributed to reproductive inefficiency. Regular reproductive health management and production based ration formulation could be the management options to reduce or alleviate some of the problems.

Keywords: abortion, retention of placenta, repeat breeding, Bako, dairy cows

Introduction

Crossbreeding of improved exotic dairy cattle breeds on a wide scale was introduced five decades back to upgrade the genetic potential of the indigenous zebu cattle, and subsequently to improve the dairy sector in Ethiopia. Since then, various efforts have been made to improve the dairy sector through artificial insemination or shared crossbreed bull service or by distributing crossbred F_1 heifers particularly to the smallholder dairy farmers (Fikre, 2007). However,

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the overall cost of keeping dairy cattle in terms of costs associated with the healthcare, nutrition, and management has not matched to their contribution to the livelihood and the economic contribution of the people (Takele *et al.,* 2005).

Though the country is endowed with substantial potential for dairy production, the current productivity is significantly low as compared to the domestic demands of dairy products suggesting a chronic shortage (Tigrie, 2004).

Reproductive health problems result in considerable economic losses to the dairy industry and are the main causes for poor reproductive performance (Bekana *et al*., 1994a). Among the major reproductive problems that have a direct impact on reproductive performance of dairy cows, retention of placenta and the subsequent endometritis and pyometra have been reported **(**Bekana *et al*., 1994b**)** to be the most common clinical and economical problems. Others include dystocia, abortion, uterine and vaginal prolapses (Bekana *et al*., 1994b, 1997).

In Ethiopia dairy cattle are maintained under different management systems. The difference in management systems and environmental conditions under which cattle are maintained could greatly affect the occurrence of reproductive health problems (Takele *et al.,* 2005). This particular study is therefore, carried out to determine the major reproductive health problems of the dairy cows in and around Bako area, West Ethiopia and assess possible risk factors that play a role in reproduction.

Materials and Methods

Study site

The study was conducted in and around Bako which is located in eastern Wellega and western Shoa zones of Oromiya. It is a high rainfall and humid environment and is situated at 251 km west of Addis Ababa. The area lies between 09° 6'N latitude and 37° E longitude at an attitude of 1650 m above sea level. The mean annual rainfall is 1210 mm, and it is uni-modal in distribution. The rainy period covers April to October. It has a warm humid climate with mean minimum; mean maximum and average temperatures of 13°c, 27°c, and 20°c respectively. According to the new agro-ecological zonation, it represents tepid to cool sub humid highlands. A number of livestock including cattle, sheep, goat, and donkey are reared in this area and are managed extensively with the

exception of few farms at Bako Agricultural Research Center and few others which are managed in semi intensive form.

Study animals' management system

The study involved both management systems extensive and semi-intensive. Classification of the management systems was based on the criteria adopted by Richard (1993). Accordingly, semi-intensive system included all animals that were kept indoor and fed and watered in their barns or shade by cut and carry system or zero grazing. Extensive management system included all animals that were kept outdoor during the day time and allowed to graze on a communal or private owned pasture land.

Study design

A cross sectional study (longitudinal or follow up) and questionnaire survey were used. Questionnaire surveys – a standard questionnaire formats were prepared and about 115 household heads were interviewed. The interview was made randomly to those households that came to the clinic for different veterinary service. Accordingly, a total of 142 dairy cows were examined during the interview process.

A total of 75 dairy cows that was pregnant during the study period were used for longitudinal (follow up) study for any abnormalities during pregnancy period, parturition and up to two weeks post-parturition. This was because some reproductive problems like milk fever and retention of placenta mostly occurs within few days or hours following parturition. General clinical examination including measuring vital signs, examination of the udder, and visible reproductive organs were carried out during the follow up period.

Data analysis

The prevalence and the relative frequencies of reproductive health problems were determined as the proportion of affected animals out of the total animals examined and the total number of cases, respectively. General Linear Model (GLM) procedures of SAS (SAS, 2002) were used to assess the effect of risk factors such as breed, parity, body condition and management (production system) on the prevalence of reproductive health problems.

Results

A total of 217 dairy cows from different production systems were examined and of the total cows examined, 30.41% (n= 66) were found to be affected either with one or more of the major clinical reproductive health problems (Table 1).

Table 1. The prevalence rate of clinical reproductive problems of dairy cows in and around Bako, western Ethiopia

Method of study	Total number of cows examined	Number of cows with problem	Percent affected
Questionnaire survey	142	54	24.88%
Regular follow up	75	12	5.53%
Total	217	66	30.41%

The major clinical reproductive problems encountered during the study period were repeat breeding, retention of placenta, abortion, dystocia, anoestrus and uterine prolapses. Among these repeat breeding, retention of placenta and abortion were being the most prevalent problems accounting for 8.12, 6.88, and 5.96%, respectively of the cases (Table 2).

The effect of parity (lactation stage) on the prevalence rate of major clinical reproductive problems was assessed and there was significant association (X^2: 12.75; $P<0.05$) between prevalence rate of reproductive problems and the parity of the individual cow. The prevalence was higher in pleuripara cows 36.5% (n = 61) as compared to primipara cows 10% (n= 5) (Table.3).

Reproductive problems were also assessed with respect to the breeds of the animals and there was no significant association between prevalence rate of reproductive problems and breeds of animals (X^2:0. 035: $P>0.05$) (Table 4).

Table 2. Major clinical reproductive health problems of dairy cows and their overall prevalence rate

Reproductive health problem encountered	Prevalence rate (%)
Repeat breeding	8.72
Retention of placenta	6.88
Abortion	5.96
Dystocia	2.75
Anoestrus	2.29
Prolapses	0.92

Table 3: The association of prevalence rate of major clinical reproductive problems and parity of the dairy cow.

Parity groups	Number of animals affected	Number of animals not affected	Total	X^2	P- value
Primipara heifers	5 (15.2)	45 (34.8)	50	12.76	P<0.05
Pleuripara cows	61 (50.7)	106 (11 6.3)	167		
Total	66	151	217		

Numbers in brackets indicate expected values

Table 4. The Association of prevalence rate of major clinical reproductive problems and breed of the animals

Breed	Number of animals affected	Number of animals not affected	Total examined	X^2	P- Value
Local	45(44.4)	101(101.6)	146	0.035	P > 0.05
Cross	21(21.6)	50 (49.4)	71		
Total	66	151	217		

Numbers in brackets are the expected values of the observations

Reproductive problems were also assessed in relation to body condition score of the cows and the association were found statistically significant (X^2: 9.6698 P= 0.022). And higher prevalence was obtained in lean and moderate body conditioned cows' 39.3% (n = 28), and 36.3% (n= 104), respectively than in animals with good and fat body condition, 16.44 and 33.7%, respectively (Table 5).

The effect of management on the prevalence rate of major clinical reproductive problems was significant (X^2: 16.27, P<0.05), where the prevalence rate of reproductive problems is much higher for extensively managed cows compared to those in semi-intensive management systems.

Table 5. The association of prevalence rate of major clinical reproductive problems and body condition score (BCS)

Body condition score	Number of animals affected	Number of animals not affected	Total animals examined	X^2	p- value
Lean (0-2)	11 (8.5)	17 (19.5)	28	9.67	P<0.05
Moderate (3)	40 (33.5)	70 (76.5)	110		
Good (4)	11 (20.38)	56 (46.62)	67		
Fat (5)	4 (3.65)	8 (8.35)	12		
Total	66	151	217		

Numbers in brackets are the expected values of the observation

Table 6.The association of prevalence rate of major clinical reproductive problems and production management system

Management system	Number of animals affected	Number of animals not affected	Total examined	X^2	P-value
Extensive	54 (40.14)	78 (91.86)	132	16.27	P<0.05
Semi-intensive	12 (25.85)	73 (59.15)	85		
Total	66	131	217		

Numbers in brackets are the expected values of the observation

Discussion

A lower prevalence (30.41%) rate of major clinical reproductive problems was obtained in this study when compared with the values reported by Tigrie (2004) 48.5%, Takele *et al.* (2005) 31.76% and Oumermohamed (2003) 34.9% and higher than the values reported by Tesfaye (1996) 26.7%. This variation in prevalence rate could possibly be attributed to management system, breed of animals and environmental conditions.

The prevalence rate (8.72%) of repeat breeding found in this study fairly agrees with the 8.9% reported by Takele *et al.* (2005), but it is higher than 4.6% reported by Tigrie (2004) and lower than 21.8% reported by Mekonnen (2000). Hence, the difference between the findings of the current study and previous reports may be attributed to the climatic condition of the area and managerial factors.

The prevalence rate (6.88%) of retention of placenta found in this study is lower than those reported in and around DebreZeit (14.28%) by Mamo, (2004), in central high lands of Ethiopia (7.1-28.9%) by Tekleye *et al.* (1992) and in and around Holeta (10.6%) by Tigrie, (2004). The variation in the incidence of re-

tention of placenta may be attributed to variations in predisposing factors to which the animals are subjected, such as nutritional status and management.

The prevalence rate (5.96%) of abortion recorded in this study is similar to the 6.3, 5.33, 5.4 and 6.3% reported by Tigire (2004), Shiferaw (1999), Mekonnen (2000) and Kassahun (2003), respectively. Tekleye *et al*. (1992) has also reported higher (16.3%) rate. On the other hand, Oumermohammed (2003) and Takele *et al.* (2005) reported a prevalence rate of 2.23% and 3.19%, respectively, which are lower than this finding.

Previous reports of the prevalence of dystocia of 5.79 % by Mamo (2004), 7.5% by Tigrie (2004) and 6.95% by Takele *et al.* (2005) are higher than the current finding of 2.75%. However, this finding fairly agrees to the 2.2- 4.4% reported by Zewdu (1992).

The prevalence rate of anoestrus found in the current study (2.29%) is lower than that of Oumermohammed (2003) who reported an overall prevalence rate of 4.6 %. The current finding is also lower than the 30% reported by Kapitano (1990), 70.7% in older cows and 65 % in heifers by Mekonnen (2000) and 26.8% by Tigrie (2004). The lower prevalence of anoestrus obtained in this study could be due to better heat detection practices especially in the animals of Bako Agricultural Research Center farm and adequate reproductive records. Besides, the management system particularly nutrition in animals of the farm could also have a strong effect on the reduction of anoestrus prevalence in the study area.

The analysis of the occurrence of major clinical reproductive problems showed that production system had significant effect and a higher (40.0%) prevalence rate of major reproductive problem was obtained in animals managed extensively than those managed under semi-intensive management practice (14.12%) in contrary to the previous reports (Kassahun, 2003; Tigrie, 2004; Takele *et al.,* 2005).

A statistically significant association was found between body condition score and reproductive problems with lean cows being the most susceptible, followed by moderately lean and fat cows. This could be probably lean animals have poor body defense, weak expulsive force to expel the fetal membrane together with the high possibility of contamination that increases the infection rate.

Strong association of parity and reproductive problems was obtained in this study with pleuripara cows being most susceptible. This is similar to the pre-

vious findings (Tadesse, 1999; Oumermohammed, 2003; Tigrie, 2004; Mamo, 2004; Takele *et al*., 2005) and is possibly due to the repeated exposure of the genital tract to environmental risk factors that can impart uterine infection of pleuripara cows. Mild infections gaining access to the reproductive tract after repeated calving and the tendency of older cow taking longer recovery time from pregnancy and lactation stress could also be the other reasons for this age related variation.

Even though a slightly higher prevalence rate was found in local Horro breeds as compared to the crossbreed cows, there was no significant association between breed and reproductive health problems. The probable reason is that the cross breeds included in the study are having at most 50% exotic blood type and this will help them to cope up the tropical weather conditions and hence yield better result up on better management.

Conclusions and Recommendations

The results obtained in this study demonstrate that parity, body condition, and production management system had a significant effect on the prevalence rate of major clinical reproductive disorders. Breed had no effect on the prevalence of the major reproductive health problems of the dairy cows in the study area.

It also suggested that repeat breeding, retention of placenta, abortion, and subsequent endometritis are the most common reproductive problems of the dairy cows in and around Bako. From the general fact that reproductive health problems consequence and also based on the results obtained in this study, the following recommendations are forwarded:

- Regular reproductive health management and production based ration formulation could be the management options to reduce or alleviate the problems in intensive and semi-intensive farms;
- Detailed causal and management factors study should be conducted in the study area on the reproductive health problems of dairy cows to help in designing a model of reproductive health program to prevent the possible causes;
- Train all dairy farmers on the management of exotic breeds, how to keep records of their cattle and the importance of consulting animal production development agents and veterinarian about their breeding program and herd heath management.

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Morphological characters and body weight of Menz and Afar sheep within their production system

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Abstract

Morphological characters and body weight of Menz and Afar sheep breeds were recorded under mixed crop-livestock and pastoral systems, respectively. Menz sheep are fat tailed and the tail is curved upward at the tip. Plain red, white and black coat colours were the commonest colours observed in Menz sheep with proportions of 29.3%, 21.6% and 15.8%, respectively. Menz ewes are polled whereas most of the rams were horned. About 18.5% of the males had ruff whereas females had no ruff. Menz rams had no wattle while 6.1% of the ewes were with wattle. About 15% of the Menz sheep had rudimentary ear, 35% had short ear showing a tendency to incline downward and the remaining half (49.3) of the sheep had larger and dropping/semi-pendulous ears. Afar sheep breed is fat tailed and the tail is curved upward having a wider tail both at the base and at the tip. The major (90%) coat colour of Afar sheep ranged from white to light red. Almost all of the sheep had straight head profile. Both sexes of Afar sheep breed are polled. About 2.4% of the female had wattle while males had no wattle. The breed has no ruff, but dewlap is present in both sexes. Majority (78.6%) of the Afar sheep were short eared showing a tendency of inclination downwards and about 19.7% were with rudimentary ear. Menz Sheep breed showed higher variability than Afar sheep breed in most of the qualitative characters. The age of the sheep at which the body weight change became maximum was at 2.3 pairs of permanent incisor for Menz and 2.2 pairs of permanent incisor for Afar sheep (approximately equal to 22.5 months). Sex and age of the sheep had a significant ($p<0.01$) effect on body weight and many of the body measurements. Body weight of mature (2 and above PPI) Menz ram and ewes were 24.9 ± 0.67 kg and 22.3 ± 0.13 kg, respectively. The corresponding values for Afar rams and ewes were 29.0 ± 0.84 and 24.5 ± 0.14 kg, respectively. The results of the study indicated the morphological description and performance level of the

two breeds and could help in designing sheep utilization strategy.

Keywords: *body measurement, crop-livestock system, pastoral system, qualitative characters*

Introduction

Ethiopia is home for about 14 traditional sheep breeds (Solomon *et al.,* 2007_b) and has an estimated 25 million sheep population (CSA, 2007). Menz and Afar sheep breeds are well adapted to the low input production systems of the country. Menz sheep breed is adapted to the very cold climate of the cool highlands and are tolerant to drought and variable seasonal feed availability, tolerant to endo-parasite infection, produce meat, coarse wool, skin and manure (Haile, 1999; Tibbo, 2006). The Afar sheep breed, to the contrary, is well adapted to the arid and semi arid environment of the pastoral management system (Galal 1983). Information on morphological characters and performance of the breeds under traditional management is required for designing community-based breeding strategy. Unfortunately, information available on Ethiopian sheep breeds is scanty (Workneh *et al.,* 2004) for Afar sheep and most of the available information so far for Menz sheep has been based on on-station managed flocks and some on-farm studies on Menz sheep was done many years ago. Therefore, the objective of this study was to characterize the general morphology, body weight and other qualitative characters of the Menz and Afar sheep breeds under traditional management systems.

Materials and Methods

Description of the study area

The study was conducted on Menz and Afar sheep breeds of Ethiopia. In Menz area the study was conducted in Menz Mamma and Menz Gera woredas of North Shewa of the Amhara National Regional State at altitude range from 2800 to 3200 m.a.s.l. Based on the meteorological data obtained from Debre Berhan Agricultural Research Centre for the years 1985 to 2005, the annual rainfall at Mehal Meda town (the capital of the Menz Gera woreda) was about 900 mm and the minimum and maximum average temperatures were 6.8 ^{o}C and 17.6 ^{o}C, respectively. In Afar area the survey was conducted in Amibara woreda, part of the zone 3 of the Afar National Regional State. The study was conducted at altitude ranging from 750 to 812 m.a.s.l. Based on the meteorological data from Werer Research Centre for the years 1965 to 2006, the an-

nual rainfall is 588 mm and average daily temperature is about 27.6 °C with a maximum approaching 38 °C in June and a minimum of 15.4 °C in November.

Selection of the study sites

A rapid field survey was conducted by a team of researchers and the respective woreda Agricultural office professionals in each of Menz and Afar areas to locate appropriate site for the establishment of community-based sheep breeding strategy. Two kebeles in Menz area (Sina Amba and Yecha) and three kebeles in Afar (Ambash, Hallidegi and Awash Arba) were selected based on their suitability for sheep production, influence of crossbreeding, market and road access and willingness of the farmers or pastoralists to participate in the program.

Methods of data collection

Qualitative and quantitative morphological characters were collected from a total of 1888 (1095 Menz and 793 Afar) sheep. The sheep were sampled within approximately 50 km radius of the selected sites. Each sampled animal was identified by sex, site and estimated age group. Adult sheep were classified into five age groups based on the number of pairs of permanent incisors (PPI) following the finding of Wilson and Durkin (1984) for African sheep breed as follows: 0 PPI= less than 15 months, 1 PPI= 15.5 to 22.0 months, 2 PPI = 22.5 to 27.0 months, 3 PPI = 28.0 to 38 months and 4 PPI= above 39.0 months. Qualitative characters: coat color pattern, coat color type, hair type, head profile, ears, wattle, horn, ruff and tail were observed. For linear body measurements sheep were put in standing position on a level and hard floor and held by personnel. All measurements were taken by the same personnel while sheep were in an up-right plane during measurement. The following 8 body measurements were measured using measuring tape calibrated in centimeters (cm): chest girth (CG - taken as the circumference of the body immediately behind the shoulder blades in a vertical plane perpendicular to the long axis of the body); body length (BL- measured as the horizontal distance from the point of shoulder to the base of the tail); wither height (WH- taken to be the height of an animal from the bottom of the front foot to the highest point of the shoulder between the withers); pelvic width (PW- measured as the distance between pelvic bones across the dorsum); horn length (HL- length of the horn on its exterior side from its root at the poll of the tip); scrotum circumference (SC- taken by pushing the testicles to the bottom of the scrotum and the greatest circumference was measured); tail length (TL- distance from the base to the tip of the tail on

the outer side of the tail); tail circumference (TC- circumference of the base of the tail) while body weight was measured using suspended spring balance having 50 kg capacity with 0.2 kg precision. Body condition (BC) scoring was done subjectively using scoring from 1 (emaciated) to 5 (obese or extremely fat).

Data analysis

Body weight increased at higher rate till 2 PPI and then after body weight increased at lower rate. The age of the sheep at which the body weight change become maximum (at about 2 PPI) were obtained from the quadratic equation using body weight change of each breed as response variable and dentition class as explanatory variable. Thus, for the analysis of least squares means of body weight and other body measurements, sheep were classified in to 3 age groups; young (0 PPI = less than 15 months), intermediate (1 PPI = 15.5 to 22.5 months) and oldest (2 and above PPI = above 22.5 months). Measurements on qualitative characters were analyzed for male and female sheep within breed using frequency procedure of SAS (SAS, 2003). The coefficient of unalikeability (u_2) was used to measure the variability of qualitative characters within the breed. As described by Kader and Perry (2007) Coefficient of Unalikeability (u_2) was calculated using the formula: $u_2 = 1-\sum pi^2$, where pi is the proportion of each response within a category. Body weight and quantitative linear body measurements were analyzed using the Generalized Linear Model (GLM) procedures of the Statistical Analysis System (SAS, 2003). For adult animals, sex and age group of the sheep were fitted as fixed independent variables while body weight and linear body measurements except scrotum circumference and horn length were fitted as dependent variables. Scrotum circumference was analyzed for each breed by fitting age group as fixed factor. Horn was specific character of male Menz sheep only and therefore analysis of horn length was employed for male Menz sheep only by fitting age group as fixed effect. When analysis of variance declares significance, least square means were separated using adjusted Tukey-Kramer test.

Results

Qualitative morphological characters

Menz sheep: Menz sheep is fat tailed and the tail is curved upward at the tip. Nearly 69% of the sheep had plain coat color pattern followed by patchy pattern (28%). Sheep with spotty pattern (2.8%) were rarely observed. Almost all (98.8%) of Menz sheep had long and coarse wool/hair. Coat color types of plain red, white and black were observed with proportions of 29.3, 21.5 and 15.8%,

respectively. The mixtures of red and white; and black and white accounted for 16.4% and 6.3%, respectively. Black with white head, dark grey locally known as *'jibma'* and black color with white or red belly accounted for 3.0, 6.0 and 1.7%, respectively. Majority (98%) of the sheep had straight and slightly concave head profile. Almost all (99.1%) of the ewes were polled whereas most (92.3%) of the rams were horned. Horn shape and orientation of Menz ram were also variable. Out of the horned rams, 95.7% had spiral horn shape and the remaining 4.3% had short and straight horn. Out of the total rams having spiral shape, almost half (52.9%) of the ram had back ward oriented horns and the remaining 47.1% had laterally oriented horns. About 19% of the males had ruff (long hair around the neck region of the inner part) whereas females had no ruff. Menz rams had no wattle while 6.1% of the ewes were with wattle. About 15% had rudimentary ear, 35.3% had short ear showing a tendency to be inclined downward and the remaining 49.3% of the sheep had larger and dropping/semi-pendulous ears. Menz ram and ewe are shown in Figure 1.

Figure 1. A mature Menz ram (left) and ewe (right)

Afar sheep: Afar sheep breed is fat tailed and the tail is curved upward having a wider tail both at the base and at the tip. Coat colour pattern was patchy (58.1%), plain (40.6%) and spotty (1.3%). Almost all (99.7%) had short and coarse hair. Coat colour type of the breed was white with red patch along the back (41.9%), plain light red (30.9%), plain white (17.2%) and plain dark red (7%). This showed that majority (90%) of the sheep are found in between white and red colours. Other colors were found rarely; plain black (1.2%), black and white (1.1%) and dark grey (0.7%). Almost all of the sheep (99.2%) had straight head profile. Both sexes of Afar sheep breed were polled. About 2.4% of the female had wattle while all of the males had no wattle. The breed had no ruff,

but dewlap is present in both sexes. Majority (78.6%) of the Afar sheep were short eared showing a tendency to be inclined downwards and about 19.7% were with rudimentary ear. Figure 2 shows the physical appearance of Afar ram and ewe.

Figure 2. A mature Afar ram (left) and ewe (right)

Variability of qualitative characters

Generally Menz Sheep breed showed higher variability than Afar sheep breed in most of the qualitative characters. Menz sheep have shown more variability in coat color type, ear form, head profile and coat color pattern among other qualitative characters with coefficient of unalikeability (u_2) of 0.81, 0.61, 0.52 and 0.44, respectively. Afar sheep breed showed more variability on coat color type with u_2 of 0.69 followed by ear form and coat color pattern with u_2 of 0.40 and 0.34, respectively.

Body Weight and body condition score

Figure 3 shows a plot of body weight against dentition class for Menz and Afar ewes. Body weights of both Menz and Afar sheep breeds increased at increasing rate from milk tooth stage (dentition class 0) to the eruption of 1 pair of permanent incisor (dentition class 1) and also from dentition class 1 to the eruption of 2 pairs of permanent (dentition class 2). The age of the sheep at which the body weight change became maximum was at an average of 2.3 pairs of permanent incisor for Menz and 2.2 pairs of permanent incisor for Afar sheep (approximately equal to 22.5 months). Body weight of both Menz and Afar sheep started to decline at old age (dentition class 5) when sheep started to wear their permanent incisors (approximately above 5 years old).

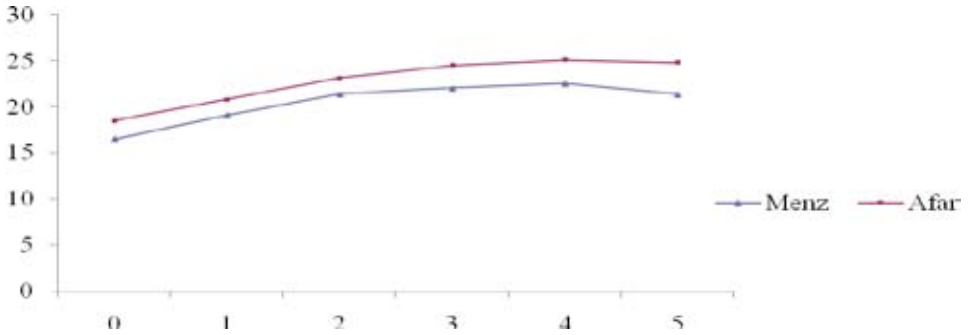

Figure 3. Growth curve of Menz and Afar sheep

Least squares means ± standard errors of body weight (kg), body condition score for the effects of sex, age and sex by age interaction for Menz and Afar sheep breed are presented in Tables 1 and 2, respectively. Sex and age of the sheep had significant ($p<0.01$) effect on body weight (BW) of both Menz and Afar sheep breeds. Body condition (BC) was affected ($p<0.01$) by sex and age for Menz sheep whereas for Afar sheep breed it was affected ($p<0.01$) by sex of the sheep but not by the age ($p>0.05$). In all age groups of Menz and Afar sheep, males were heavier ($p<0.01$) than females. Body weight in Menz and Afar sheep significantly increased as the age increased from the youngest (0 PPI) to the oldest (≥ 2 PPI) age group. The interaction of sex and age group was significant ($p<0.01$) for BW and BC of Menz sheep but for Afar sheep it was significant for BC ($p<0.01$) only.

Table 1. Least squares means ± standard errors of body weight (kg), body condition score for the effects of sex, age and sex by age interaction for Menz sheep

Effects and level	Body weight		Body condition score	
	N	LSM±SE	N	LSM±SE
Overall	1072	20.6±0.15	1095	1.9±0.03
CV%	1072	15.0	1095	29.8
R^2	1072	36.0	1095	6.0
Sex		**		**
Male	217	22.0±0.27	224	2.1±0.05
Female	858	19.3±0.13	872	1.8±0.02
Age group		**		**
0 PPI	264	17.2±0.19[a]	271	1.7±0.03[a]
1 PPI	202	21.0±0.23[b]	204	2.0±0.04[b]
≥ 2 PPI	609	23.6±0.32[c]	621	2.1±0.06[b]

Effects and level	Body weight		Body condition score	
	N	LSM±SE	N	LSM±SE
Sex by age group		**		**
Male, 0 PPI	127	18.0±0.28[a]	133	1.7±0.05[a]
Male, 1 PPI	65	22.9±0.39b[e]	66	2.3±0.07[b]
Male, ≥ 2 PPI	25	24.9±0.67[b]	25	2.3±0.11[b]
Female, 0 PPI	137	16.5±0.27[c]	138	1.7±0.05[a]
Female, 1 PPI	137	19.1±0.27[d]	138	1.8±0.05[ac]
Female, ≥ 2 PPI	584	22.3±0.14[e]	596	1.9±0.02d[c]

[a,b,c,d,e]Means with different superscripts within the same column and class are statistically different. **significant at 0.01. 0 PPI = 0 pair of permanent incisors; 1PPI = 1 pair of permanent incisor and ≥ 2 PPI = 2 or more pairs of permanent incisors.

Table 2. Least squares means ± standard errors of body weight (kg), body condition score for the effect of sex, age and sex by age for Afar sheep

	Body weight		Body condition	
Effects and level	N	LSM±SE	N	LSM±SE
Overall	779	22.76±0.26	793	2.04±0.04
CV%	779	14.0	793	27.4
R^2	779	33.0	793	9.0
Sex		**		**
Male	46	24.3±0.50	46	2.3±0.08
Female	733	21.2±0.16	747	1.8±0.02
Age group		**		NS
0 PPI	102	19.4±0.40[a]	102	2.1±0.06
1 PPI	117	22.1±0.53[b]	121	1.9±0.08
≥ 2 PPI	560	26.8(0.42[c]	570	2.1±0.06
Sex by age group		Ns		**
Male, 0 PPI	21	20.3±0.71	21	2.2±0.11[a]
Male, 1 PPI	10	23.5±1.02	10	2.2±0.15[a]
Male, ≥ 2 PPI	15	29.0±0.84	15	2.4±0.12[a]
Female, 0 PPI	81	18.5±0.36	51	2.1±0.05[a]
Female, 1 PPI	107	20.8±0.31	111	1.7±0.05[b]
Female, ≥ 2 PPI	545	24.5±0.13	555	1.7±0.02[b]

[a,b,c] Means with different superscripts within the same column and class are statistically different (at least $p < 0.05$). Ns = non significant; **significant at 0.01. 0 PPI = 0 pair of permanent incisors; 1PPI = 1 pair of permanent incisor and ≥ 2 PPI = 2 or more pairs of permanent incisors

Linear body measurements

Least squares means ± standard errors of body measurements (cm) for the effect of sex, age and sex by age for Menz and Afar sheep breeds are presented in Tables 3 and 4, respectively. For Menz breed, sex had significant effect on CG ($p<0.01$), WH ($p<0.01$) and PW ($P<0.05$) but had no ($p>0.05$) effect on BL. For Afar sheep, BL, CG, WH were significantly ($p<0.01$) affected by sex, whereas PW was not affected ($p<0.05$). All body measurements (BL, CG, WH and PW) were significantly ($p<0.01$) affected by age group for both Menz and Afar sheep breeds. In body measurements affected by sex, males had larger values than females. Chest girth of Menz breed and WH of Afar sheep were affected ($p<0.01$) by the interaction of sex and age group.

Table 3. Least squares means ± standard errors of body measurements (cm) for the effect of sex, age and sex by age for Menz sheep

Effects and level	Body length		Chest girth		Wither height		Pelvic width	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Overall	1095	53.5±0.17	1095	65.1±0.22	1095	58.4±0.16	1095	18.1±0.07
CV%	1095	6.3	1095	7.1	1095	5.7	1095	8.3
R^2	1095	27.0	1095	28.0	1095	19.0	1095	22.0
Sex		NS		**		**		*
Male	224	53.9±0.29	224	65.7±0.39	224	59.6±0.28	224	18.2±0.13
Female	871	53.7±0.15	871	64.5±0.20	871	57.1±0.14	871	17.9±0.06
Age group		**		**		**		**
0 PPI	271	51.3±0.22[a]	271	61.4±0.28[a]	271	56.1±0.20[a]	271	17.0±0.09[a]
1 PPI	204	54.3±0.26[b]	204	66.1±0.35[b]	204	59.0±0.25[b]	204	18.4±0.11[b]
≥ 2 PPI	620	55.9±0.35[b]	620	67.7±0.48[c]	620	60.0±0.34[b]	620	18.9±0.16[b]
Sex by age group		Ns		**		Ns		Ns
Male, 0 PPI	133	51.7±0.31	133	62.2±0.40[a]	133	57.4±0.29	133	17.1±0.13
Male, 1 PPI	66	54.7±0.43	66	67.7±0.57[b]	66	60.8±0.41	66	18.6±0.19
Male, ≥ 2 PPI	25	55.5±0.71	25	67.3±0.93[bc]	25	60.8±0.67	25	18.9±0.30
Female, 0 PPI	138	50.8±0.30	138	60.7±0.40[a]	138	54.8±0.28	138	16.8±0.13
Female, 1 PPI	138	53.9±0.30	138	64.5±0.40[c]	138	57.3±0.28	138	18.2±0.13
Female, ≥ 2 PPI	595	56.4±0.14	595	68.2±0.19[b]	595	59.2±0.14	595	18.8±0.06

[a,b,c,d.] Means with different superscripts within the same column and class are statistically different (at least $p<0.05$). Ns = non significant; * significant at 0.05; **significant at 0.01. 0 PPI = 0 pair of permanent incisors; 1PPI = 1 pair of permanent incisor and ≥ 2 PPI = 2 or more pairs of permanent incisors

Table 4. Least squares means ± standard errors of body measurements (cm) for the effect of sex, age and sex by age for Afar sheep

Effect and level	Body length		Chest girth		Wither height		Pelvic width	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Overall	792	60.58±0.28	792	66.50±.31	792	61.37±0.23	793	0.55±0.13
CV%	792	5.5	792	5.7	792	4.6	793	7.4
R^2	792	22.0	792	30.0	792	21.0	793	23.0
Sex		**		**		**		Ns
Male	46	61.3±0.52	46	67.3±0.58	46	62.1±0.44	46	20.5±0.24
Female	746	59.9±0.17	746	65.7±0.19	747	60.7±0.14	747	20.7±0.08
Age group		**		**		**		**
0 PPI	102	57.3±0.41[a]	102	62.4±0.46[a]	102	58.6±0.35[a]	102	19.3±0.19[a]
1 PPI	121	61.2±0.56[b]	121	66.5±0.62[b]	121	61.6±0.47[b]	121	20.8±0.26[b]
≥ 2 PPI	570	63.2±0.44[c]	570	70.5±0.49[c]	570	63.9±0.37[c]	570	21.6±0.21[c]
Sex by age group		Ns		Ns		*		Ns
Male, 0 PPI	21	57.3±0.74	21	62.5±0.82	21	58.6±0.62[a]	21	19.2±0.34
Male, 1 PPI	10	62.4±1.07	10	67.6±1.20	10	62.4±0.90[bcd]	10	20.9±0.50
Male, ≥ 2 PPI	15	64.2±0.87	15	71.9±0.97	15	65.3±0.74[b]	15	21.3±0.41
Female, 0 PPI	81	57.2±0.38	81	62.4±0.42	81	58.6±0.32[a]	81	
Female, 1 PPI	111	60.1±0.32	111	65.4±0.36	111	60.9±0.27[c]	111	20.7±0.15
Female, ≥ 2 PPI	555	62.3±0.14	555	69.2±0.16	555	62.6±0.12[d]	555	21.8±0.07

[a,b,c,d,] Means with different superscripts within the same column and class are statistically different (at least p <0.05). Ns = non significant; * significant at 0.05; **significant at 0.01. 0 PPI = 0 pair of permanent incisors; 1PPI = 1 pair of permanent incisor and ≥ 2 PPI = 2 or more pairs of permanent incisors

Least squares means ± standard errors of tail length and tail circumference (cm) for the effect of sex, age and sex by age; and horn length and scrotum circumference (cm) for the effect of age for Menz and Afar sheep breed are presented in Tables 5 and 6, respectively. For both Menz and Afar sheep, sex had significant ($p<0.01$) effect on tail length (TL) and tail circumference (TC). Tail length, TC and SC were significantly ($p<0.05$) affected by the age of the sheep in both Menz and Afar sheep breed except for TL which was not different ($P>0.05$) among the age groups for Afar sheep. The interaction of sex and age group was significant ($p<0.05$) only for TC in Menz sheep.

Table 5. Least squares means ± standard errors of tail measurements (cm) for the effect of sex, age and sex by age; and horn length and scrotum circumference (cm) for the effect of age for Menz sheep

Effect and level	Tail length		Tail circumfer-ence		Scrotal circum-ference		Horn length	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Overall	1078	18.67±0.15	1096	15.47±0.15	219	23.16±0.24	295	20.15±0.46
CV%	1078	17.2	1096	23.3	219	12.2	295	39.5
R2	1078	10.0	1096	25.0	219	25.0	295	19.0
Sex		**		**		Na		Na
Male	216	20.0±0.27	224	18.1±0.270				
Female	862	17.4±0.13	872	12.8±0.140				
Age group		**		**	**	**		**
0 PPI	269	18.1±0.19a	271	13.9±0.20a	131	20.9±0.24a	127	15.3±0.68a
1 PPI	198	19.3±0.23b	204	15.9±0.24b	66	24.0±0.33b	90	21.7±0.81b
≥ 2 PPI	611	18.6±0.34ab	621	16.6±0.33b	22	24.5±0.58b	78	23.5±0.87b
Sex by age group		Ns		**		Na		Na
Male, 0 PPI	131	19.0±0.27	133	15.4±0.28a				
Male, 1 PPI	64	20.9±0.38	66	19.1±0.40b				
Male, ≥ 2 PPI	21	19.9±0.67	25	20.0±0.64b				
Female, 0 PPI	138	17.2±0.26	138	12.4±0.27c				
Female, 1 PPI	134	17.8±0.26	138	12.8±0.27c				
Female, ≥ 2 PPI	590	17.3±0.13	596	13.2±0.13c				

[a,b,c,d] Means with different superscripts within the same column and class are statistically different (at least $p<0.05$). Ns = non significant; Na = not applicable. **significant at 0.01. 0 PPI = 0 pair of permanent incisors; 1PPI = 1 pair of permanent incisor and ≥ 2 PPI = 2 or more pairs of permanent incisors.

Table 6. Least square means ± standard error of tail measurements (cm) for the effect of sex, age group and sex by age; and scrotum circumference (cm) for the effect of age for Afar sheep

Effect and level	Tail length		Tail circumference		Scrotal circumference	
	N	LSM±SE	N	LSM±SE	N	LSM±SE
Overall	792	16.68±0.24	791	41.16±0.51	43	25.69±0.39
CV%	792	19.1	791	16.4	43	9.8
R2	792	4.5	791	7.8	43	29.0
Sex		**		**		Na
Male	45	17.8±0.46	46	45.0±0.97		
Female	747	15.6±0.15	745	37.3±0.32		
Age group		Ns		**		**
0 PPI	101	16.3±0.38	102	39.0±0.77a	19	23.9±0.57a
1 PPI	121	17.3±0.49	121	41.6±1.04ab	10	25.7±0.79a

Effect and level	Tail length		Tail circumference		Scrotal circumference	
	N	LSM±SE	N	LSM±SE	N	LSM±SE
≥ 2 PPI	570	16.4±0.38	568	42.9±0.82b	14	27.5±0.67b
Sex by age group		Ns		Ns		Na
Male, 0 PPI	20	16.9±0.66	21	42.2±1.40		
Male, 1 PPI	10	18.9±0.93	10	45.2±2.00		
Male, ≥ 2 PPI	15	17.7±0.76	15	47.6±1.60		
Female, 0 PPI	81	15.8±0.33c	81	35.8±0.70		
Female, 1 PPI	111	15.8±0.28	111	38.1±0.60		
Female, ≥ 2 PPI	555	15.1±0.12	553	38.2±0.27		

[a,b.] Means with different superscripts within the same column and class are statistically different (at least $p < 0.05$). Ns = non significant; Na = Not applicable. **significant at 0.01. 0 PPI = 0 pair of permanent incisors; 1PPI = 1 pair of permanent incisor and ≥ 2 PPI = 2 or more pairs of permanent incisors.

Presence of horn was sex and breed dependent and was observed in Menz rams only. Horn length was affected by the age of the ram. Horn length at the youngest age group was 15.3 cm which was significantly shorter ($p<0.01$) than the intermediate age group (21.7 cm) and oldest age group (23.5 cm) while the later age groups were not different ($p>0.01$) from each other.

Discussion

In this study we describe Menz and Afar sheep breeds based on their body weight and other body measurements in their production systems. The proportion of white coloured sheep observed in Menz was larger than that of black colour. The results are contrary to the report of Galal, (1983) who reported black and brown as the dominant colors of Menz sheep while white color was rarely observed. On the other hand, on-station characterization of Menz sheep by Tibbo *et al.* (2004) found white colored sheep in larger proportion. Examining the results of the present study against the earlier ones indicated that the proportion of white is increasing and that of black is decreasing through time. This is strongly supported by the preference of farmers of white and red colors against the black color for which the farmers are exercising some kind of selection for the preferred ones. In general the qualitative morphological description of Afar sheep breed obtained in this study is in agreement with those of Galal (1983) and Sisay (2002) who described Afar sheep breed at Werer Research Center and in eastern Amhara Regional State, respectively. Lower value of coefficient of unalikability were observed for qualitative morphological characters of Afar than Menz sheep breed suggesting the Afar breed was more close to bred true (able to produce offspring of the same phenotype). Higher hetero-

geneity of coat color obtained for Menz sheep was supported with the finding of Sisay (2002). Higher variability in coat colour and pattern of Menz sheep, small size and presence of horn, short fat tailed makes them similar with the primitive Soay sheep breed (Marrs, 2006). Higher variability in qualitative characters like coat color, ear size and head profile of Menz sheep indicated the existence of different types and thus when designing breeding strategy for Menz sheep one might consider the possibility of developing different lines within the breed.

The effect of sex on body weight and other measurements obtained in this study is in agreement with previous results (Abebe, 1999; Tibbo *et al.,* 2004). Body weight and most of the body measurements of Menz sheep reported in this study are comparable with the previous recent report on the same breed from on-station (Tibbo *et al.,* 2004) and on-farm (Abebe, 1999) management conditions. However, the value of body weight obtained at the oldest age group of male and female Menz sheep was lower than those reported by Galal (1983). Wither height of Afar sheep is comparable with the result of Galal (1983) who reported 66 cm and 61 cm for mature ram and ewe, respectively. Body weight of Afar sheep at the youngest age group was lower than the on-station yearling weight (Yebrah, 2008) of Afar sheep reported as 25.6 kg and 23.5 kg for male and female, respectively. Body weight of Afar ram and ewe (29.0 ± 0.84 and 24.5 ± 0.13 kg, respectively) in the oldest age group were lower than the previous report of Galal, (1983). The comparatively lower body weight for both Menz and Afar sheep breeds recorded compared with previous reports might be attributed to the difference in the level of management. This is so because the on-station management of the other studies increased the growth of the sheep and resulted in higher weight. The difference might also be related to the year/ time effect. Due to the fact that the values, for instance of Galal (1983), were estimated before 25 years and the feed situation and genetic make up of animals is not expected to be the same over the long years.

Generally, live weight of Menz and Afar sheep breeds is far lower than the recommended live export body weight of 30 kg at yearling age (Tibbo, 2006). Menz and Afar sheep breeds are also lower in live weight and other body measurements when compared with other sheep breeds found in the country. For example, in north western Ethiopia, body weight of 32.5 kg at 13 to 18 months age were recorded for Gumuz ram under on-farm management (Solomon, 2007); and 33.1 kg for Washera ram and 26.1 kg for Washera ewe were reported (Mengiste, 2008) at the age when sheep had 3 PPI, under farmers management. Under station management at Bako Research Center, 34 kg body weight

was reported for Horro sheep breed (Yohannes *et al.,* 1998). Small body size and reduced productivity in Menz and Afar sheep breeds might be attributed to the fact that these attributes could be used as means of survival in the harsh environmental situation (Silanikove, 2000) prevailing in the Afar and Menz areas. However, research findings indicated the possibility of genetic improvement on these sheep breeds due to the existence of within breed variability and moderate to high heritability for body weight (Solomon *et al.,* 2007_a; Yebrah, 2008). Indigenous Menz sheep improved through selection could reach 30 kg live weight at yearling under better management (Solomon *et al.,* 2006).

Mean body condition for male Menz and Afar sheep were found to be thin. This might be due to the existing feed situation in the areas. Unpublished report from Debre Berhan Agricultural Research Center indicated that poor body condition has contributed to meat darkening after slaughter. Low body weight of Menz and Afar sheep breeds obtained in this study might be partly due to poor body condition score implying the possibility of improvement in body weight by improving the condition of animals through better management.

The overall tail length of Afar sheep was 16.7 cm which was lower than tail length of Menz sheep (18.7 cm). The tail lengths of Menz and Afar sheep were lower than that of Horro sheep (36 cm) (Kasahun, 2000). Tail circumference of Afar sheep breed (41.2 cm) is much higher than tail circumferences of Menz sheep (15.5 cm), and was also higher than earlier reported value of 15.0 cm for Menz and Horro sheep (Kasahun, 2000). Large tail circumference of Afar sheep recorded in this study is in agreement with the report that the breed has a wide tail base (Galal, 1983). The small tail length for Afar sheep is unexpected as it seemed large visually. This was because of the large width of Afar sheep tail both at the base and the tip, the tail fat hang on the tail down wards and some times reached below the hock. But the actual measurement of tail length was measured following the tail bone from the base to the tip of the tail which is lower than visually observed.

Conclusions

In this study we described morphological characters and body weight of Menz and Afar sheep breeds. Higher variability in qualitative characters of Menz sheep indicated the existence of different types and thus when designing breeding strategy for Menz sheep one might consider the possibility of developing different lines within the breed. This study revealed that Menz and Afar sheep breed showed lower body weight and body measurements than results of the

on-station management of the same breeds and compared with other breeds found in the country. Low body weight of Menz and Afar sheep breeds obtained in this study might be partly due to management and could provide an opportunity for improvement in body weight through better management. The observed difference might also be partly due to genetics and could be improved using appropriate breeding strategy. Generally, growth traits have moderate to high heritability implying the possibility of improving through pure breeding.

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Morphological Characterization of Bonga and Horro Indigenous Sheep Breeds under Smallholder conditions in Ethiopia

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Abstract

Characterization of animal genetic resource is a pre-requisite for designing proper breeding strategies. This study was conducted to morphologically and biometrically characterize Bonga and Horro indigenous sheep breeds of the smallholders. A total of 10 traits which included body weight, body length, chest width, wither height, chest width, pelvic width, tail length, tail circumference, ear length and scrotal circumference were measured from 755 Bonga and 820 Horro sheep kept by smallholder farmers. For the analyses of quantitative data, the main effects of breed and dentition were fitted in the model within each sex groups. In both of the breeds the coat color is dominated by brown which is found in plain and patchy patterns. Polldness is common in both of the breeds. Coat pattern, coat color, tail conformation and ear orientation were found to significantly ($P<0.01$) differ between the two breeds. More of the animals in Horro had plain coat pattern, brown coat color, and semi-pendulous ear orientation. Horro females had significantly ($P<0.01$) greater values for chest girth, wither height and tail length than Bonga females. On the contrary, Bonga ewe's had significantly ($P<0.01$) higher values than Horro with respect to body weight, body length, chest width, pelvic width and ear length. Horro male had higher values ($P< 0.01$) for chest girth; wither height and scrotal circumference than Bonga males. With the exceptions of ear length, tail circumference, tail length and body condition score, age was found to have a significant influence ($P<0.01$) on most body measurements in both sexes. The two breeds can be classified as large breeds and should be given emphasis for their

improvement and conservation since they can better thrive and produce where disease and internal parasites are problems. To explore the genetic potential of Bonga sheep there is a need to undertake performance testing studies under improved management conditions unlike Horro sheep where there is good deal information on performance the breed.

Key words: Bonga sheep, Horro sheep, Adiyo, Horro, morphological characters

Introduction

Sheep population of Ethiopia is estimated at 24 million heads, with majority (75%) of these being kept in small scale mixed farms in the highland regions, while the remaining 25% are found in the lowlands (Tibbo, 2006). The majority of sheep kept in Ethiopia are indigenous to the country. These are valuable genetic resources adapted to the harsh climatic conditions of the country, resistant and/or tolerant to parasites and diseases and have the ability to efficiently utilize limited feed resources (Solomon *et al.,* 2007) and might be more productive under low input systems of smallholders than exotic breeds. They provide regular cash income through sale of live animal and skins, are living bank against the various environmental calamities (crop failure, drought, flooding) and have socio-cultural values for diverse traditional communities. Therefore, there is a need to study variation among the breeds so as to facilitate their efficient utilization and conservations. Past studies were limited in their scope as they were concentrated only on few indigenous sheep breeds or are based on few animals compared to the whole population. Information on morphological characteristics is a prerequisite to the development of sustainable breed improvement, utilization and conservation strategies. For example, community based breeding strategies warrant that the breeds have to be well studied, and traits, which make them unique, be characterised phenotypically and genetically (Baker and Gray, 2003). The objective of this study was, therefore, to morphologically

characterize indigenous Bonga and Horro sheep breeds.

Materials and Methods

Study areas

The study was carried out in Adiyo Kaka (Southern Nations, Nationalities and Peoples' Regional State of Ethiopia) and Horro (Oromia Regional State of Ethiopia) districts from December 2007 to March 2008. Adiyo Kaka falls within longitude of 36º 47'E and latitude of 7º 26'N with altitude ranging from 500 to 3500 meters. The temperature in the area can be as high as 36 ºC and can also reach lowest value of 3 ºC (SUDACA, 2007). Horro district is situated within longitude of 36º 47'E and latitude of 7º 26'N with altitude ranging from 1800 to 2835 meters HARDO (HARDO, 2006).

Morphological characters studied

A total of 1575 (755 Bonga and 820 Horro sheep) were randomly sampled from the study districts. The categorical traits scored were: coat pattern, coat color type, head profile, ear orientation, presence or absence of ruff, presence or absence of wattle, tail conformation, and body condition. Likewise, the quantitative traits measured for both male and female were: live body weight (BW, measured using a 100kg portable weighing scale graduated at 500gm interval); body length (BL, measured as the horizontal distance from the point of shoulder to the pin bone); chest girth (CG, the circumference behind the forelegs); wither height (WH, the height from the bottom of the front foot to the highest point of the shoulder between the withers); pelvic width (PW, the distance between the pelvic bones, across dorsum); chest width (CW, the width of the chest between the briskets); tail length (TL, the length of tail from the base to the tip); tail circumference (TC, the circumference of the tail at its widest part); ear length (EL, the length of the ear on its exterior side from its root at the poll to the tip); and scrotal circumference (SC, the circumference of the testis at the widest part). Body measurements were obtained by the use of measuring tape calibrated in centimeters (cm) after restraining and holding the animals in an unforced position. In addition, the age of animals was estimated from dentition to support the age information given by farmers. Based on dentition, sampled sheep were categorized as 0 dentition (only for males), one pair of permanent incisors, two pairs of permanent incisors, three pairs of permanent incisors and four pairs of permanent incisors following Wilson and Durkin (1984) (Table 1). Body condition score (BCS) was assessed subjectively and scored using the 5 point scale (1= very thin, 2 = thin, 3 = average, 4 = fat and 5 = Very fat/

obese) for both of the sexes according to Hassamo *et al. (*1986). Body score of an animal was done by feeling the back bone with the thumb and the end of the short ribs with fingers tips immediately behind the last ribs.

Table1. Size of samples of the studied flock

Breed	Number of animals used for qualitative and quantitative measurements					
	Female				Male	
	1PPI	2PPI	3PPI	4PPI	1-4PPI	Total
Bonga	85	102	169	325	74	755
Horro	61	138	90	503	28	820
Total	146	240	259	828	102	1575

Estimate ages of sample population: 1PPI = 15.5 months; 2PPI months= 22.5 months; 3 PPI = 28 months; 4 PPI = 39 months (Wilson and Durkin, 1984).

Data Analysis

Qualitative data from individual observation were analyzed for the breeds and sexes separately using SAS (2003). Chi-square test was employed to test for independence between the categorical variables. Owing to the low number of males in each dentition class, quantitative data sets were analyzed for the two sexes (female and intact male) separately fitting breed and dentition and their interaction in the model (models 1). Four dentition classes for females namely 1, 2, 3 and 4 and two dentition classes for male 0-1 and ≥ 2 were used. The General Linear Model (GLM) procedure of SAS (2003) was employed to analyze quantitative variables. Tukey Kramer test was used to separate means of effects with three or more levels which were significant in the least squares analysis of variance (SAS, 2003).

Model used for the least - squares analysis in females and males was:

$$Y_{ijk} = \mu + B_i + D_j + (B \times D)_{ij} + e_{ijk}$$

Where: Y_{ijk} = Observed body weight or linear measurements

μ = Overall mean

B_i = the fixed effect of i th breed (i = Bonga, Horro)

D_j = the fixed effect of jth dentition classes (j = 1PP, 2PPI, 3PPI, 4PPI)

$(B \times D)_{ij}$ = Breed by dentition interaction effect

e_{ijk} = random error

Results and Discussion

Categorical traits

Bonga sheep

The proportion of categorical traits for Bonga sheep is presented in Table 2. The Bonga sheep have a characteristic of fat-tailed which hangs just at the hocks or below the hocks. About 67% of the sampled population had straight and tip down ward tail where as the remaining 33% carry straight and twisted end tail. In both of the sexes, the predominant coat pattern was plain (63.8%) though the proportion of patchy (32.6) is high. The commonest color was brown (46.9%) in both sexes, followed by mixture of brown and white (21.2%). This result is in agreement with the earlier report of Tibbo and Ginbar (2004) that the majority of Bonga sheep had brown coat color. The presence of wattle is low (5.1%) in both sexes. This is in agreement with the work of Tibbo and Ginbar (2004). It was observed that ruff is the feature of male (13.4%) and was absent in females. Both the males and females were devoid of horn. Higher proportions of females were docked (81.1%) whereas none of the males were docked. A picture of representative Bonga ewe and ram are depicted in Fig. 1 and 2, respectively.

Table 2. Summary of the qualitative traits in the female and male Bonga sheep

Character	Attributes	Sex				Total	
		Female		Male			
		No.	%	No.	%	No.	%
Coat colour pattern	Plain	448	63.8	100	63.7	548	63.8
	Patchy	232	33.0	48	30.6	280	32.6
	Spotted	22	3.1	9	5.7	31	3.6
	Overall	702	100.0	157	100.0	859	100.0
Coat color type	White	64	9.1	14	8.9	78	9.1
	Brown	329	46.9	74	47.1	403	46.9
	Black	20	2.8	1	0.6	21	2.4
	Grey	5	0.7	2	1.3	7	0.8
	Creamy white	34	4.8	8	5.1	42	4.9
	White and black with white dominant	11	1.6	7	4.5	18	2.1
	Brown and White with brown dominant	151	21.5	31	19.7	182	21.2
	Brown and White with white dominant	70	10.0	15	9.6	85	9.9
	Black and white with black dominant	18	2.6	5	3.2	23	2.7
	Overall	702	100.0	157	100.0	859	100.0

Character	Attributes	Sex				Total	
		Female		Male			
		No.	%	No.	%	No.	%
Head profile	Straight	557	79.3	35	22.3	592	68.9
	Slightly convex	145	20.7	122	77.7	267	31.1
	Overall	702	100.0	157	100.0	859	100.0
Tail conformation	Straight and tip down ward	91	69.6	43	62.3	134	67.0
	Straight and twisted end	40	30.5	26	37.7	66	33.0
	Overall	131	100	69	100.0	200	100.0
Wattle	Present	41	5.8	3	1.9	44	5.1
	Absent	661	94.2	154	98.1	815	94. 9
	Overall	702	100.0	157	100.0	859	100.0
Ruff	Present	-	-	21	13.4	21	13.4
	Absent	-	-	136	86.6	136	86.6
	Overall	-	-	157	100.0	157	100.0
Ear form	Horizontal	74	10.5	11	7.0	85	9.9
	Semi-pendulous	628	89.5	146	93.0	774	90.1
	Overall	702	100.0	157	100.0	859	100.0

Figure 1. Adult Female Bonga sheep

Figure 2. Adult male Bonga sheep

Horro sheep

The proportion of categorical traits for Bonga sheep is presented in Table 3. Horro sheep is fat-tailed and the tail commonly hangs below the hocks. Straight downward tail and twisted end tail were observed in 69.6% and 30.4% of the sampled populations, respectively. In Horro breed the common coat pattern was plain (87.5%). Brown coat color (56.2%) was predominantly observed followed by creamy white (20.4%). This is in agreement with the earlier report of Galal (1983) and Tibbo *et al*. (2004) that the majority of Horro sheep had brown coat color.

Table 3. Summary of the qualitative traits in the female and male Horro population

Character	Attribute	Sex				Total	
		Female		Male			
		No.	%	No.	%	No.	%
Coat color pattern	Plain	715	87.5	60	87.0	775	87.5
	Patchy	85	10.4	9	13.0	94	10.6
	Spotted	17	2.1	-	-	17	1.9
	Overall	817	100.0	69	100.0	886	100
Coat color type	White	34	4.2	4	5.8	38	4.3
	Brown	454	55.6	44	63.8	498	56.2
	Black	48	5.9	-	-	48	4.4
	Grey	9	1.1	-	-	9	1.0
	Creamy white	168	20.6	13	18.8	181	20.4
	White and black with white dominant	1	0.1	1	1.4	2	0.2
	Brown and White with brown dominant	61	7.5	7	10.1	68	7.7
	Brown and White with white dominant	39	4.8	-	-	39	4.4
	Black and white with black dominant	3	0.4	-	-	3	0.3
	Overall	817	100.0	69	100	886	100.0
Head profile	Straight	803	98.3	18	26.1	821	92.7
	Slightly convex	14	1.7	51	73.9	65	7.3
	Overall	817	100.0	69	100.0	886	100.0
Tail form	Straight and tip down ward	574	70.3	43	62.3	617	69.6
	Straight and twisted end	243	29.7	26	37.7	269	30.4
	Overall	817	100.0	69	100.0	886	100
Wattle	Present	49	6.0	3	4.3	52	5.9
	Absent	768	94.0	66	95.7	834	94.1
	Overall	817	100.0	69	100.0	886	100.0
Ear form	Horizontal	23	2.8	-	-	23	2.6
	Semi-pendulous	794	97.2	69	100.0	863	97.4
	Overall	817	100.0	69	100	886	100
Ruff	Present	-	-	24	34.8	24	34.8
	Absent			45	65.2	45	65.2
	Overall	-	-	69	100.0	69	100.0

However, solid white (4.3%) and solid black (4.4%) colors were rarely observed. The higher proportion of animals with brown coat color could be a reflection of strong selection for animals manifesting brown color. Generally, horn is not the feature of the breed. Wattle was observed only in 5.9% of the cases

(6.0% females and 4.3% of males); ruff was identified only in about 34.8% of the males. Similar proportion (5%) of wattle was reported for the same breed from on-station flock (Tibbo *et al*., 2004). Some of the categorical traits like coat color and tail type observed in both of breeds may appear to have economic importance. The chi-square test of independence of categorical variables in the two breeds sample population indicated that among the variables considered in this study coat pattern, coat color, tail conformation and ear orientation were found to significantly ($P<0.01$) differ between the two breeds. More of the animals in Horro had plain coat pattern, brown coat color, and semi-pendulous ear orientation. A picture of representative Horro ewe and ram are depicted in Fig. 3 and 4, respectively

Figure 3. Adult Female Horro sheep

Figure 4. Adult Male Horro sheep

Live body weight and linear measurements

***Breed effect*:** For female sheep**, t**he results of least squares analysis indicated that breed has a significant effect (P<0.01) on body weight and other body measurements except tail circumference and body condition score (P>0.05) (Tables 4 and 5). Bonga females had significantly higher values for body weight, body length, chest width, pelvic width, and ear length (P<0.01) than Horro female. On the other hand, Horro ewes' had greater values for chest girth, wither height, and tail length (P<0.01). Results for body weight and linear measurements of male sheep revealed that Horro males had significantly larger (P<0.01) chest girth, wither height, chest width, scrotal circumference and body condition score than Bonga males (Tables 6 and 7). Bonga male on the other hand had longer (P<0.01) ear length than Horro male. The disparity on the effect of sex on body measurement might be associated with the fact that most data of the males in Bonga sheep were taken from younger age group and for Horro they

were from advanced age groups. The overall scrotal circumferences for Horro and Bonga males were 27.17±0.48cm and 23.02±0.47cm, respectively. The values obtained for body weight in this study were lower than those reported by Solomon *et al.* (2007). The much lower values in body weight in the present study may be due to difference in pasture availability or animals of different age groups were considered. Body weight in adult females of Bonga sheep is higher than most indigenous sheep breeds (Sisay, 2000; Solomon, 2007). Figures for body length, height at wither and chest girth in females of both breeds observed in this study were higher than those reported for central highland sheep, rift valley and north-western highland sheep (Sisay, 2000) and Gumuz sheep (Solomon, 2007). The value of scrotal circumference for Bonga ram is within the rage of earlier report of Tibbo and Ginbar (2004) which was 22 to 30cm. The observed scrota circumference for Horro male was the same as that reported previously for the breed (Solomon and Thwaites, 1997) which was 27cm. A scrotal circumference is an indirect measure of ram fertility and used to asses breeding soundness of ram and it has high heritability (Söderquist and Hulten, 2006).

Age effect: In females of the two breeds, age was found to strongly influence ($P< 0.01$) live body weight and other linear measurements with exception of ear length, tail circumference, tail length and body condition scores ($P>0.05$). The insignificant difference for these traits doesn't mean there is no growth, rather it implies that there is no much difference for adult animals. Animals in dentition group 3 and 4 had higher values than those of dentition groups 1 and 2. This shows that younger animals (in dentition one and two) were still growing compared to animals at advanced age. Likewise, in males, dentition significantly ($P<0.01$) affected body weight, body length, chest girth; wither height, tail length, and scrotal circumference ($P<0.05$). Nsoso et al. (2004) also reported these trends in Tswana sheep. For body weight, body length, chest girth and wither height in females of both breeds, larger variation was observed between animals in dentition 6 and 7. The lower variation observed between animals in dentition 3 and 4 was due to the attainment of matured body weight at those ages. This is in accordance with the report of Samuel and Salako (2008) who reported a sharp decline in body weight and other traits between age groups 3-4 years and 4-5 years in West African Dwarf goat. The fact that the two breeds reached their highest body weight and linear measurements (BL, CG, and WH) at their oldest age group (4PPI) is explained by physiology, as large sized animals continue to grow until maturity (Mekasha, 2007). This further confirmed that the two breeds under consideration are classified as

large and late maturing. This is in agreement with findings of Mekasha (2007) that large sized indigenous bucks reach maturity at later age as compared to early maturing small sized bucks.

Table 4. Least squares means (LSM) ± standard error (SE) for the effects of breed, dentition and breed by dentition interaction on the live body weight and body measurements in female Bonga and Horro sheep breeds

Effects and level	N	BW	BL	CG	WH	CW
Overall	1487	30.76 ± 0.27	68.28 ± 0.11	73.36 ± 0.13	68.77 ± 0.11	14.15 ± 0.05
C.V		14.35	4.97	5.19	4.69	11.12
R2		0.29	0.19	0.24	0.17	0.08
Breed		**	**	**	**	**
Bonga	688	31.87 ± 0.19	69.16 ± 0.15	72.92 ± 0.17	68.12 ± 0.14	14.52 ± 0.07
Horro	792	27.65 ± 0.21	67.40 ± .164	73.81 ± 0.19	69.43 ± 0.16	13.78 ± 0.08
Age groups		**	**	**	**	**
1PPI	146	26.81 ± 0.37a	66.19 ± 0.29 a	70.62 ± 0.33 a	67.17 ± 0.27 a	13.63 ± 0.13 a
2PPI	247	28.62 ± 0.29 b	67.38 ± 0.22 b	72.31 ± 0.25 b	68.26 ± 0.21 b	13.92 ± 0.10 a
3PPI	259	30.81 ± 0.29 c	68.99 ± 0.22 c	74.35 ± 0.25 c	69.41 ± 0.21 c	14.36 ± 0.10 b
4 PPI	825	32.79 ± 0.16 d	70.56 ± 0.13 d	76.19 ± 0.14 d	70.26 ± 0.12 d	14.68 ± 0.06 c
B × D		Ns	Ns	Ns	**	Ns
Bonga						
1PPI	85	28.69 ± 0.48	67.20 ± 0.37	70.19 ± 0.4	66.82 ± 0.35	14.07 ± 0.17
2PPI	102	31.12 ± 0.42	68.41 ± 0.33	72.20 ± 0.37	68.10 ± 0.31	14.24 ± 0.15
3PPI	169	32.79 ± 0.34	69.63 ± 0.26	73.93 ± 0.29	68.33 ± 0.25	14.79 ± 0.12
4 PPI	325	34.88 ± 0.25	71.40 ± 0.19	75.34 ± 0.22	69.22 ± 0.18	14.97 ± 0.09
Horro						
1PPI	61	24.92 ± 0.57	65.18 ± 0.44	71.03 ± 0.49	67.51± 0.42	13.18 ± 0.20
2PPI	138	26.12 ± 0.57	66.36 ± 0.29	72.43 ± 0.33	68.42 ± 0.28	13.59 ± 0.14
3PPI	90	28.84 ± 0.47	68.37 ± 0.36	74.76 ± 0.41	70.49 ± 0.34	13.93 ± 0.17
4 PPI	503	30.71 ± 0.19	69.71 ± 0.15c	77.03 ± 0.17	71.29 ± 0.15	14.39 ± 0.07

[a,b,c,d] means in the same column with different superscripts within the specified dentition group are significantly different (P<0.05); Ns = Non-significant (P>0.05); ** P < 0.01

Scrotal circumference differed significantly between the age-classes (P<0.05). As age advances scrotal circumference tends to increase. But, to give conclusive information further study is suggested with large sample size. Despite the lower body weight recorded for Horro ewe, body condition score was not significantly (P>0.05) different between females of the two breeds. This showed that in some cases there was no direct relationship between body weight and body condition score. This phenomenon is attributed to the fact that body condition score reflects body lipids more than body weight as the later is affected by gut

contents which vary according to the type and quantity of feed available. This fully agrees with reports of Nsoso *et al*. (2003) and Cisse *et al*. (2002) who indicated that body weight in Tswana goat and in Sahel goats, respectively did not always parallel with body condition scores.

Table 5. Least squares means (LSM) ± standard error (SE) for the effects of breed, dentition and breed by dentition interaction on the live body weight and body measurements in female Bonga and Horro sheep breeds

Effects and level	N	PW	EL	TL	TC	BC
Over all	1487	20.33 ± 0.05	11.55 ± 0.03	33.62 ± 0.21	16.00 ± 0.17	2.48 ± 0.02
C.V		7.32	8.05	11.20	20.00	28.46
R2		0.04	0.01	0.07	0.01	0.03
Breed		**	**	**	Ns	Ns
Bonga	688	20.52 ± 0.06	11.62 ± 0.04	32.07 ± 0.37	15.92 ± 0.30	2.52 ± 0.03
Horro	792	20.15 ± 0.07	11.48 ± 0.05	35.18 ± 0.19	16.08 ± 0.15	2.44 ± 0.03
Age groups		**	Ns	Ns	Ns	Ns
1PPI	146	19.92 ± 0.13 a	11.48 ± 0.08	33.16 ± 0.49	15.99 ± 0.41	2.44 ± 0.06
2PPI	247	20.22 ± 0.09 ab	11.47 ± 0.06	33.60 ± 0.45	15.50 ± 0.37	2.47 ± 0.05
3PPI	259	20.49 ± 0.09 bc	11.63 ± 0.06	33.93 ± 0.41	16.35 ± 0.34	2.52 ± 0.05
4 PPI	825	20.69 ± 0.05 c	11.61 ± 0.03	33.81 ± 0.28	16.16 ± 0.23	2.49 ± 0.03
B × D		Ns	Ns	Ns	Ns	NS
Bonga						
1PPI	85	20.21 ± 0.16	11.59 ± 0.10	31.52 ± 0.85	16.83 ± 0.70	2.38 ± 0.08
2PPI	102	20.43 ± 0.14	11.57 ± 0.09	32.05 ± 0.83	15.14 ± 0.68	2.46 ± 0.07
3PPI	169	20.49 ± 0.12	11.67 ± 0.07	32.40 ± 0.71	16.15 ± 0.59	2.58 ± 0.05
4PPI	325	20.94 ± 0.08	11.64 ± 0.05	32.29 ± 0.53	16.22 ± 0.43	2.65 ± 0.04
Horro						
1PPI	61	19.62 ± 0.19	11.38 ± 0.12	34.79 ± 0.49	15.15 ± 0.41	2.51 ± 0.09
2PPI	138	20.01 ± 0.13	11.38 ± 0.08	35.16 ± 0.33	15.87 ± 0.27	2.49 ± 0.06
3PPI	90	20.51 ± 0.16	11.59 ± 0.09	35.46 ± 0.41	16.56 ± 0.34	2.46 ± 0.07
4 PPI	503	20.45 ± 0.07	11.59 ± 0.04	35.33 ± 0.17	16.10 ± 0.14	2.33 ± 0.03

[a,b,c,d] means on the same column with different superscripts within the specified dentition group are significantly different ($p < 0.05$); Ns = Non-significant ($P>0.05$); ** $P< 0.01$

Table 6. Least squares means (LSM) ± standard error (SE) for the main effect of breeds and dentition and breed by dentition interaction on the live body weight and body measurements in male Bonga and Horro sheep breeds

Effects and level	N	BW	BL	CG	WH	CW	SC
Over all	102	30.68 ± 0.85	68.78 ± 0.65	73.06 ± 0.75	69.09 ± 0.62	14.74 ± 0.25	25.09 ± 0.34
C.V		21.45	7.09	7.72	6.77	12.55	8.37
R2		0.19	0.22	0.35	0.38	0.10	0.53
Breed		Ns	Ns	**	**	**	**
Bonga	74	29.70 ± 0.17	68.27 ± 0.89	70.0 ± 1.03	66.53 ± 0.85	14.07 ± 0.35	23.02 ± 0.47
Horro	28	31.66 ± 1.23	69.30 ± 0.94	76.12 ± 1.08	71.66 ± 0.90	15.42 ± 0.36	27.17 ± 0.48
Age groups		**	**	**	**	Ns	*
1PPI	76	27.83 ± 1.06	66.19 ± 0.81	70.89 ± 0.93	66.96 ± 0.77	14.758 ± 0.31	24.39 ± 0.36
≥ 2PPI	26	33.54 ± 1.33	71.36 ± 1.01	75.23 ± 1.17	71.24 ± 0.97	14.73 ± 0.39	25.80 ± 0.57

Ns = Non-significant (P>0.05); * P < 0.05; ** P< 0.01; BW

Table 7. Least squares means (LSM) ± standard error (SE) for the main effect of breeds and dentition and breed by dentition interaction on the live body weight and body measurements in male Bonga and Horro sheep breeds

Effects and level	N	PW	EL	TC	TL	BCS
Over all	102	19.48 ± 0.32	10.98 ± 0.12	22.15 ± 0.69	36.46 ± 0.68	2.97± 0.10
C.V		12.37	8.20	23.27	13.87	26.56
R2		0.11	0.11	0.11	0.22	0.17
Breed		Ns	**	Ns	Ns	*
Bonga	74	19.03 ± 0.45	11.33 ± 0.17	20.85 ± 0.97	35.40 ± 0.96	2.71 ±0.138
Horro	28	19.92 ± 0.47	10.65 ± 0.18	23.46 ± 0.97	37.52 ± 0.95	3.23 ± 0.15
Age groups		Ns	Ns	Ns	**	Ns
1PPI	76	18.86 ± 0.40	10.95 ± 0.16	21.30 ± 0.83	34.35 ± 0.82	2.82 ± 0.13
>2PPI	26	20.09 ± 0.51	11.03 ± 0.19	23.00 ±1.09	38.58 ± 1.07	3.12 ± 0.16

Ns = Non-significant (P> 0.05); *P < 0.05; ** P<0.01

Conclusion

The two breeds can be classified as large breeds and emphasis should be given for their improvement and conservation since they better thrive and produce where disease and internal parasites are prevalent. To fill the information gap and to explore the genetic potential of Bonga sheep there is a need to undertake performance testing studies under improved management conditions.

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Effect of time of Pregnant Mare Serum Gonadotrophin Administration on Oestrus Synchronization Efficiency and Fertility in Blackhead Ogaden Ewes

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Abstract

A study was conducted on 84 Blackhead Ogaden (BHO) ewes to evaluate the appropriate time of Pregnant Mare Serum Gonadotrophin (PMSG) administration in relation to Medroxyprogesterone acetate (MAP, 60mg) sponge withdrawal on oestrous response and fertility. The treatments include administration of 300IU PMSG at (1) Twenty-four hours prior to MAP sponge withdrawal, (2) at MAP sponge withdrawal or (3) control (without PMSG administration). Regardless of the time of administration, oestrous response and pregnancy rate were higher ($P \leq 0.01$) in PMSG administered than control groups of ewes. Similarly, the time to onset of oestrous was earlier ($P < 0.01$) in PMSG administered than in control groups of ewes. However, there was no significant difference ($P \geq 0.05$) in all parameters between PMSG administered groups of ewes. In conclusion, administration of 300IU PMSG either at 24 hours prior to or at MAP sponge withdrawal is important to attain better synchrony of oestrus and increased pregnancy rate from BHO sheep kept under extensive management conditions of Eastern Ethiopia.

Key words: Blackhead Ogaden; ewe; MAP sponges; oestrous synchronization; PMSG

Introduction

The BHO sheep is found mainly in the eastern and south-eastern lowlands of Ethiopia. This sheep breed is the second largest in number next to camels in the lowland areas of Ethiopia. Meat from this breed of sheep plays a vital role in the local economy of Ethiopia and as a source of foreign currency. Apparently, little effort has been made to improve productive and reproductive performances of this sheep breed despite a great ambition of pastoralists to improve productivity by controlled mating (Girma, 1990). To this end, the owners apply traditional practices to match the lambing season with the availability of water and feed to improve the survival rate of the offspring and to match the

slaughter age of animals with the season of highest market demand. However, the traditional attempt to synchronize lambing season with availability of forage and water is not accurate. Thus, the current productive and reproductive performances of the BHO sheep are far below the owners' and the country's needs (Girma, 1990).

Taking into consideration the importance of this specific sheep breed on one hand and lack of scientific information to support the traditional attempts to synchronise oestrus on the other hand, this study was initiated to assess the response of this sheep breed to controlled-breeding techniques practised in other European sheep breeds. Previous study by Zeleke (2003) indicated that oestrus response of BHO sheep to MAP and Fluorogesterone acetate (FGA, 40mg intravaginal sponge treatments for 14 days period to be 90.2 and 93%, respectively. It has also been stated that the two intravaginal sponge types did not have significant difference in inducing oestrus. However, there is a paucity of information regarding the resultant pregnancy rate following intravaginal sponge treatment and time of PMSG administration in relation to sponge withdrawal. Thus, the synchronization efficiency in terms of inducing oestrus and fertility by using MAP sponge treatment and time of PMSG administration relative to MAP sponge withdrawal were evaluated in this experiment.

Materials and methods

Study site

The experiment was conducted at Haramaya University, which is situated 25km from the town of Harar and 42km from Dire-Dawa, Ethiopia. The site is located $9^0$24"N latitude, $41^0$5"E longitude, and at an altitude of 1980m above sea level. The annual total rainfall and the mean maximum and minimum temperatures of the area are 870mm, 22.9^{0}C and 7.8^{0}C, respectively (Heluf, 1982).

Experimental animals and their management

One hundred and twenty ewes (2 - 2.5 years and 15 – 26 kg body weight) were purchased from pastoralists. All animals were drenched with a broad-spectrum anti-helminthes, dipped with a standard acaricide solution for external parasites and were vaccinated against pasteurollosis and anthrax. All sheep were provided with fresh clean water throughout the experimental period and allowed to graze on natural pastures for about 8 hours a day (8:00 h - 12:00 h in the morning and 14:00 h - 18:00 h in the afternoon). At the end of the ad-

aptation period, 84 non-pregnant ewes weighing between 20 and 26 kg were selected and treated with intravaginal MAP Sponges (60 mg; Upjohn) for 14 days.

PMSG treatment

At the end of the MAP sponge treatment period, ewes were randomly allotted to groups of 29, 27 and 28 animals, respectively. The 1st and the 2nd groups were treated with 300IU PMSG at MAP sponge withdrawal and 24h prior to sponge withdrawal, respectively, whereas the 3rd group was kept as a control (administered with sterile physiological solution, i.e. 0.9% NaCl Solution).

Oestrus observation

The signs of oestrus were observed at 8-hourly intervals following MAP sponge withdrawal for a period of 96 hours. Intact rams fitted with aprons were used for heat detection. The ewes were kept in their respective groups, and each group was observed trice daily for a period of 30-minutes. Between 13 and 28 days after AI, all ewes were monitored twice daily for return to oestrus.

AI procedures

Semen was collected from healthy rams with the aid of the artificial vagina. Following each semen collection and prior to its use for artificial insemination, the viability of the sperm was microscopically evaluated according to standard procedures (Watson, 1990). Fresh semen was diluted at a ratio of 1:2 with sterile skimmed cow milk. Cervical insemination with 0.1ml diluted semen (150 x 10^6 sperm/insemination) at 53-55 hours following MAP sponge withdrawal was performed.

Statistical analysis

The general linear model (GLM) procedures of SAS were used to run analysis of variance test for the effect of time of PMSG administration on the time to onset of oestrus and the duration of the induced oestrus. The categorical modeling (CATMOD) procedures of SAS were used to test the effect of duration of progestagen treatment and time of PMSG administration on pregnancy rate and oestrous response. The treatment means were compared by Duncan's multiple range test (DMRT) as described in Gomez and Gomez (1984).

Results

The effects of time of PMSG administration relative to MAP sponge withdrawal on oestrus response is indicated in Table 1. The response to oestrus was significantly higher (P<0.01) in PMSG treated than in controlled ewes.

Table 1. Effect of time of PMSG administration in relation to Medroxyprogesterone sponge withdrawal on oestrous response in Blackhead Ogaden ewes

Time of PMSG administration	n	Oestrous response (%)
24 hours prior to MAP sponge withdrawal	29	29(100.0a)
At MAP sponge withdrawal	27	27(100.0a)
Control (without PMSG administration)	28	21 (75.0b)
Overall	84	77 (91.7)

[a, b] Values in a column with different superscripts differ significantly (P<0.01)
n number of ewes

The duration of the induced oestrus was not significantly affected by the time of PMSG administration relative to MAP sponge withdrawal. The interval from MAP sponge withdrawal to the onset of oestrus was, however, significantly longer (P<0.01) in control ewes, compared to those treated with PMSG at 24 hours prior to MAP sponge withdrawal or at sponge withdrawal (Table 2).

Table 2. Effect of time of PMSG administration on time to onset and the duration of induced oestrus in Blackhead Ogaden ewes

Time of PMSG administration	n	Time to onset of oestrus (h)	Duration of Oestrus (h)
24 hours prior to MAP sponge withdrawal	29	32.1^{b}± 2.4	45.6±2.7
At MAP sponge withdrawal	27	38.2^{b} ± 2.5	46.6±2.8
Control (without PMSG administration)	21	48.8^{a}±2.9	42.8±3.2

[a, b] Means in a column with different superscripts differ significantly (P<0.01)
n number of ewes

Pregnancy rate was significantly lower (P<0.01) in control ewes, compared to ewes given PMSG administration regardless of the time of administration (Table 3). Furthermore, PMSG administration at the time of MAP sponge withdrawal resulted in a significantly higher (P<0.05) pregnancy rate, compared to the administration of PMSG at 24 hours prior to sponge withdrawal. Similarly, the non-return rate was significantly lower (P<0.05) in control ewes, compared to ewes administered PMSG at 24 hours prior to sponge withdrawal or at MAP sponge withdrawal. There was, however, no significant difference in the non-return rate between ewes administered with PMSG at MAP sponge

withdrawal and those administered at 24h prior to MAP sponge withdrawal. In all cases, the values obtained for the non-return rates were higher than those for pregnancy rates (63.1% vs. 73.8%).

Table 3. Reproductive performance following oestrous synchronisation and artificial insemination in Blackhead Ogaden ewes

Time of PMSG administration	n	Pregnancy rate (%)	Non-return rate (%)
24 hours prior to MAP sponge withdrawal	29	20 (69.0[a])	24 (82.8[a])
At MAP sponge withdrawal	27	20 (74.1[a])	22(81.5[a])
Control (without PMSG)	28	13 (46.4[b])	16(57.1[b])
Overall	84	53 (63.1)	62(73.8)

[a, b] Means in a column with different superscripts differ significantly (P<0.05)
n number of ewes

Discussion

In the present experiment, only seven out of 84 ewes failed to exhibit overt signs of oestrus. Three of these seven animals had lost their MAP sponges at one stage of the treatment period although these were immediately replaced. The oestrous response value obtained in this experiment is comparable to the values reported in the literature (Greyling and Brink, 1987; Crosby *et al*., 1991; Greyling *et al*., 1997; Rosado *et al*., 1998; Zarakawi *et al*., 1999). This implies that BHO ewes maintained under traditional management conditions also respond to MAP sponge treatment.

Attainment of significantly higher (P<0.01) oestrous response in PMSG administered ewes, regardless of the time of application, compared to the control (Table 1) in this experiment is in agreement with Knight *et al*. (1992), Artingsih *et al*. (1996), Cordova *et al*. (1999) and Cline (2001) who reported a low dose of PMSG administration results in compact and predictable oestrus in ewes treated with MAP sponges.

The time of PMSG administration relative to MAP withdrawal did not significantly influence oestrous response. This disagrees with the previous results of Zhang and Yuan (1988) who reported oestrous synchronization rate to be 100% in does treated with PMSG 48h prior to MAP withdrawal, compared to does treated with the same amount of PMSG but at sponge removal (66.7%). Probably, the gap between 24 hours prior to MAP withdraws and at sponge withdrawal may be too short to affect oestrous response in the present experiment.

Several factors may influence the extent of the interval between the removal of MAP sponge and the onset of induced oestrus. Generally, oestrus starts at about 36 hours after MAP withdrawal, although some ewes may be in oestrus as early as 24 hours or as late as 48 hours (Gordon, 1997). The overall mean time interval between intravaginal progestagen sponge withdrawal to the onset of oestrus in the present trial (Table 2) is in agreement with Gordon (1997) and Vancleef *et al.* (1998) who reported the time to oestrus to be 36h in ewes. The current result is also fairly comparable to the findings of Greyling *et al.* (1997) in MAP (60mg) synchronized Merino ewes during the natural breeding season (30.5 hours). However, the interval observed in this study was shorter compared to the values obtained by Greyling and Brink (1987) in MAP treated Karakul ewes (62.5±18.7h). This discrepancy in the time of oestrous onset may be due to breed, nutritional and/or seasonal differences.

The significantly shorter ($P<0.01$) interval from MAP withdrawal to the onset of oestrus in ewes administered 300IU PMSG compared to control (Table 2) is in line with the available literature (Zhang and Yuan, 1988; Eppleston, 1991; Knight *et al.*, 1992; Artingsih *et al.*, 1996), who reported the use of PMSG in combination with progestagen sponges to shorten the time from sponge withdrawal to the onset of oestrus. The shortening of the onset of oestrus in PMSG treated ewes may be due to the hastening effect of PMSG on follicular maturation.

The main focus of controlled reproduction is to obtain optimum fertility rate at prescribed time. Although the average lambing rate recorded in this experiment (Table 3) could not be considered as optimum, it would encourage further study as controlled breeding techniques like artificial insemination and oestrous synchronization have never been tried before in BHO sheep in Ethiopia. In fact, the lambing rate recorded in the present study agreed with the values of Greyling *et al.* (1988) and Hill *et al.* (1998) who reported the mean pregnancy rate following MAP treatment and AI in Merino ewes to be 63.5% and 64.6%, respectively.

The difference between the pregnancy rate and the non-return rate was very big (63.1% vs. 73.8%), probably due to the occurrence of embryonic resorption and/or occurrence of silent heat in some of the experimental animals.

In the present experiment achievement of significantly higher ($P<0.05$) fertility rates (pregnancy and non-return rates) from ewes administered with PMSG, compared to control indicates the importance of PMSG administration

in improving pregnancy rate from oestrous synchronized BHO ewes. The higher fertility rate achieved in PMSG administered groups is in line with many previous works **(**Zhang and Yuan, 1988; Eppleston *et al*., 1991; Knight *et al*., 1992; Artingsih *et al*., 1996; Cordova *et al*., 1999; Cline, 2001). The result of the present experiment, however contradicts the reports of Romano *et al*. (1996), who recorded similar fertility rates between ewes administered 250IU PMSG or no PMSG. Perhaps, 250IU PMSG administered in their study might have been below the threshold level to significantly affect fertility rate. Unlike the previous reports of Zhang and Yuan (1988) who indicated an increase in fertility when PMSG is administered 24 hours prior to pessary removal, compared to PMSG administration at sponge withdrawal, there were no significant differences in fertility rates between the two groups in the current trial. However, the results of the present trial are in agreement with Eppleston *et al*. (1991), who stated that the time of PMSG administration relative to progestagen withdrawal could not improve fertility, except shortening the time of ovulation.

In conclusion, administration of 300IU PMSG either at 24 hours prior to, or at progestagen sponge withdrawal has paramount importance in attaining better synchrony of oestrus and increased lambing rate from BHO sheep kept under traditional management conditions in Eastern Ethiopia.

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Effects of Energy and Bypass Protein Supplementation on Feed Intake, Milk Yield and Composition of Crossbred Lactating Goats

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Abstract

Thirty crossbred lactating goats were assigned according to randomized complete block design in to five groups of six animals each to study the feed intake, milk production and composition for a period of 180 days. All groups received iso-nitrogenious (18% CP) concentrate, but varied energy densities. Groups I was used as a control being fed about 720 g/d/animal of DM from concentrate to provide medium energy. Lactating goats in group II were provided similar feed to the control but varied by formaldehyde treatment of the protein concentrate. Group III were fed with 20 % higher, whereas groups IV and V were given 20% lower amount of concentrate than the control. However, the mustard cake for group V was protected with formaldehyde. Average daily milk yield of group III (1.37±0.06) was significantly higher ($P<0.05$) than those of groups I (1.20±0.05), IV (1.19±0.06), and V (1.18±0.06). Milk yield (1.26±0.05) in group II was similar ($P>0.05$) to other treatment groups. Fat corrected milk (FCM) yield and milk composition (fat, SNF, protein and formalin) were similar ($P>0.05$) among all the groups. The high and medium energy groups consumed significantly ($P<0.01$) higher dry matter (10%) as compared to the two low energy fed groups. However, there was no variation ($P>0.05$) in nutrient intake as percent of body weight, gross energy of lactation and net return from sale of milk among treatment groups indicating proportional consumption of nutrient to their performance. In conclusion, provision of higher energy than the control improved the milk yield by 15% per animal compared to animals fed on lower energy levels. However, they had higher nutrient intake leading to higher production cost, so that future work is suggested using large herd size to confirm the small variations obtained under this trial.

Keywords: bypass protein; energy; feed intake; goat; milk yield

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Introduction

The contribution and population of goat is immensely increasing world wide, especially in developing countries (Devendra, 2001; Olivier *et al*., 2005). These countries, however, face feed inadequacy with respect to quantity and quality (Adugna *et al*., 2000; Walli, 2005). Poor nutrition results in low production and reproductive performance, loss of body condition and increased susceptibility to diseases and parasites (Osuji *et al*., 1993).

Feeding strategies like supplementation of energy and/ or rumen bypass protein were suggested as a solution for improved ruminant animal productivity (Chatterjee and Walli, 2003; Walli, 2005). However, feed supplementation especially of protein concentrates incurs much cost and could be wasted during rumen degradation system. For this reason, several recommendations were suggested in facilitating proper utilization of highly degradable proteins through protection of their rumen degradability (Sampth *et al.*, 1997; Sahoo and Walli, 2007). Moreover, Formaldehyde treatment (at 1.2 g/100 g CP) of mustard cake improved the rumen undegradable protein resulting in significant increase in milk production of cows (Morgan, 1985) and goats (Sahoo and Walli, 2005). Moreover, the feeding of goats at higher plane of energy improved the efficiency of feed utilization and milk production (Srivastava *et al*., 1994), optimizing growth and reproductive performance of female sheep under grazing condition (Hossain *et al*., 2003).

Formaldehyde treatment is not only effective in protecting protein degradation in the rumen, but is also cheap and required in small doses (Walli, 2005). Hence, it can be applied in developing countries like Ethiopia to improve the nutrient utilization from local oil feeds like noug seed cake. Sahoo and Walli (2005) reported net return per lactating goat per day was Rupees† (Rs) 7.30 in groups fed on formaldehyde treated mustard cake compared to Rs 4.8 in the control. There are also reports on non significant influence of supplementing bypass protein to various groups of lactating animals (Clark et al., 1975; Small and Gordon, 1990), which implies further verification of such controversies.

The effects of various levels of energy and the use of bypass protein technology have been studied independently to increase the productivity of animals. However, information is lacking on relative comparison of feeding bypass protein at different energy densities on performance of lactating goats. Therefore, the objectives of this study was to investigate the effect of varying levels of

† 1 Ethiopian Birr= 5 Indian Rupees (in 2005)

energy and bypass protein on feed conversion efficiency, economic efficiency, milk yield and composition of crossbred lactating goats.

Materials and methods

Study site

The study was carried out at National Dairy Research Institute, Karnal (India) for a period of 180 days. National Dairy Research Institute, Karnal is situated in eastern zone of Haryana state at an altitude of 250 m above sea level on 29.42°N latitude and 79.54°E longitude. The minimum ambient temperature falls to near freezing point in winter and maximum goes approximately up to 45 °C in May / June months of summer. The annual rainfall is close to 700 mm, most of which is received from July to September (Prasad, 1994).

Experimental Design

Thirty Alpine-Beetal crossbred lactating goats were divided into five, having six animals in each following a completely randomized design (Gomez and Gomez, 1984), to study the influence of varying levels of energy and bypass protein on feed intake and production performances. The lactating goats were weighed using weighing scale with precision of 0.01 for seven days. Then six goats with average of 37.33±1.57 kg body weight and 1.36±0.05 kg/day were randomly allotted to the five treatment groups (Table 1). Care was taken to avoid variation in age and parity of the animals.

A concentrate mixture comprising maize grain, wheat bran, mustard cake, mineral mix and common salt was used for all treatments but with varied proportion (Table 1). All groups received concentrate mix made iso-nitrogenious (18% CP), but varied in energy densities. Groups I was used as a control being fed about 720 g/d/animal of DM from concentrate to provide medium energy adjusted per NRC (1981). Lactating goats in group II were provided similar feed to the control but varied by formaldehyde treatment of the protein concentrate (mustard cake). Group III were fed with 20% higher, whereas groups IV and V were given 20% lower TDN than the control and protecting the protein in group V. All animals were provided the concentrate at two installments per day (every morning at 9:00 AM and afternoon at 1:00 PM). Green fodder was provided *ad lib* from Berseem (*Trifolium alexandrium*). The ration was changed every two weeks depending on change in body weight, milk yield as well as feed dry matter. Mustard cake in the concentrate provided to groups II and V was treated with 1.2% formalin (40% formaldehyde) equivalent to 1.2 g

of formaldehyde per 100 g CP of cake in accordance with Chatterjee and Walli (2003).

Table 1. Chemical composition (%) and level of ingredients offered for the different groups

Feed*	Chemical composition (%)						Average amount offered (g/d/animal)		TDN contribution (from both fodder and concentrate)	
	Ash	OM	CP	EE	CF	NFE	concentrate	fodder	(g/d/animal)	% of NRC
Maize fodder	9.40	90.60	8.50	1.78	27.10	29.72				
Berseem	6.80	93.20	14.63	30.40	31.20	2.65				
Concentrate *										
I	10.20	89.80	19.62	3.56	10.20	53.22	800	5537.03	576	100
II	11.42	88.58	19.42	3.78	13.47	49.34	800	5537.03	576	100
III	10.00	90.00	19.85	1.76	10.60	61.22	930	5537.03	692.75	120
IV	11.00	89.00	19.13	3.21	11.57	55.67	666.67	5277.78	460	80
V	8.80	91.20	19.64	2.96	8.60	58.07	666.67	5277.78	460	80

* Concentrates I, II, III, IV and V refer to the concentrates ration formulated for the respective groups

Feed intake was daily recorded from weighed quantity of feed offered and refusal per individual. The costs per quintal of feed as well as daily labour cost per animal per day were included to estimate total operational cost of milk production. The fixed costs were not used in the economic analysis since the farm is already well established and makes similar impact for all the groups. The daily average nutrient intakes of the animals and the relative feed conversion efficiency into milk were used to determine the feed utilization and economic efficiencies.

Milk yield of individual doe was recorded each day from pooled weights of the morning and evening milk production. However, the daily record of milk yield was pooled to obtain the weekly milk yield of individual goats for statistical comparison. Samples of morning and evening milk were collected every two weeks for the analysis of the chemical compositions. Each time 100 ml of milk sample was collected in clean plastic bottle after uniform mixing of total milk in bucket. Representative amount from each sample was used for estimation of fat, Solids non-fat (SNF), and protein (AOAC, 1995) and formalin content as per Bansal and Singhal (1990).

Statistical Analysis

The data on periodic effects of the treatment on feed intake, milk yield & composition and efficiency parameters were analyzed using Analysis of Variance (ANOVA) with Generalized Linear Model procedure of SYSTAT (SPSS, 1996). Means were separated using Tukey's HSD multiple comparison technique whenever ANOVA showed significant variation.

Results and Discussions

Feed utilization and economic efficiencies

The results for nutrient intake of lactating goats showed statistically significant (P<0.01) variation among the groups (Table 2). The high and medium energy groups had significantly (P<0.01) higher total dry matter, TDN and crude protein intakes as compared to the two low energy groups, regardless of the bypass protein. Moreover, lowering the energy level by 20% than NRC with or without bypass protein resulted in 10% reduction of dry matter intake than the medium and high energy groups. Therefore, variation in intake was attributed to energy level in the diet rather than protection of proteins.

Table 2. Least squares means ± SE for feed utilization and economics of the experimental feeds given to lactating goats

Intake	I	II	III	IV	V
DMI-g/d**	1471.25a±33.97	1482.17a±33.97	1545.65a±33.97	1367.27b±33.97	1352.33c±33.97
TDN Intake (g/d)**	966.65 a±18.52	973.20a±18.52	1027.28a±18.52	889.91 b±18.52	885.59 b±18.52
CP intake (g/d)**	238.08 a±5.90	239.76 a±5.90	249.73 a±5.90	227.83 b±5.90	226.46 b±5.90
DMI (kg/100kg W)	3.99±0.13	3.81±0.13	4.21±0.13	3.72±0.13	3.72±0.13
DMI (g/kg BW0.75)	98.44 ±4.44	95.13±4.44	95.91 ±4.44	92.01±4.44	91.38±4.44
Gross Energy of Lactation (%GEL)	22.94±1.36	23.57±1.36	25.53±1.36	25.53±1.36	26.03±1.36
Milk Yield (kg)/kg DMI*	0.78 b±0.01	0.81ab±0.01	0.85 a±0.01	0.83ab±0.01	0.85a±0.01
Total feed cost (Rs/d)**	5.10 c±0.01	5.65 b±0.01	5.91 a±0.01	4.60 d±0.01	5.07 c±0.01
Labour cost (Rs/d)	1.50±0.00	1.50±0.00	1.50±0.00	1.50±0.00	1.50±0.00
Overall cost (Rs/d)**	6.60 c±0.01	7.15 b±0.01	7.41 a±0.01	6.10 d±0.01	6.57 c±0.01
Gross income (Rs/d) from milk @10/kg*	11.63ab±0.47	12.39ab±0.47	13.29a±0.47	11.44b±0.47	11.45ab±0.47
Net return (Rs/d/animal)	4.99±0.49	5.09±0.49	5.86±0.49	5.21±0.49	4.68±0.49

*Means in a row having different superscript are statistically different.; * P<0.05, ** P<0.01*

Earlier works by Clark *et al.* (1975) did not find significant variation in dry matter intake between sheep provided formaldehyde treated and untreated

feed. However, Crawford and Hoover (1984) reported increased dry matter intake by lactating cows fed formaldehyde treated soybean meal. Similarly, Sahoo and Walli (2005) found that formaldehyde protected proteins resulted in increased dry matter and TDN intakes by lactating goats. Singh *et al.* (1986) reported increased dry matter and TDN intakes with increase in energy level to lactating goats. Similar report was given by Liu *et al.* (2005), where higher energy level improved dry matter intake of sheep. However, Hossain *et al.* (2003) didn't find any variation in dry matter and crude protein intake of grazing sheep by provision of additional energy density.

The trend in weekly nutrient intake of lactating goats (Fig. 1) showed a gradual increase up to the tenth fortnight and then declined thereafter perhaps due to change in climate, nature of feed and production level.

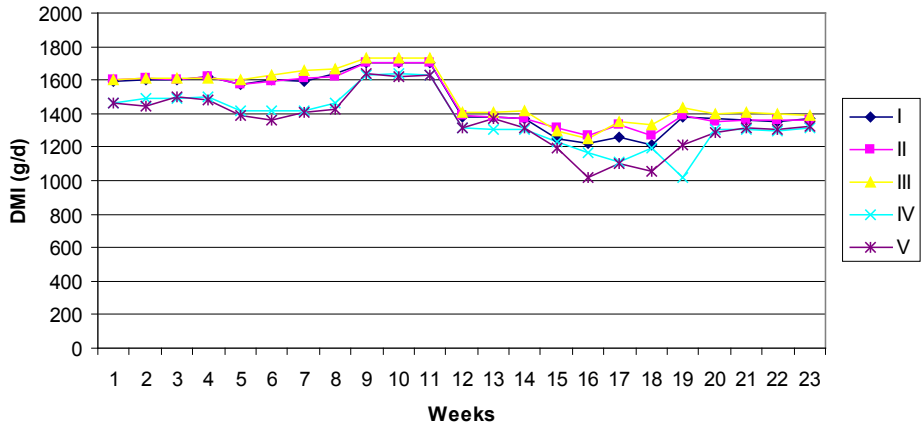

Figure 1: Weekly Dry matter intake (kg) of lactating goats

The feed conversion efficiency in terms of kg milk yield per kg dry matter intake showed significant variation ($P<0.05$). Groups III and V had higher milk yield (kg) per kg dry matter intake than all the rest (Table 2). While the better efficiency by group III could be due to increased milk yield; the lower feed intake in relation to milk production by group V compared to group I could be explained for the difference in their efficiency. On the other hand, the variation in gross energy of lactation among the groups was statistically non-significant ($P>0.05$) because the amount of energy (TDN) utilized was proportional to the level of milk/FCM produced in each group.

In agreement with the present study, Srivastava *et al.* (1994) reported feeding goats at higher plane of energy resulted in increased efficiency of feed utilization and production of milk. Such an increase did reflect that with higher levels of energy in the ration, more of it was available as a precursor of milk in the mammary gland. However, Karanjkar *et al.* (1993) indicated that the Sannen x Osmanabadi (F_1) goats couldn't utilize higher levels of TDN (120 or 140%) more efficiently for milk production. The same study suggested that the lower gross energy efficiency observed was attributed to lower milk yield by the goats, especially during the last weeks of lactation.

Due to differences in dry matter intake, the feed cost in rupees (Rs/d) was higher for the high energy group (III) followed by groups II, I and V in that order and the lowest cost was shown by group IV (Table 2). The variation in cost within the two medium energy as well as two low energy groups was due to cost of formaldehyde treatment rather than feed intake. The gross income (Rs/d) was higher for group III as compared to IV ($P<0.05$) due to better milk yield, while there was no significant variation among the rest of the treatment groups. When net return was considered, there was no variation ($P>0.05$) among the groups due the fact that group III which had better milk yield and sale, also had higher cost for the higher DMI than IV. However, some of these variations in net return could be crucial for a farm with large herd size so that the higher return from group III relative to the others could be considered. Hence, it is suggested that future study would be geared to large herd size, different species of lactating animals and varied production level to verify the economic benefits.

Little information is available to support economics of feeding bypass protein to lactating animals. Sahoo and Walli (2005) reported net return per lactating goat per day at Rs 7.30 in formaldehyde treated group compared to Rs 4.8 in the control. Garg *et al.* (2003) and Garg *et al.* (2005) also found formaldehyde treated bypass protein was economical for milk animals (local cows, crossbred cows and buffaloes) producing 5 to 8 liters of milk per day under farm condition. Similarly, Walli *et al.* (2004) found that the feed cost was reduced by Rs 0.60/day in lactating crossbred animals fed formaldehyde treated cake.

Milk yield and composition

The least squares means and standard errors for milk yield and composition of lactating goats is presented in Table 3. The results indicated that the groups significantly ($P<0.05$) varied in milk yield. Group III had significantly ($P<0.05$) higher milk yield (by about 15% per animal) than all the other groups, except group II. However, there was no variation ($P>0.05$) in fat corrected milk (FCM) and, all milk constituents studied. Though milk yield was variable, the statistically similar values obtained for the fat composition in this trial diluted the variation in FCM yield of the lactating goats.

The weekly milk yield (kg/d) in Fig 2 showed a similar and steady increase for all groups up to the 8th week and slowly declining there after, which is a typical lactation curve. The decline in milk yield could also be attributed to changes in climate (commencement of summer season at the end of April) leading to slight reduction in weekly dry matter intake (Fig 1).

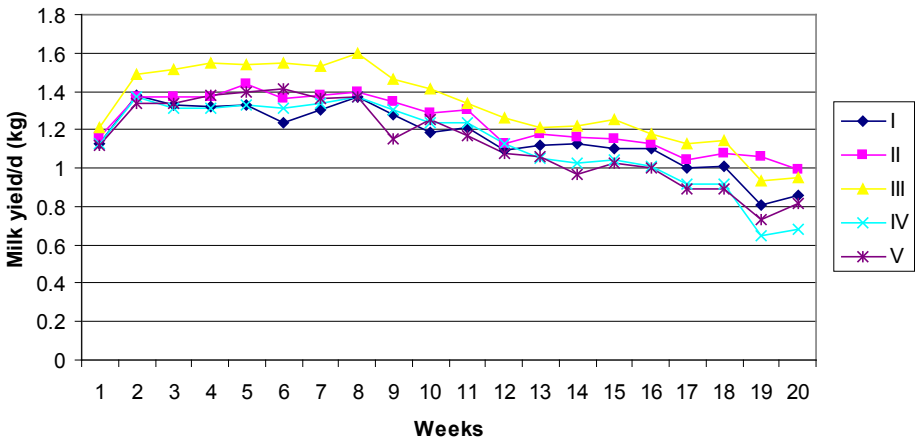

Figure 2: Weekly milk yield of lactating goats

Reports on the effect of formaldehyde treated cakes on milk production of lactating animals have shown variable effects, which may be due to several factors apart from the optimum level used for the treatment. Feeding of formaldehyde treated soyabean meal to cows had no significant effect on milk yield or milk protein synthesis at 0.9% (Clark *et al.*, 1975) and on milk yield of cows (Small and Gordon, 1990). Feeding of crossbred dairy cattle at 30% lower level of energy and/or protein than recommended was also found to be more eco-

nomical, without influencing efficiency of milk production and its composition (Ashok and Singh, 1997).

However, positive result in milk yield was reported upon formaldehyde treatment of the oil seed cake fed to cows (Morgan, 1985; Kim *et al.,* 1992), buffaloes (Chatterjee and Walli, 1998) and goats (Sahoo and Walli, 2005). Sampath *et al.* (1997) reported higher FCM yield on lactating crossbred cows fed formaldehyde treated groundnut cake (9.4 kg/d) than the control group (7.8 kg/d). Walli et al. (2004) reported that the feeding of formaldehyde treated rape seed meal showed 15.13% increase in milk yield in crossbred cows over the untreated groups (from 18.9 kg/d to 10.35 kg/d).

Similarly, the positive influence of energy supplementation on milk yield has been reported in cows (Prasad, 1994) and lactating goats (Singh *et al.*, 1986; Srivastava *et al.*, 1994). Higher energy level improves the availability of nutrients for the mammary glands during milk synthesis.

Reports on the influence of energy level and/ or bypass protein supplementation on milk composition are also variable. Most of the researchers (Hadjipanayiotou, 1992; Sahoo and Walli, 2005) however, didn't report any variation in milk fat and protein while Crawford and Hoover (1984), Morgan (1985), Garg *et al.* (2003) reported increased fat content of milk due to supplementation of energy and/or bypass protein.

Lack of significant variation in milk formalin residue and its relatively lower concentration than the limits given by Liteplo *et al.* (2002) was another encouraging factor to be noted for those who are on the virtue of expanding the use of bypass technology in high and medium yielding dairy animals. According to Liteplo *et al.* (2002) for the general population, dermal exposure to concentrations of formaldehyde, in solution, in the vicinity of 1–2% (10 000–20 000 mg/liter) is likely to cause skin irritation; however, in hypersensitive individuals, contact dermatitis can occur following exposure to formaldehyde at concentrations as low as 0.003% (30 mg/liter). Therefore, the range of milk formalin detected during this study (Table 3) is below the minimum risk level set for hypersensitive individuals. Moreover, study made by Mills *et al.* (1972) using C^{14} labeled formaldehyde, has shown that the chemical gets metabolized in the body of the animal especially liver to non-toxic forms, mainly carbon-dioxide and methane by the enzyme alcohol dehydrogenase. No detectable formalin was also recovered in milks of animals fed formaldehyde treated mustard cake

and even the plasma urea concentration of the treated group was lower than animals fed on non treated feeds (Sahoo and Walli, 2005).

Table 3. Least squares means ± SE for milk yield and composition for lactating goats

Parameter	I	II	III	IV	V
Milk yield (kg/d)*	1.20 b±0.05	1.26ab±0.05	1.37 a±0.06	1.19b±0.06	1.18b±0.06
FCM (kg/d)	1.31±0.07	1.37±0.07	1.50±0.07	1.32±0.07	1.32±0.07
Fat (%)	4.20±0.06	4.20±0.06	4.19±0.06	4.19±0.06	4.25±0.06
Solids non-fat (%)	8.26±0.02	8.28±0.02	8.31±0.02	8.28±0.02	8.32±0.02
Protein (%)	3.50±0.11	3.68±0.11	3.64±0.11	3.513±0.11	3.37±0.11
Formalin (µg/ml)	1.43±0.35	1.14±0.35	1.19±0.35	1.29±0.35	1.22±0.35

* Means in a row having different superscript are statistically different at P<0.05

Conclusions

Energy densities at NRC recommendation as well as 20% higher concentrate supplementation than the control improved the nutrient intake and milk yield (15% per animal) but with higher production cost than the two low energy groups, regardless of bypass protein. The feed conversion in terms of milk yield per unit dry matter intake was improved either by provision of higher energy or bypass protein at low energy, while economic efficiencies didn't show conclusive trend to favor the levels of energy and/or bypass protein. Therefore, future works should be geared towards large herd size to confirm the results of small differences in return obtained under this trial regarding supplementation of energy concentrates and/or bypass protein.

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A survey on the occurrence of anthelmintic resistance in nematodes of sheep and goats found in different agro-ecologies in Ethiopia

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Abstract

A survey was conducted on the occurrence of anthelmintic resistance in nematodes of communally grazed sheep and goats belonging to 17 small-holder peasant farmers and to two institutional farms found in different agro-ecologies. The efficacies of albendazole and levamisole were tested by fecal egg count reduction (FECR) tests. Resistance was seen in three out of the 22 flocks belonging to smallholders and was suspected on one farm. The percentage reductions were 67%, 77%, 85%, and 92% with the 95 % confidence intervals below 86%. On Debre-Birhan and Hawasa University farms, the level of resistance to albendazole and levamisole were in a range of 45% to 65%. Resistance was suspected in a flock of sheep on one smallholder farm, where a percentage reduction of 94% and 95% was observed with the lower 95% confidence interval less than 90%. Post-treatment fecal cultures indicated that *Haemonchus* was the resistant nematode to both anthelmintics. This survey indicates that anthelmintic resistance to nematode parasites is developing gradually. Appropriate measures need to be implemented without delay.

Keywords: Anthelmintic resistance, FECR, farms, goats, nematodes, sheep.

Introduction

Resistance is an inevitable consequence of the use of anthelmintics, and the history of parasite resistance to anthelmintics started with the first report on phenothiazine resistance in sheep in the USA by Drudge *et al*. (1957). After five decades, the problem has become an important limiting factor in the control of nematode parasites of ruminants. The geography of resistance is widening and numerous instances of anthelmintic resistance in Africa have been reported, e.g. in Cameroon (Ndamukong and Sewell 1992), Kenya (Maingi *et al*., 1996), Tanzania (Ngomuo *et al*., 1990), Zimbabwe (Boersema and Pandey 1997), and Mozambique (Atanasio *et al*. 2002). In South Africa, anthelmintic resistance has become a major problem with 90% of farms harbor resistant helminth strains (van Wyk *et al*. 1997a, b).

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Ethiopia is among the few countries in Africa where anthelmintic resistance was not reported (Anonymous, 2004). Because of among other reasons, the frequent and continuous use of same class of anthelmintic and inappropriate dosage rates it was unlikely that resistance could not occur. In the absence of other alternatives, worm control continues to rely on anthelmintics because of their high performance and, their use is likely to continue in the foreseeable future as the first and foremost line of defense against parasites (Martin, 1985). This study aims to investigate the occurrence of resistance to anthelmintics in selected areas in Ethiopia, by using the fecal egg count reduction test.

Materials and Methods

Study areas

East and North Shewa zones located in the regional States of Oromia and Amhara respectively were identified as the study areas. East Shewa is situated in the Great Rift Valley where the altitude is between 1200-1700 meters above sea level. The Great Rift Valley extends its vast escarpments, cliffs, rivers and plains from the red sea southward through Ethiopia, Kenya, Tanzania, and Malawi to end into the Zambezi river in Mozambique. The valley is some 50-60 Km wide. Several large lakes occur along the study areas. North Shewa is in the highland area where the altitude is more than 2000 meter above sea level (Fig. 1).

In East Shewa the climate is hot and dry with unpredictable rains that vary from year to year. The annual rainfall averages 600 mm and the mean annual temperature is about 26°C. Relative humidity is between 50-80%. Daily minimum and maximum atmospheric temperatures, relative humidity and rainfall data were collected at Metehara Sugar Factory Research Center, Adamitulu Agricultural Research Center and the National Meteorological Services Agency.

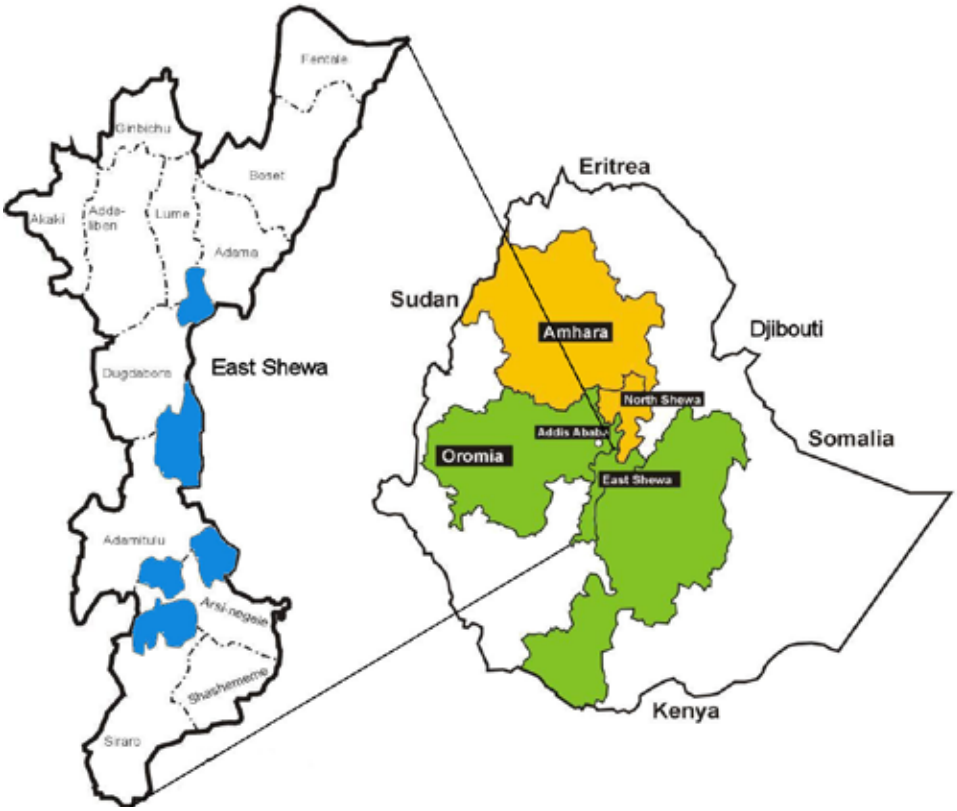

Figure 1. Map of East Shewa showing sub-districts where the study sites located. North Shewa is not expanded as only one sub-district was studied.

The climate in north Shewa is characterized by a long, cool rainy season (June-September) that accounts for 75% of the annual rainfall, a short, rainy warm season (February-May) and a dry, cold season (October-January). The annual rainfall averages 960 mm and the mean maximum temperature ranges from 14-23°C and the mean minimum from 7-18°C. The climate data for north Shewa was obtained from the National meteorological services agency.

A systematic sampling procedure was followed to select the study sites. Firstly, a list of all accessible districts found in both zones was prepared. The districts were selected from this list. Similarly a list of peasant farmer's villages that met certain criteria, such as accessibility by vehicle all year round, availability of veterinary clinics, animal health representatives from the local Peasant As-

sociation, farmers' villages where questionnaire survey on the management of worms took place, willingness of peasant farmers to participate in the current study, the availability of more than 15 sheep or goats on the farm with a nematode egg count of more than 500 per gram of feces, and the assurance that animals in the flock were not treated in the last 8-10 weeks, was prepared. Twenty two smallholder farms in 17 localities and two institutional farms (Debre-Birhan sheep breeding and improvement center in north Shewa, and Hawasa University (the then Debub University) goat farms in east Shewa were selected. Thus, a total of 24 farms were involved in this study (Table 1).

Study animals

Sheep and goats belonging to the peasant farmers in East Shewa were of the local breeds and they were of the East African type (Galal, 1983 cited by Gatenby, 1986). The indigenous goats at Hawasa University were of mixed local breeds. For ease of reference we kept the name "rift valley goats," as they were identified by the university farm. In general the goat breeds that were used in this study were the rift valley goats, and their crosses with Toggenburg or Anglo-Nubian, and pure Toggenburgs. Ten, fifteen, or more goats (<12 months old) were identified to be included in the study. The animals were divided into different breed groups, namely local rift valley goats, crossbred with Toggenburgs or Anglo-Nubians, and pure Togenburgs, all of them with the same worm population on the same farm to detect differences in the extent of resistance.

At Debre Birhan in north Shewa, flocks of Menz sheep breed, exotic sheep breed namely Awasi and their crosses with Menz which were mostly (<12 months old) were used in the study. No goats were included in the study as there were no goats in the selected study sites. On every peasant farm up to 15 sheep or goats with their worm eggs per gram (epg) counts more than 500 were divided into three treatment groups, the albendazole, levamisole and non-treated positive control groups. Animals were randomly allocated to each of the groups and each animal was identified by an ear tag with a code number.

Table 1. Location and number of sheep and goats in the anthelmintic resistance survey

Number.	Survey zone	Location of smallholders	Number of Farms	Number of Sheep	Number of Goats
1	East Shewa zone	Shashemene	1	-	35
2		Meki	2	26	26
3		Zewai	2	30	30
4		Dugdabura	1	-	23
5		Wolenchiti	2	-	26
6		Fentale	1	22	20
7		Alemgena	1	-	30
8		Arsi negele	1	25	35
9		Boset	1	-	22
10		Chabi	1	30	35
11		Modjo	2	35	35
12	North Shewa none	Karafino	1	27	-
13		Yato	1	37	-
14		Chacha	1	45	-
15		Faji	1	30	-
16		Sululta	1	20	-
17		Sheno	2	45	-
18	DSBIC	DSBIC1	1	45	-
19	HU	HU	1	0	197
TOTAL			24	417	514

1Debre Birhan Sheep Breeding & Improvement Center; Hu = Hawasa University, - = No Animals Sampled

Anthelmintics

Albendazole (albenol) and levamisole were selected for this study, to represent the benzimidazoles and imidazothiazoles. The anthelmintics that had been used mostly frequently and for six consecutive years were used. The anthelmintics were identified based on the findings of a questionnaire survey where the drugs did not change for over four or more years in the study area (Desalegn, 2005). The anthelmintics used in the present study were suspensions for oral use and administered to the animals with 10 or 20 ml plastic syringes. One ml albenol contains 100 mg albendazole. The recommended dose equals 1ml/20kg body weight. Double of the recommended dose was given to goats. A dose of 5 mg kg^{-1} of albendazole and 7.5 mg kg^{-1} levamisole were given to each animal.

The dose rates for sheep were based on the manufacturer's dose rates, while goats were given one and a half to two times' higher dose because of pharmacokinetic differences (Gillham and Obendorf, 1985). Each animal was drenched according to its actual weight in kg.

Determination of fecal egg count

Faecal egg count reduction test (FECRT) was used to determine changes in fecal egg count using the method of Coles *et al*. (1992), as advocated by the World Association for the Advancement of Parasitology (WAAVP). Feces were collected from the rectum of each sheep and goat and placed in clean specimen bottle. Fecal samples were kept in a cool-box and transported to the laboratory at Sebeta. Samples were examined the same day using a modified McMaster technique (Hansen and Perry, 1994). Fecal samples were recollected 14 days from the same animals after the first treatment. For an anthelmintic to be fully effective no worms should survive following the time taken to empty the intestine(3 days for LEV, 8 days for BZs, MLs 14-17 days), *i.e*. allowance has to be made for temporary suppression of egg production and timing are based on best guesses (Coles *et al*., 2006). Pre-treatment samples with fewer than 100 epg were omitted from this experiment.

The use of arithmetic means in the method of Coles *et al*. (1992) has been considered to be a more stringent criterion reflected in a more conservative estimation of therapeutic activity of drugs (Vercruysse *et al*., 2001). The method of Presidente (1985) was used calculating the geometric means as it is considered appropriate estimate of central tendency and has less potential for misinterpretation. The method of Presidente (1985) was used merely to observe the distinctions of the methods. The following formulas were used to assess FECRT.

1. FECRT%=100×(1-[T_2 /C_2]) - Coles *et al*. (1992) use arithmetic means, 95% confidence level is provided; resistance is present if the percentage reduction is less than 95% and the lower 95% confidence limit for the reduction is less than 90%. In this formula the T_2 and C_2 designate the counts after treatment, using the arithmetic means.
2. FECRT%=100 ×(1-[T_2/T_1] [C_1/C_2]) - Presidente (1985) uses logarithmic transformation of egg counts to stabilize variances. Efficacy is corrected for changes that occur in the control group by the equation listed. Resistance is present if the percentage reduction is less than 90%. In this formula the T and C were the geometric means for the treated and control groups and the subscripts 1 and 2 designate the counts before and after treatment.

Larval identification and counts

Pooled samples were collected from each group on the day of first treatment and again 14 days after treatment. To identify the species of nematodes present, cultures were made and up to 100 larvae identified with the aid of the descriptions of Reinecke (1983), van Wyk *et al.* (1997b) and van Wyk *et al.* (2004).

Results

Tables 2 and 3 show the fecal egg count reduction percentages for the 22 smallholder and the two institutional farms, which were calculated before and after treatment, according to the methods proposed by the WAAVP (Coles *et al.*, 1992). Albendazole was tested on 21 smallholder farms, while levamisole was tested on six farms. Of the 22 farms only six of them were tested both for albendazole and levamisole. The fecal egg count reduction percentages tested according to Coles *et al.* (1992) and (Presidente (1985) in sheep treated with albendazole were {77%, 46} and {65%, 66%} at Chacha and Sheno in north Shewa, and {67%, 65%} at Mojo in east Shewa respectively (Table 2). Albendazole resistance was suspected on one of the smallholder farms at Shashemene in east Shewa where the FECR% were {96%, 90%} (Table 2). Similarly, levamisole resistance was detected in goats on one of the smallholder farms at Zewai in east Shewa, where the FECR% was {95%, 72%} (Table 2).

Resistance in a flock of sheep at Debre-Birhan government sheep farm showed a 94 % reduction in the faecal egg count and the lower 95 % confidence interval was less than 90 (Table 3). Therefore, the results obtained at this farm suggest that there was a low resistance or resistance can be suspected. Resistance to both benzimidazole and levamisole groups of anthelmintics occurred in all the goat herds on the Hawasa University goat farm. The level of resistance ranged between 45 % & 65 % in the FECRT obtained in the Benzimidazole/ albendazole and levamisole tests both at institutional and at peasant farms levels (Tables 3-6).

Table 2. Results of FECRT of local breeds of sheep and goats on smallholder farms. Numbers in brackets are the 95% confidence intervals

Number	Survey zone	Localities	Species	n	Drug	Coles et al. (1992)	Presidente (1985)
1	East Shewa	Shashemene	Goat	35	Albendazole	96 (88-99) s	90 (91-99)
2		Meki	Sheep	26	Albendazole	98 (93-100)	91 (90-98)
3		Meki	Goat	26	Levamisole	98 (90-100)	92 (91-99)
4		Zewai	Sheep	30	Albendazole	98 (93-100)	91 (92-99)
5		Zewai	Goat	30	Levamisole	95 (84-98) r	72 (65-90) r
6		Dugdabura	Goat	23	Albendazole	99 (90-99)	92 (92-98)
8		Wolenchiti	Sheep	22	Albendazole	98 (91-99)	93 (91-99)
9		Fentale	Goat	20	Levamisole	99 (95-100)	90 (92-100)
10		Alemgena	Goat	30	Albendazole	98 (93-100)	90 (92-99)
11		Arsi Negele	Sheep	25	Albendazole	98 (93-98)	93 (91-100)
12		Arsi Negele	Goat	35	Levamisole	98 (93-100)	91 (92-99)
13		Boset	Goat	22	Albendazole	98 (91-100)	92 (94-100)
14		Chabi	Sheep	30	Albendazole	99 (95-100)	88 (58-98)
15		Chabi	Goat	35	Levamisole	98 (90-99)	92 (91-99)
16		Mojo	Sheep	35	Albendazole	67 (25-86) r	65 (32-88) r
17		Mojo	Goat	35	Levamisole	98 (93-100)	91 (90-98)
18	North Shewa	Karafino	Sheep	27	Albendazole	98 (90-100)	92 (91-99)
19		Yato	Sheep	37	Albendazole	98 (95-100)	93 (92-99)
20		Chacha	Sheep	25	Albendazole	77 (50-89) r	46 (25-68) r
21		Faji	Sheep	30	Albendazole	97 (90-99)	94 (93-99)
22		Sheno	Sheep	45	Albendazole	65 (15-89) r	66 (25-79) r

s = low resistance (resistance suspected)
r = resistance
- = missing data

Table 3. Results of FECRT on institutional farms

Localities	Species	Breed	N	Drug	Coles et al. 1992	Presidente 1985
DSBIC	Sheep	MC	15	Albendazole	97 (88-99) s	86(72-98)
"	Sheep	"	15	Levamisole	95 (93-98)	84 (89-98)
HU	Goat	rv	15	Albendazole	86 (61-95) r	31(25-80) r
"	"	"	15	Levamisole	89 (77-94) r	55 (27-72) r
"	"	Rvc	10	Albendazole	88 (71-95) r	24 (12-26) r
"	"	"	10	Levamisole	93 (80-98) r	35 (2-65) r
"	"	Toggenburg	7	Albendazole	92 (77-98) r	50 (1-20) r
"	"	trc	10	Albendazole	71(28-88) r	12 (1-42) r
"	"	Trc	10	Levamisole	96 (82-99) r	32 (15-68) r

DSBIC =Debre-Birhan sheep breeding & improvement center, HU=Hawasa University
s = resistance suspected (low resistance), r= resistance, MC=Menz sheep crossed with Awasi
rv = local goat breed (HU goat farm refer them as rift valley goats)
trc = crossed with Togenburg

The results of pre- and post-treatment larval recovery in the anthelmintic resistance test were determined using the faecal egg/ worm count reduction test analysis using RESO a simple software method of calculation (1990). In the pre-treatment larval cultures, *Haemonchus* was the predominant nematode (75-89 %), while *Trichostrongylus* and *Oesophagostomum* were present in small numbers (1-11 %). Post-treatment faecal cultures indicated that *Haemonchus* was the only parasite recovered at the highest level and hence, resistant to albendazole. Detailed results of the calculations on FECR are presented in Tables 4-6.

Table 4. Results of FECRT calculated using RESO according to Coles *et al.*, 1992 in goats and sheep on smallholder farms in East Shewa

	Zeway				Mojo			
	Goats control	Goats Treated	Sheep control	Sheep Treated	Goats Control	Goats Treated	Sheep control	Sheep Treated
Drench number	20	20	10	20	15	20	15	20
Arith.mean epg (pre)	1013	1135	860	805	973	1220	933	1055
Arith.mean epg (post)	"	80	"	45	"	40	933-	305
Variance (FEC)	411238	376079	347100	9974	482095	6737	463810	223658
% Reduction		92		95		96		67
Variance (Reduction)		0.25		0.29		0.24		0.16
Upper 95% c.l.		97		98		99		86
Lower 95% c.l.		78		84		88		25
Interpretation		R		R		LR		R
Post treatment L3								
H. contortus	87	89	90	80	90	74	88	80
T. colubriformis	10	11	7	15	10	16	12	14
O. columbianum	3	0		5	0	10	0	6

Benzimidazole/ albendazole treatment: Pre-treatment $L_{3=}$ 89 *H. contortus*; 11 *T. colubriformis* and 5 *O. columbianum* larvae were recovered froma pooled samples

Table 5. Results of FECRT calculated using RESO according to Coles et al. 1992 in sheep on smallholders farm in north Shewa

	Sheep control 1	Sheep Treated1	Sheep control 2	Sheep treated 2	Sheep control3	Sheep treated3
Drench number	10	20	7	15	15	15
Arith.mean epg (pre)	855	805	757	640	650	1067
Arith.mean epg (post)	"	45	"	27	"	113
Variance (FEC)	347111	9974	469524	3524	116071	24095
% Reduction		95		96		85
Variance (Reduction)		0.29		0.35		0.24
Upper 95% c.l.		98		99		95
Lower 95% c.l.		84		86		58
Interpretation		R		LR		R

	Sheep control 1	Sheep Treated1	Sheep control 2	Sheep treated 2	Sheep control3	Sheep treated3
Post-treatment L3						
H. contortus	90	80		94	89	91
T. colubriformis	7	15		15	0	0
O. columbianum	0	5		0	0	0

Benzimidazole/albendazole treatment: [1] at Karafino, [2] at Faji, [3] at cha-cha, " = same mean epg count as above
Pre-treatment L_3: 90 *H. contortus*, 10 *T. colubriformis* were recovered from pooled samples

Discussion

The results of the fecal egg count reduction percentage tests are in agreement with studies carried out in South Africa (Van Wyk *et al*. 1997a, b; 1999), in Kenya (Mwamachi *et al*., 1995), in Denmark (Maingi *et al.* 1996), in Malaysia (Pandey and Sivarja 1994) and in Peninsular Malaysia (Dorny *et al*.1994) where resistance of *Haemonchus* and *Trichostrongylus* spp. to benzimidazoles and levamisole was found.

The factors responsible for the occurrence of resistance on the study at smallholders (peasant farms) can be speculated. The mean numbers of anthelmintic treatments per year for goat and sheep as reported in the questionnaire survey (Desalegn, 2005) were between 2 and 4 during the wet seasons. The lower frequency of treatments recorded at peasant farm level implies lower selection pressure for resistance worms. However, other practices observed in the study areas may have contributed to the occurrence of resistance. Prolonged use of the same classes of anthelmintics, and the distribution and availability of drugs of dubious quality, might have contributed to the development of resistance in some flocks of sheep and goats belonging to smallholders. Under dosing was also very common on the study farms and veterinary clinics because of the probably under estimating of animals weight. Anthelmintic doses recommended for sheep were similarly used for the treatment of goats, which could have promoted selection for resistant worms (Waller, 1987; Coles and Roush, 1992). Reports on resistance of nematodes to anthelmintic are scanty from different regions of the country. Bersissa and Abebe (2007) reported a high efficacy of albendazole and tetramisole tested against *H. contortus* in experimentally infected lambs with the Ogaden isolates of the parasite, which indicate that in areas where farmers or pastoralists practice not frequent chemo-therapeutic treatments has no yet developed resistant worms to drugs.

Table 6. Results of FECRT calculated using RESO according to Coles *et al.*, 1992 in goats at Hawasa Univesrity goat farm

Combined species	Control	Bz1	Lev1	Control	Bz2	Lev2	Control	Bz3	Lev3	Control	Bz4	Lev4
Drench number	10	10	10	10	10	10	15	15	15	10	10	10
Arith mean epg (pre)	1 010	1 290	2 390	720	820	720	850 (821)	1 607	1 007	2 696	1 490	1 560
Arith.mean epg (post)	"	800	420	"	90	50	"	120	93	"	790	80
Variance (FEC)	16 544	1 5111	510 667	315 111	7 667	5 000	491923	38 857	13 524	4 330 827	77 111	21 778
% Reduction		92	58		88	93		86	89		71	96
Variance (Reduction)		0.25	0.31		0.16	0.26		0.23	0.11		0.18	0.43
Upper 95% c.l.		97	87		95	98		95	94		88	99
Lower 95% c.l.		77	33		71	80		61	77		28	82
Interpretation		R	R		R	R		R	R		R	LR
Post-treatment L3												
H. contortus	87	89	90	79	90	74	88	80	91	75	86	72
T. colubriformis	10	11	7	15	10	16	12	14	5	15	14	18
O. columbianum	3	0		6	0	10	0	6	4	10	0	10

The superscript 1, 2, 3 and 4 designate the albendazole and levamisole tests on mixed goat breed, rift valley crossed, rift valley local, crossed Toggenburg breeds respectively. R- resistance, LR-low resistance. " = the same mean epg count as above

Pre-treatment L_3: 85 *H. contortus*, 15 *T. colubriformis*, 10 *O. colombianum* were recovered

The mean number of anthelmintic treatments at Debre-Birhan sheep breeding and improvement center and at Hawasa University goat farm (6 or 8 times per year) was much higher than treatments carried out at peasant farms level. The use of the same groups of anthelmintics more frequently and for a number of years was very common in most of the government as well as private veterinary clinics. In the questionnaire survey that was carried out in the area, the majority of animal health workers (87-90 %) used benzimidazole groups of anthelmintics for four or more consecutive years before changing to a different group, like levamisole or for short periods with ivermectins (Desalegn, 2005).

Unless control measures are designed and uniformly applied, anthelmintic resistance has the potential to spread rapidly and widely. This is likely to further aggravate the "ill thrift" or nutritional inadequacies, poor helminth control and husbandry practices in small ruminant production in the area, and may further enhance selection for resistance. Possible introduction of worms to sheep and goat rearing farms or areas from within and outside the country which may be resistant to anthelmintics can also play the role in spreading the problem of resistance. For example, goats imported from New Zealand to Slovakia had multiple resistances to anthelmintics (Varady *et al.* 1993 cited in Maingi *et al.* 1996). Newly introduced animals to any farm should be treated with effective anthelmintics and held in a confined area for up to 48 hours before they are allowed to graze freely. This gives ample time to kill the worms inside the host animals.

Currently the responsibility of supplying and distributing of anthelmintics and other veterinary drugs to regional, zonal or district level veterinary clinics has been taken over by the zonal or regional bureau of agriculture of each of the regional states in the country. This should have brought about changes in the use of anthelmintics in most of the veterinary clinics. Conversely, because of the Government's free market economic policy, several private companies import veterinary drugs in bulk from various manufacturers in Africa, Europe and Asia and distribute these products in Ethiopia. This has contributed towards reducing the shortages of drugs. Anthelmintics of which the sources are not known are often available in the open market (guilt), and peasant farmers purchase them because of their trade names and affordable prices (Desalegn, 2005). However, no attempt has been done so far to study the quality and therapeutic values of anthelmintics that are being sold in most of the open markets through out the country. Waller (1997) stated that adulterated and/or anthelmintics of dubious quality obviously lead to development of resistance. Problems that require serious attention from the drug regulatory authority

include the marketing of same group of anthelmintics under different trade names, formulations and presentation of the drugs.

Using the arithmetic mean, for calculating the percentage reduction in fecal egg count (Coles *et al*., 1992) is universally accepted because it provides a better estimate of the worm egg output and it is a more conservative measure of anthelmintic efficacy. In the current study both the arithmetic and geometric mean methods of calculating the percentage reduction in fecal egg count confirmed resistance (Tables 2 and 3) and Tables (4-6) in the flocks of sheep and goats that were examined.

The number of farms examined in both north and east Shewa were too few to represent the small holder farms in the country to declare the development and occurrence of anthelmintic resistance. However, conclusions can be made on the prevalence of anthelmintic resistance among the sheep and goat flocks in the smallholders of the two zones. The anthelmintic resistance tests that were carried out at Hawasa University using the local and cross-bred goats showed the occurrence of resistance mainly by *Haemonchus contortus*.

In order to reach a better understanding and positive decision on the current anthelmintic resistance situation in the country, a broader and extensive survey, involving more farms in other regions and at a national level, is crucial. Resistance to albendazole and levamisole should also be confirmed by other tests and observations, such as a controlled study or in vitro testing. This study, however, reports the anthelmintic resistance in nematode parasites of sheep and goats that occurs in selected areas of the country and will be an emerging problem to which attention should be paid.

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Ecological distribution of honeybee chalkbrood disease (*Ascosphaera Apis)* in Ethiopia

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Abstract

This study was conducted in Oromia, Amhara and Benishangul-gumuz regional states of Ethiopia. It was aimed to assess the infection and distribution rates of honeybee chalk brood disease (HCBD), analyse association of the disease with different bioclimatic zones and determine seasonal occurrence of the disease in Ethiopia. One- hundred and thirteen (113) peasant associations from 33 Woredas of the study regions were selected and 264 beekeepers were interviewed. A total of 1871 honeybee colonies from 133 apiaries were diagnosed externally and internally for HCBD. The infection rates of chalk brood disease in Amhara, Oromia and Beneshangul Gumuz Regional States were 37.12%, 19.89% and 17.93% respectively while distribution rates in same regions were 87.5%, 56.56%, and 33.33%. Similarly, the infection and distribution rates of HCBD were varied from zone to zones. High proportions of the respondents reported that HCBD occurred from September to November (43.6%) and from March to May (34.8%). There was significant honey yield variation between infected with HCBD and uninfected honeybee colonies ($P < 0.001$). Moist dega, moist weina dega and wet weina dega were identified to be the best suitable ecological zones for HCBD distribution. We concluded that there is high distribution of HBCD in all areas. Therefore; there is a need of avoiding transfer of honeybee products and by products from infected colonies to different places, awareness creation among beekeepers, strengthening colonies and design appropriate control strategies to combat the disease.

Key words: *Ascosphaera apis (A. apis*), Chalk brood, ecology, Ethiopia, Honeybee brood disease, bioclimaitic zones, seasonal occurrence

Introduction

Beekeeping in Ethiopia is a long-standing agricultural practice. Though beekeeping is practiced as a sideline activity, many of the rural farming com-

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munity generate substantial income from honey and beeswax selling and get benefit from the diverse use of honey. The current national average honey yield is estimated at 30 thousand tons per annum. This contributed 23.75% to the total Africa honey production and 2.48% to the total world production (MOARD, 2005). The current national beeswax yield is also estimated at 3 thousand tons per annum. Ethiopia is currently known to be one of the ten leading producers of honey and beeswax in the world (MOARD, 2005). Moreover, beekeeping has high contribution in enhancing food security, poverty reduction and food production through pollination of crops. This economically and ecologically important insect has been attacked by various pathogens (fungi, bacteria, parasite etc.). Fungi are commonly saprophytes of dead bees and combs. Some of the fungal species such as *Ascosphaera apis, Aspergillus spp*. and few others are considered to be honeybee fungal pathogen (Glinski and Buczek, 2003).

Honeybee chalk brood disease (HCBD) is a fungal disease principally attacking the brood of honeybees (*Apis mellifera L. Himenoptera: Apidae*) with ultimate death of infected larvae. It is caused by a fungus called *Ascosphaera apis.* At first the fluffy white mould covers dead larvae inside recently capped cells and later they dry and become black or white mummies. HCBD is reported to be most frequent in damp condition. The disease is widespread among honeybees in Europe and North America; infection rates in colonies of different areas in western Canada range from 20 %-39 % (Nelson *et al.,* 1977). Yakobson *et al*., 2003 reported that in Israel, chalkbrood was considered by the beekeepers to be the most important brood disease. These authors also indicated that in Germany levels of chalkbrood infection were generally low (1-15%) probably due to the favourable climatic conditions and nectar availability and the highest infection rates were observed in the hot and humid months between June and October (Yakobson *et al*., 2003). Although chalkbrood is aggravated by dump condition it is seldom found in New Zealand even in high rainfall district of West Coast of South Island during hot period (Bailey, 1959; Bailey, 1967; Bailey and Ball, 1991).

In Africa it was first reported from Tunisia (Heath, 1985).In the study conducted in Egypt to asses losses in honey yield due to chalkbrood disease in clover and chinus honey yields, it was found to be 18.41 % and 18.33 % respectively (Zaghlou *et al*., 2005). In Ethiopia chalkbrood disease was reported in the beginning of the year 2001. It was detected for the first time in the apiary of Holetta Bee Research Centre (HBRC) and its surroundings (Dessalegn, 2001, 2006). About 27 % of honeybee colonies in West Shewa, East Shewa, North Shewa and Arsi zones of Oromia Regional State were infected by HCBD

(HBRC, 2004). Currently reports claiming the existence of the disease are coming from all directions in the country indicating that HCBD of honeybee is becoming a threat to the development of beekeeping sector.

Therefore, to ensure sustainable beekeeping it is of paramount important to generate information on prevalence and infection rates, analysing association of the disease with different bio-climatic zones and seasonal distribution of honeybee chalkbrood disease in Ethiopia.

Materials and Methods

Study area

The study was conducted in Illuababor, Jimma, West shewa, Arsi and East Wollega zones of Oromia, South Wollo, West Gojam and North Gonder zones of Amhara and Asossa zone of Beneshangul Gumuz regional states from March 2004 to November 2006. The selected representative Woredas were from East Wollega (Diga, Leka Dulecha, Gutowayu, Sibu Sire), Jima (Goma, Mana, Gera, Kersa), Illababora (Metu, Bedele, Chora, Yayo Hurumu),West Shewa (Bako, Cheliya, Ambo), Arssi (Limubilbilo, Tiyo, Robe, Bokoji), South Wollo (Desie zuria, Kalo, Ambasel, Amahra Saynt), North Gonder (Adiareqey, Gonder zuria, Layarmacho, Chilga),West Gojam (Baherdar zuria, Bure, Mecha) and Asosa (Asosa, Maokomo, Bambasi). Purposive and stratified random sampling techniques were used to select the nine zones and 33 woredas (district) and peasant associations based on honey production potential, high number of honeybee colonies, accessibility and willingness of the beekeepers to participate in the study. Moreover, the study sites that were suspected to be entry areas for HCBD from outside of the country and major agro-ecological zones were represented. One hundred and thirteen (113) peasant associations from 33 Woredas of the study zones were also randomly selected. The selection at all level was performed with offices of MOARD and Keble's representatives. Geographical coordinate and altitude of the study areas were recorded using Garmin 4.5 hand- held Global Positioning System (GPS)

Survey, sampling and diagnoses of honeybee brood diseases

The sampling units were households keeping apiaries. A total of two hundred and sixty-four beekeepers (households) were randomly selected from the districts and interviewed using pre-structured questionnaire, which helped to assess the distribution of the disease, effects on general production or yield of honey and its seasonality. Each respondent was interviewed to estimate honey

yield from infected and uninfected colonies at the same time since the majority of inspected colonies were found positive for HBCD.

Data were collected in single visit interviews during the main brooding seasons of the study areas. A total of 1871 honeybee colonies from 133 apiaries (1594 honeybee colonies from 111 apiaries in Oromia, 132 honeybee colonies from 16 apiaries in Amhara and 145 honeybee colonies from 6 apiaries in Beneshangul Gumuz regional states respectively) were diagnosed clinically by external and internal examination of the colonies (Hornitzky, 2001). External examination include observation of the colonies management, type of hives, dead brood/ mummies/ removed by worker bees in front of hives and in the entrances of honeybees. The internal examination was performed by opening the hives when suspected for chalkbrood disease and observe clinical evidences of the disease that are characterized by dead larvae in capped cells , dried/mummified/cadaver reminiscent of a small piece of chalk, which become dark if fruiting bodies of fungi are formed (sporulating mummies) (Hornitzky, 2001).

The prevalence and infection rates of honeybee chalkbrood disease were analysed using descriptive statistics. T test was used to compare honey yield of infected and uninfected colonies.

Infection rate (%) = (Number of bee colonies that were found positive/ Total bee colonies examined) x 100,

Distribution rate (prevalence) (%) = (Number of study sites where the diseases were found/ Total numbers of sites where samples were collected) x 100

Ecology of CHB disease causative agent

The geographical position of localities where HCBD occurred was recorded using Garmin 4.5 hand- held Global Positioning System (GPS) to establish the ecology of the disease. Number of inspected colonies, existence of infection and infection rate of HCBD were presented along northing and easting data and used as input for BIOCLIM ecological niche analysis with DIVA-GIS software (Busby, 1991) and WORLDCLIM 30x30 arc-second global climate data (Hijmans *et al*., 2005).

Bioclimatic data selection

Bioclimatic variables are derived from the monthly temperature and rainfall values in order to generate more biologically meaningful variables. These are often used in ecological niche modelling (e.g., BIOCLIM, GARP). The bioclimatic variables represent annual trends (e.g., mean annual temperature, annual precipitation); seasonality (e.g., annual range in temperature and precipitation) and extreme or limiting environmental factors (e.g., temperature of the coldest and warmest month, and precipitation of the wet and dry quarters).

BIOCLIM's definition of a quarter is any 13 consecutive weeks, (or any consecutive 3 months if running with a monthly time step) and is not necessarily aligned to any calendar quarters. For example, the driest quarter will be the 13 consecutive weeks that are drier than any other set of 13 consecutive weeks.

Bioclimatic variables are coded as follows: Annual Mean Temperature; Mean Diurnal Range; Isothermality; Temperature seasonality coefficient of variation; Maximum Temperature of Warmest Period; Minimum Temperature of Coldest Period; Temperature Annual Range (5-6); Mean Temperature of Wettest Quarter; Mean Temperature of Driest Quarter; Mean Temperature of Warmest Quarter; Mean Temperature of Coldest Quarter; Annual Precipitation; Precipitation of Wettest Period; Precipitation of Driest Period; Precipitation Seasonality coefficient of variation; Precipitation of Wettest Quarter; Precipitation of Driest Quarter; Precipitation of Warmest Quarter; Precipitation of Coldest Quarter.

This scheme follows that of ANUCLIM model, except that for temperature seasonality the standard deviation was used because a coefficient of variation does not make sense with temperatures between -1 and 1).

Generating the suitability prediction

When running BIOCLIM with the observation points as input, the input file needs to contain the independent variables used in the creation of the surface coefficient files. For BIOCLIM, the variables are usually the latitude (or Northing), longitude (or Easting) and elevation. The profile is a statistical summary of the bioclimatic parameters from each location and contains the following values for each bioclimatic parameter:

Not suitable,

0 to 2.5 percentile (low),

2.5 to 5 percentile (medium),

5 to 10 percentile (high),

10 to 20 percentile (very high),

20 to 34 percentile (excellent)

BIOCLIM computes the bioclimatic parameters for all of study sites, and then summarizes them, parameter by parameter to describe the climate that the causative agent HCB disease was found in.

Results

Infection and distribution rates of honeybee chalkbrood disease

In this study chalkbrood disease was found in all study regions (Oromia, Amhara and Beneshangul Gumuze Regional States) except dry bereha and moist bereha. The disease was detected in the majority of the study areas in these regional states (Table 1).

Table 1. Infection rates of CHB disease of honeybees in nine Zones of the study area

Region	Zone	No. Colony diagnosed	CHBD+ (%)
Oromia	E/Wollega	171	20 (11.7%)
	Jimma	499	127 (25.45%)
	Illu abbabor	418	81 (19.38%)
	W/Shewa	279	24 (8.6%)
	Arsii	227	65 (28.63%)
	South Wollo	25	16 (64%)
Amhara	N/Gonder	58	11 (18.97%)
	W/Gojam	49	22 (44.9%)
Beneshagul Gumuz	Assosa	145	26 (17.93%)
Grand Total		1871	392 (21%)

There was HBCD infection and distribution rates variation within and among the study regions. Infection and distribution of HCBD was found to be higher in Amhara Regional State compared to Oromia and Beneshangul Gumuze Re-

gional States (Fig. 1 and Table 4). The infection rate in Amhara, Oromia and Beneshangul Gumuze Regional States was 37.12%, 19.89% and 17.93% respectively and distribution rate was 87.5%, 56.56%, and 33.33% in Amhara, Oromia and Beneshangul Gumuz, respectively (Fig. 1). Though there was no much infection rate variation between Oromia and Beneshangul Gumuze Regional States, the distribution rates of HCBD was varied in both regions (Table 4).

Figure 1. Chalk brood infection and distribution rates in Oromiya, Amahara and Beneshangul Gumuze Regional States

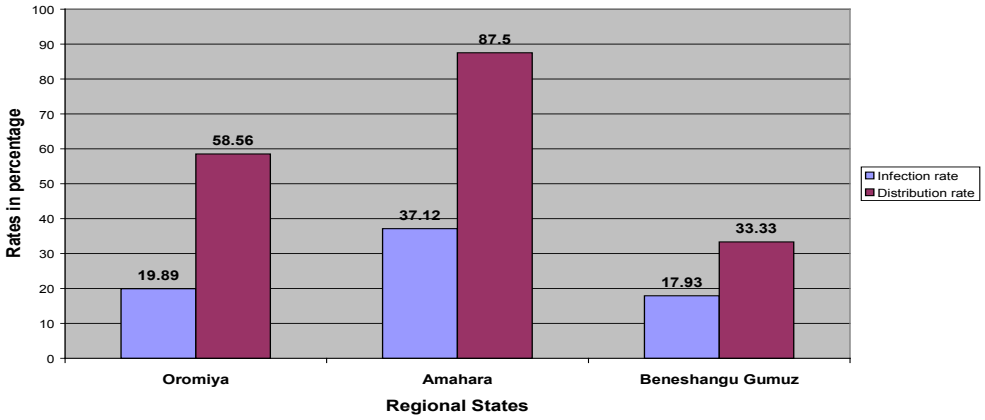

Figure1. Infection and distribution rates of CHB disease of honeybees in three regional states of Ethiopia

The infection rates of HCBD were varied from zone to zones in all regions. In Oromia the highest infection rate was found in Arsi (28.63%), followed by Jimma (25.45%) and Illuababor (19.38%) zones. The lowest infection rate was found in West Shewa (8.6%) and East Wollega (11.7%) zones (Table 1).

In Amahra the highest infection rate of HCBD was recorded in South Wollo zone (64%) followed by West Gojjam (44.9%) and North Gonder (18.97%) in the descending order (Table 1). Similarly the distribution rate was found to be much higher in West Gojjam (100 %) and North Gonder (80%) zones of Amhara Regional State while in Oromia the most affected zones are Jima (95.24) and Iluababora (64.7%) (Table 4).

Honeybee chalkbrood disease occurred during all seasons in study areas except June to August (Table 2). High proportions of the respondents reported that chalk brood disease occurred during September through November (43.6%)

and March through May (34.8%). These two seasons are times of honeybee brooding in Ethiopia and are conducive for *Ascosphaera apis* germination and sporulation in different parts of the study regions.

There was significant honey yield difference between infected and uninfected honeybee colonies by chalkbrood disease ($p < 0.001$). Chalkbrood disease affects honey yield negatively. In this study it is indicated the HCBD reduces the annual honey yield by 64 % (Table 3).

Table 2. Seasonal occurrences of chalk brood disease in the study regional states (%)

Region	Zone	No.	Season							
			September to November		December to February		March to May		June to August	
			Freq.	%	Freq.	%	Freq.	%	Freq.	%
Amhara	N. Gonder	12	5	41.7	2	16.7	5	41.6	0	0
	W. Gojjam	23	11	48	5	21.6	7	30.4	0	0
	S.Wello	17	5	29.4	7	41.2	5	29.4	0	0
Oromia	Jimma	43	20	46.5	14	32.5	9	21.0	0	0
	I/ Ababor	36	16	44.4	10	27.8	9	25.0	1	2.6
	E. Wellega	28	11	39.3	4	14.3	13	46.4	0	0
	W.Shewa	38	10	26.3	5	13.1	23	60.5	0	0.0
	Arsii	52	29	55.8	6	11.5	16	30.8	1	2.0
Beneshangul	Asosa	15	8	53.3	2	13.3	5	33.3	0	0
	Total	264	115	43.6	55	20.8	92	34.4	2	0.8

Table 3. Mean honey yield (Kg) comparison between chalkbrood disease infected and uninfected honeybee colonies in the study regional states

Status of honeybee colony	N	Mean	Sta. dev.	Minimum Honey yield Kg/colony	Maximum honey yield Kg/colony
Infected	264	2.43a	5.17	0.0	45
Uninfected	264	6.15b	11.10	0.3	80

Means with different letters are significantly different ($p < 0.0001$)

Table 4. Distribution rate (%) of honeybee chalkbrood disease in study Regional States

Region	Zone	HCBD distribution percentage
Amhara	N. Gonder	80.0
	W. Gojam	100
	S. Wollo	75
Oromiya	Jima	95.24
Oromiya	Ilubabor	64.7
	E. Wollega	25.0
	W. Shoa	40.0
	Arsi	45.45
Beneshangul Gumuz	Asosa	33.33

Ecology of CHBD

Bioclimatic predictions

A map of suitability was generated using the conditions described above by the 19-bioclimatic factors. The resulting map indicates the likelihood of presence of HCBD under the climatic conditions picked under each point of observation where HCBD was detected. Subsequently, the map was visually compared to the 19 individual climatic maps. Out of 19 climatic factors used in the model annual mean temperature, Isothermality, mean temperature of the wettest quarter, precipitation of wettest quarter, precipitation of warmest quarter and precipitation of coldest quarter seem to have explanatory power for the models result more than the rest. This observation is confirmed by finding quasi-identical result when only six of the climatic factors used (Figure 2 and 4).

Comparison with Agro-climatic zones

Overlaying the raster data obtained from the Bioclim model on a raster of agro-climatic zones' classes can give us a picture of how the disease is likely to be distributed according to the Ethiopian climate zones (Figure 3).

It was found that dry alpine, dry bereha and moist bereha areas are not suitable for the occurrence of chalk brood disease at all. On the other hand a significant portion of the area within the very high and excellent suitability classes lies in the moist *dega*, moist *weina dega* and wet *weina dega* climatic zones, 9.1%, 10.4%, and 14.9% respectively.

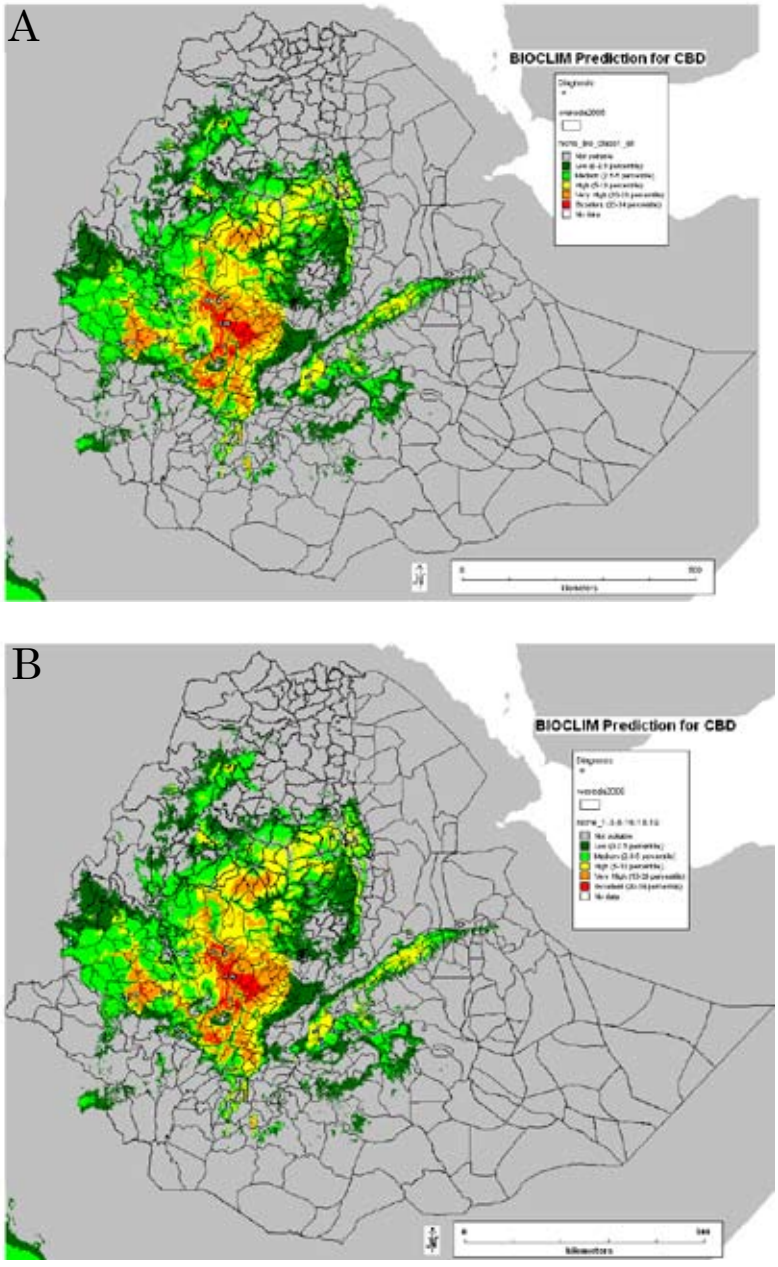

Figure 2. BIOCLIM model using all variables (A) and selected variables (B) for prediction of HBCD occurrence.

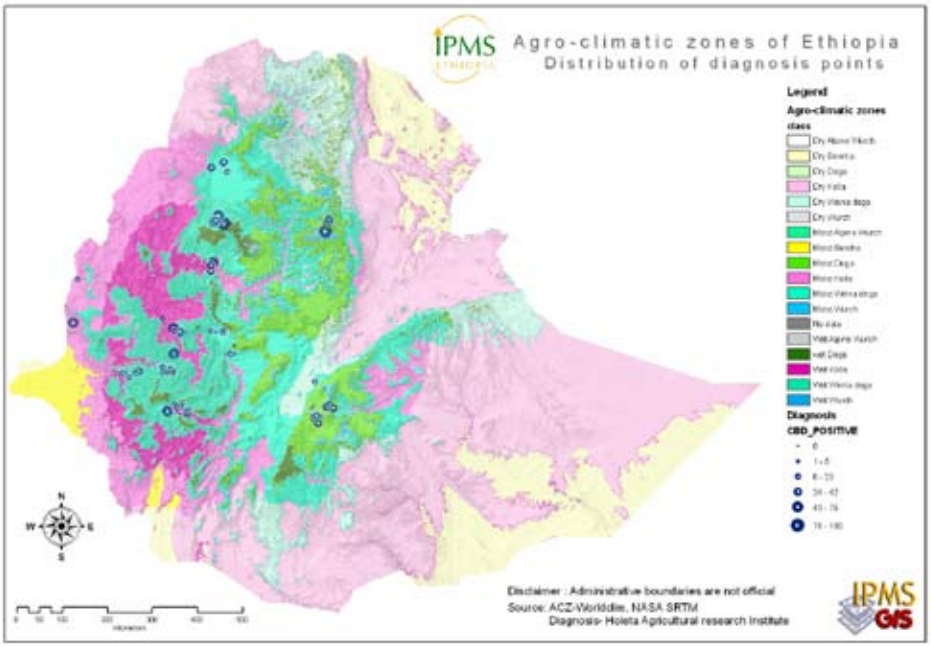

Figure 3. ACZ of Ethiopia- Distribution of observation sites with CBD positive percentages

Discussion

During the survey period attempts were made to inspect different brood diseases along with HCBD. However, chalk brood disease was the only brood disease detected in all parts of the study areas. The results of the present study clearly demonstrated that chalk brood disease was widely distributed in Amhara, Oromia and Benishangul Gumuz regional states of Ethiopia.

The infection rate and the distribution rate unequivocally indicated the seriousness of the disease. The infection rate observed in this study (17.93 % -37.12 % as summarized by regions) was similar to infection rate reported from western Canada where it ranged from 20% - 39% (Nelson et al., 1977). It was also observed that there was difference in rates of infection and distribution among the different zones of Oromia and Amhara. It was found that in those zones where bee production extension package has been practiced and where various beekeeping equipments were distributed had relatively higher distribution rate (for example West Gojam, (100%), Jima (95.24 %) of HCBD than

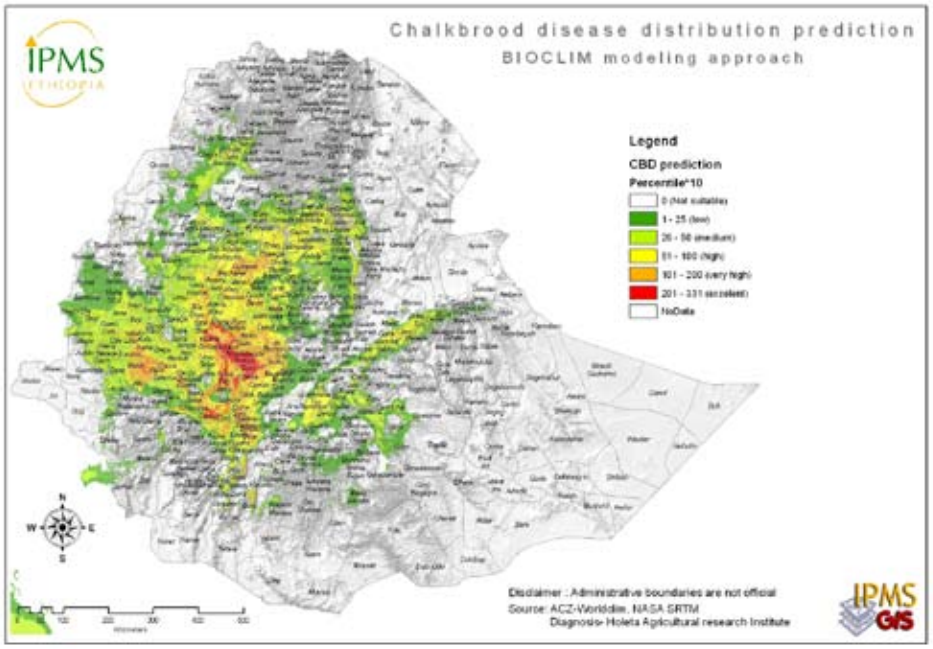

Figure 4: BIOCLIM model using only selected variables for prediction of HBCD occurrence

in those zones where relatively little intervention was done like Asosa and East Wolega (Table 4). This observation has probably led to the conclusion that the distribution of the causative agent of HCBD might be associated with delivery of contaminated apiary equipments. For instance, wax foundation sheet contaminated with spores of A. apis was shown to be a source of HCBD (Flores et al., 2005).

Based on the observations made, older hives, poor sanitation, negligence of the beekeepers to keep clean apiaries and lack of awareness about the disease among the beekeepers and other agricultural development workers found to be the prominent factors that might contribute for the high infection and wider distribution rate across all regions in the country. Seasons between September to November and from March to May were found to be peak seasons for occurrence of HCBD, which coincides with the brood rearing time of the year in the respective study sites. These months represent the cold, humid and hot seasons, which are conducive for multiplication of the causative agent of HCBD. Hence it agreed with the observation made by (Gilliam *et al*. 1977) who

observed that heavy infestation in the USA through out the year even when average monthly temperatures were 29 °C.

A significant portion of the area within the very high and excellent suitability classes lies in the moist *dega*, moist *weina dega* and wet *weina dega* climatic zones, 9.1%, 10.4%, and 14.9% respectively. This finding agreed with the fact that HCBD is more prevalent in damp and cool conditions and aggravated when the brood is chilled (Dadant *et al.*, 1975, Desalegn, 2006).

Conclusions

The significant prevalence and rapid spread of chalk brood disease and loss of honey production up to 64% due to the disease necessitates prompt attention from the relevant bodies for urgent implementation of appropriate control measures including setting up policy that could facilitate execution of monitoring activities. These may include control of movement of honeybee products, by-products and apiary equipments that could serve as a source of contamination and infection. In spite of the loss that the disease is incurring, there was lack of awareness about the importance of the disease among woreda beekeeping experts and the beekeepers themselves. The disease has not been recognized and all concerned bodies have taken no measures. Therfore, awareness creation is very important among all stakeholders.

So far there are no successful chemotherapeutic options for treatment or control of HCBD. Maintaining strong healthy colonies has been demonstrated to reduce the effects of chalkbrood disease elsewhere. Introduction of good management practices that could help to stop propagation of the pathogen should be in place. Hence, it is recommended to investigate practicable and effective options to control CHBD under Ethiopian condition. These may include investigation of potent chemicals that could help to disinfect apiaries and beekeeping equipments and to treat infected colonies and exploration of improved management practices that could help to reduce incidence and spread of HCBD.

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

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Abstracts

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

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

Introduction

The mismatch between general paucity in area devotion to forage cultivation at 6.9 million hectares for the last four decades and the livestock population growing at 1.4 per cent per annum is the challenge to the Indian feed production. The available feed resource in the country is merely meager. Only 550

million tons dry fodder from crop residues, pasture and grazing resources; 370 million tons green fodder from cultivated forages, tree fodders, weeds and sugar cane tops is available against the 949 million tons dry fodder, 1136 million tons green forages and 6.0 million tons concentrates (Hazra and Singh, 1996; ICAR, 1997) required to feed the livestock population of the country.

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

Among the essential nutrients to plant, nitrogen is the most important element taken-up by plants (Miles and Manson, 2000). Both the deficiency and excess supply of this nutrient has adverse effect on growth and yield of crops, animal health and on socio-economic and environmental welfare. As one way to get out of it, interests of identifying genetic differences in responsiveness to nitrogen fertilizer are intensifying. Producers, agricultural consultants and researchers often see genotypic variation as one way to fine-tune fertilizer management (Below, 1995). There is a desire to develop or identify genotypes that perform well under low nitrogen supply or conversely to find genotypes that will respond to high fertility conditions (Below, 1995). Therefore, it was with this in mined that study was conducted using two commercial varieties of forage oat to see the response to different levels of nitrogen in terms of morphological characters, yield and quality.

Materials and Methods

The study was conducted at Govind Ballabh Pant University of Agriculture and Technology, India, situated at an altitude of 243.8 meters above mean sea level between 29.5° N latitude and 79.3°E longitude. The region is characterized by subhumid tropical and subtropical climate having shallow water table and gentle slope with mean annual rainfall of 1385mm.The air temperature

ranges from below 10^{O}C in winter to over 40^{O}C in summer. The soil was slightly alkaline in reaction (7.3), low in available nitrogen (230 kg ha^{-1}), medium in organic carbon (0.7%), P_2O_5 (47.3 kg ha^{-1}) and K_2O (284.37 kg ha^{-1}).

Experimental design, treatments and layout

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

Experimental plots management

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

Data collection and Analysis

Morphological characters

The crop was harvested at 50% heading stage(D50)after taking measurement on plant height (PLH) and counting number of shoot (NSH) from a half meter row length. The entire herbage from the half meter row length was cut close to the ground and separated into leaves and stem; count was taken on number of

green leaves (NGL), number of dry leaves (NDL), and total number of leaves (TNL). Leaf area, leaf area index (LAI), dry matter accumulations through leaves (DMAL), stem (DMAS), and whole aerial plant part (TDMA), and the leaf to stem ratio (L/S) were all determined (Aklilu and Alemayehu (2007). Lodging percentage (LGP) was determined as percentage of the ratio of lodged area to the total area of the plot as given by Bhat *et al*. (2000). Emergence count (EGC) was taken at 15 days after planting by counting all plants from 0.5 meter row length.

Yield and quality

For the purpose of yield determination, the entire herbage from the net plot area (2m x 2m) was cut close to the ground, fresh weight was measured and the green forage yield (GFY) in q ha^{-1} determined. Subsamples of about 250 g was taken from each plot and dried in oven at $70^{O}C$ to constant weight from which the dry matter content (DM) and the dry matter yield (DMY) in qha^{-1} were determined. For crude protein, crude fiber and digestibility determination, the oven-dried samples were ground by laboratory Willey mill to pass 1 mm sieve size; two hundred mg samples were analyzed for total nitrogen content by Micro-kjeldhal method (Jackson, 1973) and the nitrogen content was multiplied by 6.25 to determine the per cent crude protein content (CP). The crude protein yield (CPY) in qha^{-1} was determined by multiplying the DMY with the CP and dividing by 100. The crude fiber content (CF) was determined according to the procedure of AOC (1980). At the same time, five gram of the ground sample was incubated in rumen of three rumen fistulated animals for 72 hours according to *Ørskov and McDonald (1979). And the* digestibility of the samples (DDM) were calculated by dividing the difference in dry weight between the before and the after incubation with that of the weight before incubation multiplied by 100. Digestible dry matter yield (DDMY) in qha^{-1} was then determined by multiplying DMY with that of the DDM divided by 100.

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

Results and discussions

Morphological characters

Analyses of variance showed significant ($P<0.05$) difference in all morphological characters due to application of different nitrogen levels (Table 1). PLH,

NSH, NGL, NDL, TNL, LAI, DMAL, DMAS, TDMA, and EGC all increased with levels of nitrogen. Maximum NSH (51.9), NGL (158), NDL (83.4), TNL (241.4), DMAL (33.25), DMAS (86.13) and TDMA (119.38) were recorded at 120 kg N ha^{-1}, while the PLH, LAI, EGC and LGP continued to increase up to the maximum level of nitrogen, indicating the need for higher amount of nitrogen to establish apparatuses involved in photosynthesis (Below, 1995).

Application of nitrogen at beyond 120 kg N ha^{-1}, however, resulted in slight decrease in NSH, NGL, NDL and TNL. The observed decrease might be due to increased EGC, because of nitrogen effect, which might have caused death of weaker and less competitive tillers (Joshi, 1996) and decomposition of leaves. Sexton (1995) also observed leaf losses associated with low light intensity in crop canopy. The observed increase in LAI (Table 1) with nitrogen could also be due to enhanced synthesis of enzymes, co-enzymes, chlorophyll and other nitrogen containing compounds (Rusel, 1973) which are essential for full expansion of individual leaf. Higher leaf area enables the crop to intercept more solar energy and synthesize more sugars for higher dry matter accumulation as reported by Saxena *et al.* (1971), Tiwari *et al.* (19 71), Verma (1984) and Chakraborty *et al.* (1999). A positive correlation of dry matter accumulation with LAI has also been documented by Rao *et al.* (1978) and Joshi (1980). The observed increase in total dry matter accumulation with the increasing levels of nitrogen could thus be due to better root growth and uptake of other essential elements (Hopkins *et al.*, 1994; Brady and Weil, 2002) with increased LAI and more light interception (Dhaliwal *et al.,* 1984).

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

Between the two varieties UPO-212 showed significantly ($P<0.05$) superior performance with respect to most morphological characters vis PLH, NSH, NDL, TNL, LAI, DMAS, TDMA, D50 and LGP. It was also responsive to higher doses of nitrogen in terms of TNL, DMAS, TDMA and PLH (Table 2). The higher dry matter accumulation of UPO-212 could be due to more assimilatory surface areas reflected by more number of shoots with higher LAI (Table 1). The dry

matter accumulation through leaves however, was significantly ($P<0.05$) higher in kent than in UPO-212. The possible reason might be better leaf thickness and specific leaf weight which were not considered in the present study. But Rao *et al.* (1978) reported negatively correlated leaf area index with specific leaf weight in some genotypes.

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

Yield and quality

Application of nitrogen significantly ($P<0.05$) affected the measured yield and quality parameters (Table 3). The GFY increased up to the maximum dose of nitrogen, while the increase in DMY, CPY, and DDMY was only up to 120 kg N ha^{-1} with a short fall thereafter, indicating that application of nitrogen above this dose level might not be beneficial under similar environmental and management conditions. Similar trends of increase in yield were reported by several authors, among which Thakuria and Gogoi (2001) in experiment with three levels of nitrogen (0, 40, and 80 Kg N ha^{-1}) noticed significant improvement in GFY with 80 kg N ha^{-1} and DMY with 40 kg N ha^{-1}. Hasen *et al.* (2000) also investigated increased GFY and DMY both up to 160 kg N ha^{-1}. Singh *et al.* (2000) in turn reported 55.5, 85.5 and 106.5 percent increment in green forage yields each with application of 30, 60 and 90 kg N ha^{-1}, respectively. The increase in green forage yield with nitrogen at above 120 kg N ha^{-1} level could be attributed to lush growth of the crop with formation of more protoplasm and increase in cell volume. Since protoplasm is highly hydrated, there would be more succulent plant growth with excessive moisture in tissues as the level of nitrogen increased (Das, 1996). The DM content of present study thus decreased with successive levels of applied nitrogen (Table 3) and the observation corroborates reports of Kumar *et al.* (2001), Thakuria and Gogoi (2001) and Singh *et al.* (2000). The decrease in DM content with increased level of nitrogen might be due to loss of significant portion of the weight of plant tissue upon dehydration.

Contrary to the DM and DDM, the CP and CF of present study showed increasing trend which is in agreement with Ayub, *et al.*(2001) in Maize and Ammaji and Suryanaraana (2003) in sorghum. The implication is that application of nitrogen made more nitrogen to be available in soil for increased uptake and contents in plant tissue. The increase in CF with nitrogen level could also be related to the observed decrease in L/S (Table 1). Kilcher and Troelsen (1973) found much higher structural cell wall constituents in stems than in leaves of oat. Since the structural carbohydrates (lignin, cellulose and hemicelluloses) are less digestible, the observed increase in CF with nitrogen levels might have reduced the DDM in plant tissue (Table 2). The observation is in agreement with Collin *et al*. (1990) and Kumar *et al.* (2001) who found more indigestible components of fibre with increased levels of nitrogen. Kilcher and Troelsen (1973) also reported negative correlation of digestibility with lignin in oat.

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

In the present study UPO-212 also showed non-significantly ($P>0.05$) more DM than Kent (Table 3 and 4) which is in conformity with reports of Kumar (2001). The higher dry matter content of UPO-212 might be due to the observed more number of days taken to attain 50% heading, more dry matter accumulations in stem and lower L/S. This is in agreement with findings of Collin *et al.* (1990) who reported more dry matter content in late heading cultivars than in early heading cultivars. The higher crude fibre content observed in UPO-212 than in Kent (Table 3 and 4) could also be due to more structural carbohydrates deposit such as, lignin, cellulose, and hemicelluloses.

In the present work Kent showed higher digestible dry matter content than UPO-212 is in agreement with findings of Raghubanshi *et al.* (2002) and Kumar *et al.* (2001). The higher digestible dry matter content in Kent could be due to more L/S in Kent than in UPO-212 is in agreement with the higher digestibility of leaves than stem reported by Kilcher and Troelson (1973). The non-significantly ($P> 0.05$) higher CP observed in Kent (Table 3 and 4) contradicts Raghubanshi *et al*. (2002) and Kumar *et al.* (2001). The deviation of the present finding might be due to combined effects of high nitrogen induced

lodging and late heading in UPO-212 (Table 1). Lodged plants are often subjected to nutrient loss due to leaf shattering and decomposition. Similarly late heading cultivars have less crude protein with more fiber contents than early heading ones (Collin *et al.,* 1990*)* 1990. In the present work UPO-212 recorded significantly ($P<0.05$) higher crude fiber content than Kent is in agreement with Raghubanshi *et al.* (2002).

Conclusions

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

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Table 1: Effect of applying different levels of nitrogen on morphological characteristics of forage oat

Morphological characters	PLH (number 0.5m-1 row)	NSH (number 0.5m-1 row)	NGL (number 0.5m-1 row)	NDL (number 0.5m-1 row)	TNL (number 0.5m-1 row)	LAI	DMAL (g 0.5m-1 row)	DMAS (g 0.5m-1 row)	TDMA (g 0.5m-1 row)	L/S	EGC (number 0.5m-1 row	D50 (days)	LGP (%)
Nitrogen level (kg ha-1)													
0	113.9d	33.6d	101.1d	54.6b	155.6d	4.11d	22.38c	41.80d	64.18e	0.54a	26.4c	111.6a	0
40	134.6c	41.8c	113.3c	76.6a	189.9c	6.65c	28.38b	65.50c	93.88d	0.43b	27.8bc	106.0b	0
80	145.4b	48.3b	129.4b	79.4a	208.8bc	7.78b	31.38a	77.00b	108.38c	0.41bc	28.9abc	104.5b	0
120	149.1a	51.9a	158.0a	83.4a	241.4a	8.33a	33.25a	86.13a	119.38a	0.39bc	29.6ab	104.1b	16.3b
160	151.2a	49.5ab	136.0b	79.5a	215.5b	8.40a	31.75a	85.13a	116.88b	0.37c	31.0a	105.1b	28.1a
SEm+	0.8	1.1	3.6	5.8	7.6	0.14	0.73	1.55	0.50	0.02	0.8	1.1	2.7
LSD ($p < 0.05$)	2.8	3.3	10.5	16.9	21.9	0.42	2.14	2.94	1.43	0.04	2.5	3.3	7.8
Variety													
Kent	130.4b	43.3b	130.4	68.3b	193.0b	6.99b	30.95a	68.38b	99.33b	0.45	31.2a	104.9b	2.3b
UPO-212	147.3a	46.9a	127.6	81.1a	211.5a	7.05a	27.90b	73.84a	101.74a	0.38	26.3b	107.7a	15.5a
SEm+	1.0	0.7	2.3	3.8	5.9	0.90	0.47	0.98	0.31	0.01	1.3	0.6	1.7
LSD ($p < 0.05$)	1.8	2.1	NS	10.7	13.9	0.26	1.35	1.86	0.90	NS	3.9	1.72	4.9

Figures with different alphabetical letters in a column are significantly different at $P< 0.05$

PLH= Plant height, NSH= Number of shoot, NGL= Number of green leaf NDL= Number of dry leaf, TNL= Total number of leaf, LAI= leaf area index, DMAL = Dry matter accumulation through leaf, DMAS= Dry matter accumulation through stem, and TDMA= total dry matter accumulation through aerial plant part, L/S leaf to stem ratio, EGC= Emergence count, D50= days to 50% heading, LGP= lodging percentage and NS= non significant

Table2: Interaction effect of level of nitrogen and variety on morphological characteristics of forage oat

morphological characteristics												
	PLH (number 0.5m-1 row)		NSH (number 0.5m-1 row)		NGL (number 0.5m-1 row)		TNL (number 0.5m-1 row)		DMAS (g 0.5m-1 row)		TDMA (g 0.5m-1 row)	
Nitrogen level (kg ha-1)	Kent	UPO-212	Kent	UPO-212	Kent	UPO-12	Kent	UPO-212	Kent	UPO-212	Kent	UPO-212
0	89.5g	38.4h	30.8de	36.5d	95.8f	106.5ef	174.5d	137.0e	40.62g	42.97g	62.38h	65.97g
40	126.8f	142.5d	35.3de	48.3b	108.3ef	118.3de	181.0cd	198.8bcd	62.75f	68.25ef	89.25f	98.50e
80	148.6bc	142.2d	46.5bc	50.0b	133.5bc	125.3cd	187.8cd	229.8b	74.00de	80.00cd	103.25d	113.50c
120	151.4b	146.8c	48.0b	55.8a	174.8a	141.3b	210.5bc	272.3a	81.50bc	90.75a	112.75c	126.25a
160	134.9e	166.6a	56.8a	42.3c	139.8bc	132.3bc	211.3bc	219.8	83.00bc	87.25ab	114.00c	120.00b
SEm+	1.4		1.6		5.12		10.7		2.20		0.70	
LSD ($p < 0.05$)	4.0		4.7		14.86		31.1		6.38		2.02	

Figures with different alphabetical letters in a column are significantly different at $P< 0.05$

PLH= Plant height, NSH= Number of shoot, NGL= Number of green leaf, TNL= Total number of leaf, DMAS= Dry matter accumulation through stem and TDMA= total dry matter accumulation through aerial plant part

Table 3: Effect of application of different level of nitrogen on yield and quality of forage oat

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

Figures with different alphabetical letters in a column are significantly different at $P< 0.05$
GFY= Green forage yield, DMY= Dry matter yield, CPY=Crude protein yield, DDMY=Digestible dry matter yield, DM= Dry matter content, CP= crude protein content, DDM= digestible dry matter content, CF= crude fiber content and NS= non significant

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

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

Figures with different alphabetical letters in a column are significantly different at $P< 0.05$

GFY= Green forage yield, DMY= Dry matter yield, CPY=Crude protein yield, DDMY=Digestible dry matter yield and CF crude fiber content

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Assessment of the prevailing handling, transportation, marketing and quality of eggs collected from local scavenging hens in Bure district, North-West Ethiopia

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Abstract

A repeated and cross-sectional survey together with egg quality analysis was conducted in seven selected farmer's kebele of Bure district, North West Ethiopia. The major objective of the study was to assess the prevailing handling, storage and quality of local/scavenging hen eggs in the district. A formal survey with structured questionnaire was used to collect all the relevant data, using a multi-stage sampling technique (purposive and random). Seven farmer kebeles (2 from highland, 3 from mid-altitude and 2 from lowland agro-ecologies) and a total of 280 village chicken owner households were considered for the study. In addition 1000 local hen eggs were collected in all seasons and egg sources (markets and producer) and used for the study. Internal and external egg quality traits including: egg shell color, egg length (EL), egg width (EWd), shape index (SI), shell weight (EW), shell thickness (ST), Albumen height (AH), yolk height (YH) and Hough units (HU) were measured. The results indicated that 71.4% of village chicken owners stored eggs inside earthen material (clay) together with grains or straws. The majority of village chicken owners (69.3%) of the study district were involved in selling of eggs. Selling of eggs was done in various places including: urban markets, local markets and farm gates. Women & children (43.2%) were the most important members of the household that were involved in marketing of eggs in the district. Large proportion of the chicken owners (66.4%) use hand carrying to transport eggs to markets. Plastic containers (festal) and grass made bags (locally called 'kofeda') were used. The average egg weight was 43g (ranged 34-60g). The mean egg width and egg length measurements were 37.2mm and 50.8mm, respectively. Thus, the average shape index percentage was calculated and found to be 73.2%. The average albumen height and yolk height were 4.1mm and 15.1mm, respectively. The mean Hough unit was calculated using albumen height and egg weight and found to be 66.5 (ranged 36.4-84.8). The average egg shell thickness measurements for sharp region, equatorial region and blunt regions were 0.27mm, 0.26mm and 0.24mm,

respectively. Hence the average egg shell thickness was found to be 0.26 mm. It was generally noted that local hen eggs collected from Bure district were poor in quality as compared to the quality of eggs collected from intensively managed local hens. And this indicated that the quality of local hen egg's of the district could be partially improved by chicken management interventions such as; proper housing, feeding, health care and good handling of eggs.

Keywords: local chicken's ecotypes, scavenging, internal and external egg quality traits, phenotypic correlation.

Introduction

In Ethiopia chickens are the most widespread, and almost every rural family owns village birds, which provide a valuable source of family protein and extra cash incomes (Tadelle *et al.,* 2003). The number of chicken flocks per household of most Ethiopian rural community is small in number and containing birds from each age group (Tadelle and Ogle, 1996). The total chicken population in the country is estimated to be 32.2 million (CSA, 2005). The majorities (94.12%) of these birds are indigenous breeds/ecotypes and maintained under a traditional system with little or no inputs for housing, feeding or health care (CSA, 2005).

Although eggs contain approximately 74% water, they are potentially important and balanced source of essential amino acids as well as some minerals and vitamins. Egg proteins contain all essential amino acids and therefore egg protein is used as standard for measuring the nutritional quality of other food products (FAO, 2003). A typical egg would contribute 3-4% of an adult's average energy requirement per day and has approximately 6.5g of protein (Sparks, 2006). Furthermore, chicken meat and eggs come in small packages and could be stored in hot climates under local conditions more easily than most foods of animal origin. Eggs keep their quality at room temperature without spoilage for at least 10 days to 2 weeks if stored in cool places (Sparks, 2006).

External and internal qualities of eggs are of major importance to the egg industry worldwide. However, they are not being given a due attention in the developing world, where the majority of the eggs are coming from free scavenging village chicken, as compared to that of the developed world (Juliet, 2004). Egg's internal and external quality could be influenced by factors like; genetic factors, environmental factors (such as temperature, relative humidity and the presence of CO_2), hen age, nutrition status, egg storage condition and storage time (Juliet, 2004). A good quality egg should be free from internal blemishes

such as blood spots, pigment spots and meat spots (Hamilton, 1982). In numerous researches, it has been reported that the external and internal quality of chicken eggs had significant effects on the hatchability of fertile eggs, weight and development of the day-old chicks and marketability of eggs (Nordstrom and Ousterhout, 1982).

The significance of the egg as a protein source for the nourishment of humans led the consumers to demand for some qualities in this nutrient (Uluocak *et al.*, 1995). External and internal qualities of eggs are of major importance to the egg industry worldwide. However, they are not being given a due attention in the developing world, where the majority of the eggs are coming from free scavenging village chicken, as compared to that of the developed world (Juliet, 2004).

To date there are no detailed studies conducted in the region and the study district targeted on a comprehensive description of the prevailing handling and storage of local hen eggs and assessment of internal and external quality of marketable eggs. Therefore, the study was designed to (1) assess the existing handling, storage, consumption, marketing and transportation of eggs; (2) assess the purpose/function of eggs in the district; and (3) evaluate the external and internal quality of local hen eggs.

Materials and methods

Description of the study district

The study was conducted at Bure district found in Amhara National Regional State (ANRS), North-West Ethiopia. According to ANRS-BoFED (2007), the study district has an agricultural household size of 39,323 (6370 female and 32953 male) and he total human population was estimated to be 281,310 (141,683 males & 139,627 females). From the total human population, 85 % were rural community and 15% were urban dwellers (Bure, 2007). The study district has a total of 27 kebeles, from which 5 are urban and 22 are rural kebeles. Burie, the administrative and commercial center of the district, is located 420 kms North-West of Addis Ababa and 148kms South-West from Bahir-Dar town. The study district has a total land area of 2207.2 km^2. The average altitude is estimated to be 1689masl (ranged 728-2832masl). The mean annual rain fall is estimated to be 1689.4mm (ranged 713-2832mm) and the average temperature is 18.97^{o}c (ranged 13-24^{o}c).

Livestock is considered as an important component of the prevailing crop-livestock mixed farming systems of the study district. Small holder farmers of the study area owned various livestock species such as; cattle, sheep, goat, chicken and equines. According to Burie (2007), the study district is reported to have a total population of 129,265 for cattle, 39,066 for sheep, 6,895 for goats, 16,335 for donkeys, 479 for mules, 188,310 for chicken and 13,329 bee hives.

The study district contains all the three agro-ecologies: highland (*'Dega'*), mid altitude (*'Woyna daga'*) and lowland *('Kola'*) with the higher proportion (77%) of mid altitude agro ecology. The district is known to have highest potential for crop and livestock production in the region. In the study district, crop production is highly related to village chicken production, with high seasonal fluctuation of feeds availability, high prevalence of disease and other production and marketing constraints (Burie, 2007).

Selection of the study sites and sampling techniques

A multi-stage sampling procedure (purposive & random) was applied for the study. Hence, the study district was purposively selected and divided in to three agro-ecologies based on altitude as: highland (>2500masl), mid-altitude (1500-2500masl) and low-land (<1500masl). Then, two rural kebeles from the highland, two rural kebeles from lowland and three rural kebeles from mid altitude were selected based on agro-ecology representation, village chicken production potential and accessibility. Therefore, a total of 7 representative rural kebeles were selected for the study purposively.

All village chicken owner households found in all the selected rural kebeles were freshly registered and then a simple random sampling technique was applied to choose 40 village respondents in each of the selected farmer kebeles by giving equal chance for those farmers having different flock size, chicken husbandry systems and other related practices. Hence, a total of 280 village chicken owner households were interviewed using a pre-tested structured questionnaire.

In addition, 1000 local hen eggs (500 from markets and 500 directly from producers) were collected in different seasons (dry and rainy) of the year and market types (primary and secondary) and transported to Andassa Livestock Research center for analysis. The eggs were collected from all agro-ecologies of the study district and each egg was evaluated for internal and external quality with in 2 days of collection. A representative data from 600 eggs were used for

analysis and the rest of the eggs were removed due to various problems like, rupture of yolk during breakage, presence of very thin shells, etc.

Data Collection

All the relevant data were collected through personal and house to house interviews using structured questionnaire and laboratory analysis. Some of the internal and external egg quality traits measured and the method of measurement/calculation were presented as follows:

I. External egg quality parameters:

1. Egg weight (g), (measured using digital weighing material/balance)
2. Shell thickness (mm), (measured using digital caliper)
3. Dried Shell weight (g), (measured using digital balance after drying with drying oven)
4. Egg shape index (%), [calculated using the formula: (Egg width/Egg length)*100]
5. Egg shell color (evaluated using visual observation)

II. Internal egg quality parameters:

1. Yolk height (mm), (measured using tripod micrometer)
2. Albumen height (mm), (measured using tripod micrometer)
3. Presence of blood spot and meat spot, (using visual observation)
4. Yolk color (measured using yolk color fun, ranged 1-15)
5. Hough Unit (HU), [calculated using the formula: $HU = 100\log (AH - 1.7EW^{0.37} + 7.6)$ where; HU = Hough unit, AH = Albumen height and EW = Egg weight] (Haugh, 1937)

Data management and statistical analysis

The qualitative and quantitative data-sets were analyzed using appropriate statistical analysis software (SPSS, 2002). The Duncan multiple range test and LSD were used to locate treatment means that are significantly different. The phenotypic correlation values related to egg quality traits were determined by the Pearson Correlation Analysis (Snedecor and Cochran, 1980). More specifically descriptive statistics and general linear model (GLM) were

used for the study. Tables and figures used to present summary statistics such as mean, standard deviation and percentages.

The following regression models were employed as applicable to each case: $Y = a + bx$ (simple linear regression); $Y = a + b_1X_1 + b_2X_2 + \ldots b_kX_k$ (multiple regressions). Where; Y = dependent/response variable (egg weight), a = intercept (the value of the dependent variable when the independent is zero), b = regression coefficient and x = the independent variable (egg length, egg width).

The following linear models used during analysis of quantitative data: Model statement regarding the effect of egg source on various egg quality parameters:

$$Y_{ij} = \mu + m_i + \varepsilon_{ij}$$

Where: Y_{ij} is the egg quality performance parameter estimate for egg j in egg source i, μ is the overall mean, m_i is the fixed effect of independent variable, egg source (i=2; market and farm gate) and ε_{ij} is the error. The effect of agro-ecology was not considered when analyzing data

Results and discussion

Purpose of village hen eggs

According to interviewed village chicken owners egg hatching for replacement (71.7%) was the first function/purpose of eggs in the study district (Table 1). The second and the third purpose of eggs in the study district were sale for cash income (58%) and home consumption (68.6%), respectively. Tadelle and Ogle (1996) reported that the major uses of eggs in rural societies of central Ethiopian high lands were hatching for replacement (51.8%), sale for cash income (22.6%) and home consumption (20.2%).

Table 1. Purpose of local hen eggs in Bure district, North-West Amhara, Ethiopia (N=280).

Purpose of eggs	Agro-ecology									Total (Study district)		
	High-land (N=80)			Mid-altitude (N=120)			Low-land (N=80)					
	1st (%)	2nd (%)	3rd (%)	1st (%)	2nd (%)	3rd (%)	1st (%)	2nd (%)	3rd (%)	1st (%)	2nd (%)	3rd (%)
Sale for income	15	60	17.5	18.3	42.9	27.5	7.5	70	18.8	14	58	21.4
Hatching for replacement	70	25	12.5	70.8	31.3	9.2	75	22.5	6.3	72	26	9.6
Home consumption	15	15	70	10.8	25.8	63.3	17.5	7.5	75	14	16	69

1st = First purpose eggs; 2nd = Second purpose eggs; 3rd = Third purpose eggs

Consumption of eggs in the study district

The current study identified that 52.8% of village chicken owners of the study district consumed eggs only during religious/cultural holidays, 42.5% consumed every time when needed and available, 2.5% when only they got sick and 2.2% reported that they never eat eggs. The result of the current study also showed that there were no any cultural/religious taboos against rearing a special type of chicken, not to eat chicken products and not to sell chicken & eggs. This was similar with the findings of Tadelle et al., (2003), who reported that there were no any cultural/religious taboos relating to consumption of eggs and chicken meat, like those for pig meat, in central high lands of Ethiopia.

Storage/handling of eggs in the district

Concerning storage of eggs for incubation, sale and consumption purposes; 71.4% of village chicken owners (mainly rural women) stored eggs inside earthen material (clay) together with grains or straws. It is observed that the use of grains and straws with eggs protect eggs from breakage and provide suitable environment while storage. Regarding duration of egg storage, it is observed that 95% of village chicken owners in the study district stored eggs until the end of 1 clutch period and the hen started broodiness characteristics. Figure 1 showed some pictures of various locally made containers used for egg storage in the district.

Earthen pot with grains

Earthen pot with straws

Mud made container with grain

Figure 1. Locally made containers used for egg storage in the district.

Egg transportation and marketing

The result of the current study indicated that 69.3% of village chicken owners of the study district were involved in selling of eggs. Selling of eggs was done in various places of the study area including: urban markets, local markets and farm gates. Women & children (43.2%) were the most important members of the household that were involved in marketing of eggs in the district. Most consumers of the study area (75%) preferred to buy and consume scavenging hen eggs as they were considered to be tasty and the dark colored yolk was commonly favored.

Urban market was the first priority place for most chicken owners (70%) of the study area for sale of eggs followed by nearest local markets and farm gate sales. The price of eggs was not similar during the year; it was gener-

ally low during the Orthodox Christian fasting months. In addition to selling, exchange of fertile eggs (mainly eggs from exotic chicken breeds) with other village chicken producers was common in the study area.

The result of the current study revealed that majority of chicken owners (66.4%) used hand carrying (using piece of cloths with grains/straw) to transport eggs to markets. Plastic containers (festal) and grass made bags (locally called *'kofeda'*) were also used to transport eggs to markets. Figure 2 showed some pictures of egg transportation and marketing in the district.

Transport of eggs with a piece of cloth & grain

Marketing of eggs in local markets

Figure 2. Egg transportation and Marketing in the district

External egg quality

The result of the study revealed that 49% of eggs collected from the study district were white shelled, 45% were light brown shelled and 6% were cream color shelled (Table 2). The result indicated that local chicken ecotypes of the study district were producing eggs with a mixture of shell colors. Similarly, Halima (2007) reported that the shell color of eggs collected from local hens of North West Ethiopia were a mixture of white, light brown and cream colors. The result also indicated that only 34% of the eggs collected from the study area were with clean shells.

The result of the current study showed that the average weight of eggs was 43g (ranged 34-60g). There was no any significant difference in average weight of eggs collected from different sources. The result was similar with the reported 42.9g by Hallima (2007), for eggs collected from seven local chicken ecotypes of North West Ethiopia. Teketel (1986) also reported an average egg weight of 46g for Ethiopian local chicken. Similar results were also reported by Asuquo *et al*. (1992) for eggs of Nigerian local breed chicken, which was 40.6g. Olori and Sonaiya (1992) also reported an average egg weight of 38.9g, 37.1g, & 37g for Brown, Light Brown & White Nigerian local chicken, respectively. However; the average egg weight result (43g) obtained from this study was higher than the reported egg weight range of 35-39g by Ahmed (1994) for Bangladesh indigenous scavenging chicken eggs.

The result of the current study indicated that the average dry shell weight of local hen eggs of the study district was 3.3g. However, a relatively higher average dry shell weight of 3.95g and 5.7g were reported by Halima (2007) for eggs collected from intensively managed local hens of North West Ethiopia and RIR chicken breeds, respectively.

Table 2. External qualities of eggs collected from Bure district, North West Ethiopia, (N=600)

parameters	Egg Source		Grand Mean (N=600)
	Market purchase (N=300)	Farm gate (N=300)	
Shell color (%)			
White (W)	50	48	49
Light Brown (LB)	44	47	45
Cream (C)	6	5	6
Sanitary status of eggs (%)			
Clean	22	45	34
Dirty	88	55	66
Crackness of eggs (%)			
Normal	100	100	100
Egg weight (g) (Mean ± SD)	43.2±5.0[a] (35-60)*	43.2±3.5[a] (34-54)	43.2±4.3 (34-60)
Dry shell weight (g) (Mean ± SD)	3.3±0.1[a] (2-2.6)	3.2±0.2[a] (2-2.7)	3.3±0.2 (2-2.7)
Egg width (mm) (Mean ± SD)	37.9±2.8[b] (31.6-45.9)	36.3±3.2[a] (31.6-54.5)	37.2±3.1 (31.6-54.5)
Egg length (mm) (Mean ± SD)	51.8±3.5[b] (42.9-59.8)	49.8±4.1[a] (39.0-59.8)	50.8±3.9 (39.0-59.8)
Shape index (%) (Mean ± SD)	73.3±3.2[a] (63.9-82.4)	73.1±4.9[a] (64.7-100)	73.2±4.2 (63.9-100)
Average shell thickness (mm)			
sharp region (Mean ± SD)	0.30 ±.04	0.27±.03	0.27 ±03
equatorial region (Mean±SD)	0.26 ±.03	0.27 ±.03	0.26 ±.03
blunt region (Mean ± SD)	0.24 ±.03	0.24±.03	0.24 ±.03
Average egg shell thickness (Mean ± SD)	0.25 ±.03[a] (0.18-0.34)	0.26 ±.03[a] (0.20-0.34)	0.26 ±0.03 (0.18-0.34)

[a,b]Least squares means with different superscripts with in a raw are significantly different ($P < 0.05$); * Numbers in brackets are range values

The result of the study indicated that the mean width and length of local hens eggs collected from different sources of the study district were 37.2 mm and 50.8 mm, respectively. Accordingly, the average shape index percentage was calculated and found to be 73.2%. The result did not show any significant difference between eggs collected from different sources with regard to average shape index percentage. The shape index percentage result (73.2%) obtained from this study was higher than the reported 66.9% for eggs of Nigerian Fulani chicken ecotypes (Fayeye *et al.,* 2005) and this indicated that local hen eggs collected from the study district were more circular than that of Nigerian Fulani eggs. The "normal" chicken egg is elliptical in shape. Eggs that are unusual in shape, such as those that are long and narrow, round, or flat-sided cannot

be placed in Grades AA or A. The higher and lower shape index measurement showed the deviation of eggs from its normal (oval) shape, which has an influence on hatchability performance. In addition, round eggs and unusually long eggs have poor appearance and do not fit well in cartons so are much more likely to be broken during shipment than are eggs of normal shape.

The average shell thickness measurements of eggs for sharp region, equatorial region and blunt region were 0.27 mm, 0.26 mm and 0.24 mm, respectively. The result also revealed that the sharp region shell was relatively thicker than both the blunt region and equatorial region shell. Based on the above shell thickness measurements, the average shell thickness was calculated and found to be 0.26 mm. The result was lower than the reported 0.71mm & 0.69mm by Halima (2007) for eggs collected from intensively managed local chicken ecotypes of North-West Ethiopia and RIR chicken breeds, respectively. Similarly, Teketel (1986) reported a mean egg shell thickness of 0.35mm for Ethiopian local breed chicken eggs. Asuquo *et al.* (1992) also reported an average egg shell thickness of 0.30 mm and 0.35 mm for Nigerian local breeds and Isa-Brown breed chicken eggs, respectively.

The result of the current study also showed that there was no significant difference between eggs collected from different sources of the study area, with respect to average egg shell thickness. The recognized lower average shell thickness (0.26 mm) might be attributed to deficiency of calcium and phosphorus sources in scavenging feed resource basis, which was the major feed source for village birds of the study area.

Internal egg quality

The average yolk height and albumen height measurements of local hen eggs collected from different sources of the study area were 15.1mm and 4.1mm, respectively (Table 3). The average Hough unit value was calculated using albumen height and egg weight measurements and found to be 66.5. The result revealed that there was no significant difference between eggs collected from markets and farm gates with related to average Hough unit values.

The average Hough unit value obtained from this study was higher than the reported 61.1 by Halima (2007) for eggs collected from local chicken ecotypes of North-West Ethiopia and lower than the reported 81.0 by the same author for eggs collected from intensively managed RIR chicken breeds. Asuquo *et al.* (1992) also reported higher Hough unit values of 79.8 and 89.9 for eggs collected from Nigerian local hens and Isa-Brown chicken breeds, respectively.

The current study indicated that local hen eggs of the study district could not be categorized as best in quality based on the obtained average Hough unit value (<72). The lower Hough unit value recorded in this study might be attributed to poor handling and storage of eggs until sale or hatching. Therefore, technological interventions focused in increasing awareness of village chicken owner farmers on proper handling and storage of eggs could be important.

The yolk color of local hen eggs was estimated using roach color fun (ranging 1-15). Each egg was examined by 3 observers and the average value was calculated and recorded. Accordingly, the mean yolk color of local scavenging hen eggs of the study district was calculated to be 8.6. The average yolk color result (8.6) indicated that local scavenging hens of the study area are producers of yellow yolk colored eggs. The survey also indicated that yellow yolk colored eggs were more favored by consumers of the study district.

The mean yolk color result (8.6) obtained from this study was higher than the reported 3.48 and 4.0 by Halima (2007) for eggs collected from intensively managed local hens of North-West Ethiopia and RIR chicken breed hens, respectively. Pavlovski *et al.* (1981) also reported that the yolk color score of free range local hens was higher compared to eggs collected from hens managed under intensive chicken management condition. The higher yolk color value obtained from the current study indicated that scavenging feed resource bases of the study area were rich in xanthophylls, some of which are precursors of vitamin A.

Table 3. Internal quality of local hen eggs in Bure district North West Ethiopia, (N=600)

Traits/Variables	**Egg Source**		**Grand mean (N=600)**
	Market purchase (N=300)	**Farm gate (N=300)**	
Yolk height (mm) (Mean ± SD)	15.1±1.2 [a] (8.4-18.4)*	15.2±1.4 [a] (11.3-17.5)	15.1±1.3 (8.4-18.4)
Albumen height (mm) (Mean±SD)	3.9±0.74 [a] (2.3-6.7)	4.2±2.60 [a] (2.1-7.6)	4.1±1.93 (2.1-7.6)
Hough Unit (HU) (Mean±SD)	66.2±6.8[a] (45.2-84.8)	66.9±7.5 [a] (36.4-81.7)	66.5±7.2 (36.4-84.8)
Average yolk color (1-15)	8.5±1.5 [a] (5.3-11.3)	8.7±1.4 [a] (6-11.7)	8.6±1.5 (5.3-11.7)

[a,b]Least squares means with different superscript with in a raw are significantly different

(P < 0.05); *Numbers in brackets are range values

Phenotypic correlation of external egg quality traits

The results of this study revealed that egg weight (EWt) was significantly and positively correlated (P<0.01) with most external egg quality traits like; egg width (EWd), egg length (EL), egg shape index (SI), egg shell thickness (ST) and dry shell weight (SW) (Table 4). The result was inline with the findings of Farooq *et al.* (1989) and Abanikannda *et al.* (2007), who reported positive correlations between egg weight and other external egg quality traits like; shell weight, egg width, egg length, shape index and shell thickness. However, the significant positive correlation value (0.12) between the egg weight & egg shape index obtained in this study was in disagreement with the negative correlation reported by Iscan and Akcan (1995).

Egg width was also positively correlated with other external egg quality traits like; egg length, egg shape index and dry shell weight. Egg length was negatively correlated with shape index and positively correlated with shell weight. Shell thickness showed a significant positive correlation with dry shell weight.

Table 4. The phenotypic correlations between external egg quality traits, (N=600)

External egg quality traits	EWt (g)	EWd (mm)	EL (mm)	SI (%)	ST (mm)	SW(g)
EWd (mm)	**0.49****					
EL (mm)	0.45**	0.78**				
SI (%)	0.12	0.44**	-0.22			
ST (mm)	0.16	0.04	0.1	-0.05		
SW (g)	0.52**	0.09	0.09	0.12	0.38**	

EWt = Egg weight, EWd= Egg width, EL= Egg length, SI= Shape index, SD= Shell density, ST= shell thickness, SW= Shell weight

** Correlation is significant at the 0.01 level (2-tailed)

Phenotypic correlation of internal egg quality traits

A detail of the phenotypic correlation of internal egg quality traits is presented in Table 5. Statistically significant positive correlation (P<0.01) was observed between albumen height and other egg quality traits like; yolk height and Hough unit. Similarly, significant and positive correlation was recorded between yolk height and Hough unit. Akbas *et al.* (1996) also reported significant positive correlations between internal egg quality traits including, yolk height and the albumen height (0.48), yolk height and Hough unit (0.52) and albumen height and Hough unit (0.97). Likewise, Ozcelik (2002) reported significant positive correlation between albumen height and the Hough unit (0.97).

Table 5. The phenotypic correlations between internal egg quality traits, (N=600)

Internal egg quality traits	Albumen height (mm)	Yolk height (mm)	Hough unit (HU)
Albumen height (mm)	1.0		
Yolk height (mm)	0.19	1.0	
Hough unit (HU)	0.41**	0.38**	1.0

** Correlation is significant at the 0.01 level (2-tailed)

Phenotypic correlation between internal and external egg quality traits

The result of the current study indicated that egg width (EWd) showed significant and negative correlation with yolk height (-0.27) and Hough unit (-0.23) (Table 6). A significant negative correlation was also recorded between egg weight (EWt) and Hough unit (-0.13). Correspondingly, Ozcelik (2002), Iposu *et al.* (1994) and Shawkat (2002) reported significant negative correlations between Hough unit (HU) and egg weight (EWt).

Positive correlation was observed between egg weight (EWt) and other internal egg quality traits including, albumen height (0.1) and yolk height (0.1). Likewise, Silversides (1995) & Zhang *et al.* (2005) reported significant positive correlation between egg weight (EWt) and albumen height. In this study, significant negative correlation was observed between egg length and other internal egg quality traits including, yolk height (-0.24) and Hough unit (-0.27).

Table 6. The phenotypic correlations between external and internal quality traits, (N=600).

Traits	EWt (g)	EWd (mm)	EL (mm)	SI (%)	AH (mm)	YH (mm)
EWd (mm)	0.49**					
EL (mm)	0.45**	0.78**				
SI (%)	0.12	0.44**	-0.2			
AH (mm)	0.1	0.02	0.01	0.01		
YH (mm)	0.1	-0.27	-0.24	-0.069	0.19**	
HU	-0.13	-0.23	-0.27**	0.034	0.41**	0.38**

EWt = Egg weight, EWd= Egg width, EL= Egg length, SI= Shape index, AH = Albumen height, YH= Yolk height, HU= Hough Unit

** Correlation is significant at the 0.01 level (2-tailed)

Prediction equations of selected egg quality traits

The result of the current study indicated that egg weight (EWt) could be predicted from egg length (EL) and egg width (EWd) measurements separately with sufficient reliability (R^2 = 20.3% and 24.3%, $p<0.05$). However, a better and more reliable estimate was obtained when both egg length (EL) and egg width (EWd) were fitted into the model (R^2 = 25.4 %) (Table 7). The result of the present study was in line with the findings of Yakubu *et al.* (2008) with regard to the positive estimation of egg weight (EW) from egg length (EL) and egg width (EWd).

Table 7. Prediction equations of selected egg quality traits, (N=600)

Functions	R^2 (%)	Significance
$Y_1 = 0.69X_1 + 18.03$ *	20.3	* (+ve)
$Y_1 = 0.5X_2 + 17.55$ *	24.3	* (+ve)
$Y_1 = 0.18X_1+0.51X_2+14.98$ *	25.4	* (+ve)

Y_1 = Egg weight; X_1= Egg length; X_2=Egg width
R^2 = Coefficient of determination; *$p < 0.05$

Conclusions

- The current study indicated that local/scavenging hen eggs were more preferred for the existing domestic market mainly due to the presence of yellow colored yolks.
- The lower internal and external quality trait measurements (like; egg weight, shell thickness, Hough unit) recorded in this study, as compared to the observed results in intensively managed local hen eggs in other studies, indicated that the quality of eggs could be improved by relatively simple changes in management interventions such as, proper housing, feeding, health care of local birds and good management/handling of eggs.
- As most of village chicken husbandry (feeding, housing, and health care), egg storage/handling and marketing activities of the study district are implemented by women, provision of successive trainings to rural women would be essential for future improvement of the sector.

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Information for Contributors

General

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

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

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

Objectives

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

Columns of the Journal

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

Research articles

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

Short communications

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

Review articles

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

Feature articles

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

Technical notes

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

Correspondence

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

Frequency of publication

Once a year (May)

Guidelines to Authors

General

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

Manuscripts should be written in English, double spaced throughout and should be on one side of an A4 sheet. Authors are advised to strictly stick to the format of the journal. Submit three copies of manuscript and each page should be numbered. An electronic form in Word format should also accompany the manuscript. The disk should be clean from viruses, and should be labelled clearly with the authors' names and disk file name. Manuscripts submitted to the Editorial Office will be duly acknowledged. All articles will be sent to at least two reviewers (within or outside the country) selected by the Editorial Board and will be reviewed for relevance to the journal, scientific value and technicality. Rejected papers will be returned to the author(s) immediately. Accepted papers will be returned to the author with the comments of the reviewer(s) for further improvement of the manuscript. EJAP has no page charge.

Proofs will be sent to the author. Typeset proofs are not checked for errors. Thus, it is the responsibility of the primary author of each paper to review page proofs carefully for accuracy of citations, formulae, etc. and to check for omissions in the text. It is imperative that the authors do a prompt, thorough

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Format for Manuscripts

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

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

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

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

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

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

Materials and methods: The techniques and procedures of the research, the conditions under which the study was conducted and the experimental design

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

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

*Tables***:** Tables are numbered consecutively in arabic numerals (e.g., Table 1) and should bear a short, yet adequately descriptive caption. Avoid using vertical and/or horizontal grid lines to separate columns and/or rows. Metric units are clearly to be shown, abbreviated in accordance with international procedure. Footnotes to tables are designated by lower case which appear as superscripts in appropriate entries. Tables should be compatible with column width viz. 140 mm, and should be presented on separate sheets, and grouped together at the end of the manuscript. Their appropriate position in the text should be indicated and all tables should be referenced to in the text.

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

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

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

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)

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

Examples

Journal article:

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

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Book

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Chapter in a Book

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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; and
- 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.

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