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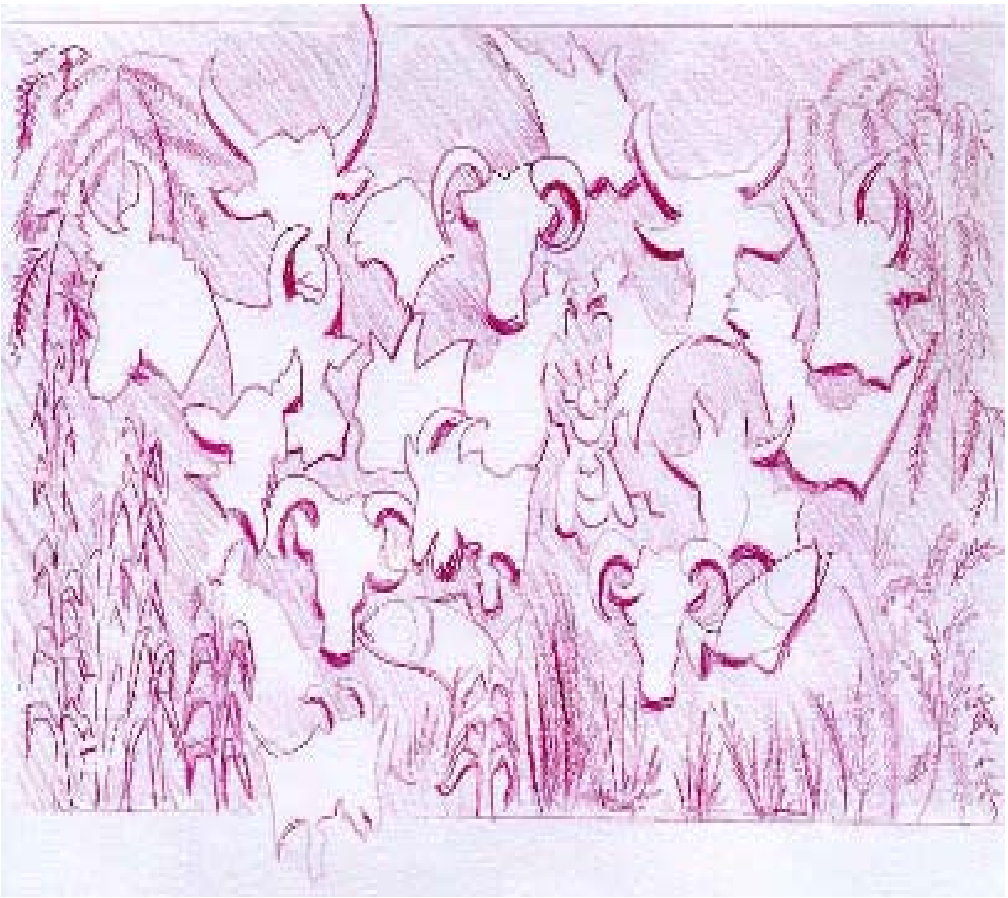

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Persistency of lactation and comparison of different persistency measures in indigenous and crossbred cows at Bako, Ethiopia

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Abstract

Persistency of lactation in indigenous and crossbred cows was studied using milk data collected at Bako Agricultural Research Centre. Persistency was measured using three methods vis-à-vis as the ratios of milk yield during the second (P2:1) and third (P3:1) 100 days of lactation to milk yield during the first 100 days of lactation, and using persistency index (PI). The overall mean P2:1, P3:1 and PI were 78.0±0.67, 59.2±0.58 and 85.7±0.70 percent, respectively. P2:1 was significantly (P<0.01) affected by sire breed, calving season and initial milk yield, while P3:1 and PI were significantly (at least P<0.05) affected by sire breed, calving season, calving weight and initial milk yield. Among the sire breed categories, Simmental crosses had significantly the highest P2:1 (86.7±1.93%), P3:1(67.9±2.14%) and PI (90.5±1.65%) while the Horro had the lowest values of these traits. Cows that calved during Bona (December to February) had the highest P2:1 (88.2±1.58%). The lowest P3:1 (46.9±2.22 %) and PI (77.2±1.82%) were recorded for cows that calved during Arfasa (March to May). Calving weight was linearly related to P3:1 (b = -0.08±0.02; $P < 0.001$) and PI (b = -0.04±0.02; $P < 0.05$). Similarly, initial milk yield was linearly and negatively related to P2:1 (b = -1.14±0.31; $P < 0.001$), P3:1 (b = -0.88±0.38; $P < 0.05$) and PI (b = -0.65±0.31; $P < 0.05$). All persistency values obtained in this study were lower for indigenous breeds than crossbreds indicating that these traits were improved through crossbreeding. Persistency was also affected by calving season, calving weight and initial milk yield, which are probably related to the availability of feed. Thus, improving the feeding system through strategic supplementation might improve persistency in both indigenous and crossbred cows. Besides, due to shorter lactation length of most indigenous cows and for periodic assessment of

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persistency of crossbred cows to make improvement interventions in the meantime, P2:1 and P3:1 are more appropriate compared to persistency index.

Key words: persistency, persistency index, Horro, Boran, Jersey, Friesian, Simmental

Introduction

Persistency is a measure of the shape of the lactation curve. It is a dimension less quantity (Wood, 1969; Cobby and Le Du, 1978) that can only be used for comparison of lactations. It is defined as the rate at which milk yield fall off from the maximum (Sanders, 1930); the degree to which milk yield in early lactation is maintained (Mahadevan, 1951); the ability of the cow to continue to produce at a higher level throughout the lactation (Cupps, 1966 as cited in Grossman *et al.*, 1999); the extent to which peak yield is maintained (Wood, 1967) or the ability to maintain a more or less constant yield during the lactation (Mahadevan, 1951). As a result of different definitions of persistency, persistency measures are inconsistent. Persistency measures have been expressed as ratio (or rate) of yields of different periods of the lactation (Madsen, 1975; Solkner and Fuchs, 1987; Ibeawuchi, 1988); as measures derived from variations of test day yields (Solkner and Fuchs, 1987; Grossman *et al.*, 1999); as measures constructed of parameters estimated from mathematical models of the lactation curves (Wood, 1968; Gravert and Baptist, 1976; Rowlands *et al.*, 1982) or using the number of days during which the level of constant yield is maintained (Grossman *et al.*, 1999).

Persistency has been studied in indigenous and crossbred cows in Ethiopia (Kiwuwa *et al.*, 1985; Gashaw, 1994; Mureja, 1994) and elsewhere in exotic and crossbred cattle (Madalena *et al.*, 1979; Ibeawuchi, 1988). All studies reported that persistency is affected by both genetic and non-genetic factors indicating that it is a trait specific to a breed, herd management practice and environmental condition. Thus, persistency, need to be estimated for a breed under the existing level of management of the farm in order to make follow up and on time adjustments in the feeding and management practices of the farm (Madsen, 1975). For instance, Solkner and Fuchs (1987) indicated that a flat lactation curve is of economic interest because it is easier to feed, the physiological strain on the cow by high daily milk yield (which often causes reproductive or metabolic disorders) is diminished and the proportion of roughages in the diet can be increased. Madsen (1975) also indicated that a

flat lactation curve (higher persistency) needs less concentrate during the lactation than a cow with the same total yield and steep lactation curve. Besides, the methods of calculating persistency are different, and hence it is appropriate to assess the suitability of different, if not all, persistency measurements developed elsewhere and recommend appropriate method for lactation yield of indigenous and crossbred cows. This study was, therefore, aimed at assessing persistency of indigenous and crossbred cows using different persistency measures and identifies the effects of genetic and non genetic factors affecting persistency of lactation in the centre.

Materials and Methods

The study was conducted based on data from Bako Agricultural Research Centre of Oromia Agricultural Research Institute. Details of the centre's climatic condition, livestock management, breeding and health care are indicated in previous works (Gebregziabher and Mulugeta, 1996).

Three persistency measures (P2:1, P3:1 and persistency index) were used to calculate persistency of milk yield of indigenous and crossbred cows:

1. P2:1:- the ratio between milk yield from 101 to 200 days after parturition and milk yield in the first 100 days of the lactation (Madsen, 1975)
2. P3:1:- the ratio between milk yield from 201 to 300 days after parturition and milk yield in the first 100 days of lactation (Madsen, 1975)
3. Persistency index (PI; Ibeawuchi, 1988):- To calculate persistency index (PI) each lactation curve was divided into four equal parts of ten weeks each after excluding the first five weeks that represented the initial rising phase of the lactation curve. The total ten weekly yield of each of the four periods was then calculated and the following ratios established $R_1 = X_2/X_1$; $R_2 = X_3/X_2$ and $R_3 = X_4/X_3$; where X_1, X_2, X_3 and X_4 were total milk production during the first, second, third and fourth period. R_1, R_2 and R_3 were then used to calculate the following weighting factors (W_1, W_2 and W_3); $W_1 = R_1/(R_1 + R_2 + R_3)$; $W_2 = R_2/(R_1 + R_2 + R_3)$; $W_3 = R_3/(R_1 + R_2 + R_3)$. The persistency index (PI) expressed in percentage was calculated for each cow as $PI = (W_1 * X_2/X_1 + W_2 * X_3/X_2 + W_3 * X_4/X_3) * 100$.

P2:1 and P3:1 do not allow use of milk yield data of cows with lactation lengths shorter than 190 and 290 days, respectively and such data were not included for calculating P2:1 and P3:1. Furthermore, persistency index was calculated based on milk yield data of 315 days lactation length. Short (<305 days) and long (>315 days) lactation lengths were not considered for calculating persistency index. Besides, cows with very long lactation length milk data of the first 315 days were utilized for the study. Thus, lactation records of 559, 315 and 234 were considered during the final analysis.

Persistency index, P2:1 and P3:1 were analysed using the General Linear Model of the Statistical Analysis System (SAS, 1999), which included fixed effects (sire breed, parity and calving season) and two covariates (calving weight (body weight of the cow shortly after calving) and initial milk yield (the first milk yield after the colostrums period)). Five sire breed categories (Jersey for Jersey x Boran and Jersey x Horro; Simmental for Simmental x Boran and Simmental x Horro; Friesian for Friesian x Boran and Friesian x Horro; Boran for pure Boran and Horro for pure Horro); six parity groups (one to six with the sixth parity including parities six and above pooled together) and four calving season categories *Gana* (June to August; main rainy season), *Birra* (September to November; post rainy season with small showers), *Bona* (December to February; dry season) and *Arfasa* (March to May; beginning of the rainy season) were considered as fixed effects. The General Linear Model used for the analysis was:

$$Y_{ijkl} = \mu + SB_i + P_j + CS_k + b_1X_1 + b_2X_2 + e_{ijkl}$$

Where:

Y_{ijkl} = l^{th} observation in the ith sire breed, j^{th} parity and k^{th} calving season

μ = the overall mean common to all observations

SB_i = the effect of ith sire breed (sire breed with i = 5)

P_j = the effect of jth parity of the cow (j = 6)

CS_k = the effect of kth calving season (k=4)

X_1 and X_2 are the effects of calving weight and initial milk yield, and b_1 and b_2 are corresponding slopes, respectively

e_{ijkl} = random error associated with l^{th} individual observation

Results

Results of analysis of variance of persistency are presented in Tables 1& 2. Persistency expressed as P2:1 was significantly (P<0.01) affected by sire breed, calving season and initial milk yield, while P3:1 and PI were significantly (at least P<0.05) affected by sire breed, calving season, calving weight and initial milk yield (Table 1). The effect of parity on P2:1, P3:1 and PI was not significant (P>0.05).

Table 1. Mean squares from analysis of variance of P2:1, P3:1 and persistency index (PI)

Source	Degree of freedom	Mean square		
		P2:1	P3:1	PI
Sire breed	4	7017.5***	2797.6***	348.5*
Calving season	3	12812.8***	4867.9***	1881.6***
Parity	5	498.3ns	116.9 ns	51.2ns
Calving weight	1	954.6ns	3554.9***	695.7*
Initial milk yield	1	6525.5***	1590.9*	660.3*
Error degree of freedom		544	300	219
Error mean square		313.1	292.9	147.9
R^2 (coefficient of determination)		32.2	25.0	21.6
Coefficient of variation		22.7	28.9	14.2

Significance level *** = *P* < 0.001; ** = P<0.01, * = *P* < 0.05 and ns (not significant) = P >0.05

The overall mean P2:1, P3:1 and PI were 78.0±0.67, 59.2±0.58 and 85.7±0.70 percent, respectively (Table 2). Among the sire breed categories, Simmental crosses had significantly the highest P2:1 (86.7±1.93%), P3:1(67.9±2.14%) and PI (90.5±1.65%) while the Horro had the lowest values of these traits indicating that Simmental crosses were more persistent compared to the other sire breeds. Cows that calved during Bona (December to February) had the highest P2:1 (88.2±1.58%). The lowest P3:1 (46.9±2.22 %) and PI (77.2±1.82%) were recorded for cows that calved during Arfasa (March to May). The effect of calving weight on P3:1 ($P < 0.001$) and PI ($P < 0.05$), and initial milk yield on P3:1 ($P < 0.05$), P2:1 ($P < 0.001$) and PI ($P < 0.05$) were significant. Calving weight was linearly and inversely related to P3:1 (b = -0.08±0.02) and PI (b = -0.04±0.02). While initial milk yield was linearly and inversely related to P2:1 (b = -1.14±0.31), P3:1 (b = -0.88±0.38) and PI (b = -0.65±0.31) (Tables 1&2).

Table 1. Source of variation, number of observations (N) and least squares means (± SE) P2:1, P3:1 and persistency index (PI)

Source	P2:1 (%)		P3:1(%)		PI (%)	
	N	Mean±SE	N	Mean±SE	N	Mean±SE
Overall mean	559	78.0±0.67	315	59.2±0.58	234	85.7±0.70
Sire breed classes		***		***		*
Friesian crosses	147	81.1^{bc}±1.62	105	58.9^{b}±1.83	73	85.2^{b}±1.53
Jersey crosses	155	81.9^{ab}±1.53	91	59.6^{b}±1.99	72	86.5^{ab}±1.60
Simmental crosses	106	86.7^{a}±1.93	81	67.9^{a}±2.14	73	90.5^{a}±1.65
Pure Horro	128	61.4^{d}±1.93	31	41.9^{c}±3.47	11	80.4^{b}±3.98
Pure Boran	23	73.1^{c}±3.87	7	57.1^{b}±6.70	5	82.1^{b}±5.69
Parity		Ns		Ns		Ns
1	77	80.6±2.31	51	58.8±3.03	40	86.8±2.53
2	89	77.2±2.03	52	57.9±2.79	40	86.2±2.33
3	128	75.7±1.68	75	55.1±2.31	52	83.9±2.10
4	108	79.1±1.88	62	58.4±2.59	51	84.9±2.16
5	83	74.2±2.09	48	55.8±2.80	32	83.7±2.56
6	74	74.3±2.25	27	56.9±3.64	16	83.9±3.17
Calving season classes		***		***		***
Gana (June – August)	93	67.9^{c}±1.98	52	56.3^{b}±2.75	44	89.4^{a}±2.28
Birra (Sept. – Nov.)	121	81.4^{b}±1.75	71	64.7^{a}±2.41	41	89.1^{a}±2.33
Bona (Dec. – Feb.)	160	88.2^{a}±1.58	97	60.5^{ab}±2.32	68	83.9^{c}±2.01
Arfasa (March – May)	185	69.9^{c}±1.46	95	46.9^{c}±2.22	81	77.2^{d}±1.82
Regression variables						
Calving weight		-0.032±0.02 ns		-0.08±0.02***		-0.04±0.02*
Initial milk yield		-1.40±0.31 ***		-0.88±0.38 *		-0.65±0.31*

Means in a column within a group followed by different superscript letters vary significantly (*** = $P < 0.001$; ** = $P < 0.01$, * = $P < 0.05$ and ns = $P > 0.05$)

Discussion

Economy of dairy production depends on the lactation yield, mainly a function of persistency, peak yield and lactation length. Highly persistent cows have more milk, longer productive life and are considered as efficient producers, thus provide regular source of income to the farmers throughout the year (Kumar *et al*., 1999). Cows are persistent if they tend to maintain their peak yield within a lactation period (Grossman *et al*., 1999). The P2:1

(78.8±0.67%) and P3:1 (59.2±0.58 %) obtained in this study for indigenous and crossbred cows is comparable to what was reported for Holstein Friesian (Mureja, 1994), Simmental (Solkner and Fuchs, 1987) and Red Danish (Madsen, 1975) cattle. Besides, the overall PI of 85.7±0.70% obtained in this study is comparable to the 71% (Kumar *et al.*, 1999) for Tharparkar cows and 82.8% for F_1 Friesian x White Fulani cattle in a tropical environment (Ibeawuchi, 1988). Similarly, Gashaw (1994) reported mean P2:1 and P3:1 of 74.5 ± 1 and 57.4 ± 1.3 percent, respectively for Arsi Friesian crossbred cows. The difference among the reports is related to differences in genotypes studied, management of the different farms and other non-genetic factors (Ibeawuchi, 1988; Gashaw, 1994; Mureja, 1994).

Under favourable conditions, unbred cows produce each month 94% of their milk yields during the preceding month (Chilliard, 1992). Low persistency could be inherited or occur due to under feeding, exhaustion of body reserves or other unknown mechanisms (Chilliard, 1992). The decrease in milk yield after lactation peak (that determines milk persistency) results primarily from the decrease in the number of secreting cells and sustaining the metabolic activity of secretory cells which is related to adequacy of feeding and management that enables expression of mammary cell secretory potential (Chilliard, 1992). The same annual yield could be obtained either with higher peak milk yield and lower persistency or inversely. Low persistency could be inherited, or due to under-feeding or exhaustion of body reserves. The extent and duration of body fat and protein mobilization after calving depends on milk potential, feeding level and quality, and initial body condition. However, when comparing different breeds of cows with the same milk yield, it was suggested that body weight loss was lower in dairy breeds because of their higher feed intake capacity (Chilliard, 1992).

Crossbreds were more persistent than indigenous breeds (Table 2) that could be attributed to the expression of heterosis in the crossbred progenies as a result of breed additive gene effect when *Bos indicus* (Horro and Boran) is crossed with the *Bos taurus* (Simmental, Jersey and Friesian). Similar works by Kiwuwa *et al.* (1985) in indigenous and crossbred cows attributed the low persistency of the F_1 Jersey x Arsi and F_1 Friesian x Arsi crosses during the last phase of lactation to the characteristic of the breed as the Arsi maternal parent breed gene gave very low coefficient of persistency during the last phase of lactation. The highest proportion of the indigenous breeds had

shorter lactation lengths. Due to this fact, persistency index (PI) is not appropriate but P2:1 and P3:1 could be used jointly or independently to assess persistency at different stages of the lactation period for both indigenous and crossbred cows.

The effect calving season on persistency of milk production observed in this study is in agreement with previous reports by Ibeawuchi (1988) and Mureja (1994). El Amin and Osman (1971), however, didn't find any significant effect of calving season on persistency. The differences among reports on the effect of calving season on persistency could be due to variations in the feeding and management levels. A cow's nutrient requirement for different body functions has to be met in order to get high and persistent production. The feeding system followed in most farms does not take into consideration the milk yield and seasonality in feed supply from grazing. Cows calving during the rainy season graze better pasture, which might have helped the cows to maintain higher levels of milk yield for a longer period compared to cows that calved during dry season.

Calving weight and initial milk yield were negatively related to P3:1 and PI (Table 2). Cow weight at calving was linearly and inversely related to P3:1 and PI probably associated with the age of the cows and availability of body reserve for high milk production. Relatively heavier cows at calving showed lower persistency compared to lighter cows at calving. The closer relationship which exist between milk yield and energy balance is highly correlated during early lactation. Individual cows meet their energy demands through combinations of feed intake and mobilization of body reserve (Butler *et al.*, 1981). Thus, heavier cows and cows with greater body reserves at calving and the ability to use these reserves during the postpartum period can partly overcome the negative energy balance during earlier lactation (Coppock, *et al.*, 1974; Butler *et al.*, 1981). Moreover, the ability to rapidly mobilize body reserve for milk production during early lactation unless compensated by better feeding and management of the cows might not enable the cows to maintain its higher yield for longer lactation period. Thus, lower persistency values were observed for persistency measures that consider late lactation data such as P3:1 or long lactation period such as persistency index than persistency measures that consider early lactation data. Similar results were reported by Collins-Lusweti (1991) in Holstein Friesian and Jersey cows in Zimbabwe.

Conclusion and recommendation

Persistency values for crossbred cows were higher than indigenous breeds indicating that crossbreeding improved persistency. P2:1 and P3:1 measures persistency under different stages of lactation, while PI considers the total lactation yield beyond the peak period to calculate the index. Thus, comparison of these three measures as a tool to make management decisions on time, leads to a conclusion that P2:1 and P3:1 have better indicative power as to the status of the cow's daily milk yield for both indigenous and crossbred cows. Besides, due to the short lactation length of indigenous cows, PI could not be used to determine persistency. Therefore, P2:1 and P3:1 could be used to the persistency of indigenous breeds.

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Assessment of the effect of ant (*Dorylus fulvus*) on honeybee colony (*A. mellifera*) and their products in West & South-West Shewa Zones, Ethiopia

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Abstract

Among so many pests existing in Ethiopia, ant (*Dorylus fulvus*) is found to be the most troublesome to honeybees and beekeeping sector. Ant causes great damage to honeybees and their products and as a result many productive bee colonies have been either killed or abscond due to intolerable ant attack. However, the extent of damage inflicted on honeybee colonies and their products under local conditions was not determined. So, the main objective of this study was to assess and quantify the losses incurred due to ant attack in terms of both life of honeybee colonies and their products in West Shewa Zone. For the purpose 7 districts and 174 beekeepers possessing 1997 bee colonies were randomly selected from the Zone and interviewed on pre-tested questionnaire. From the total of honeybee colonies in the Zone, 44.2% of them were known to be attacked by ant per year, of which 24% absconded and 4.2% died. However, 16% of the bee colonies attacked remains in their hive withstanding the fight. Honey yield amounting to 29% of the production in the Zone is found to be lost per year due to ant attack. As a whole, the economic loss in the Zone every year as a result of loss of honeybee colonies and their products due to ant attack was estimated to be over 3,839,810 birr.

Key words: ant, honeybees, beeswax, abscond, Ethiopia

Introduction

Honeybee colonies existing in the wild away from man's control produce small surplus honey above their requirements signifying beekeeping is much more productive and profitable if they only managed properly (Moeller, 1982). To this reality, protecting them from diseases, pests have been recognized many centuries back and now days became a key activity of beekeepers to make the beekeeping profitable (Crane, 1990).

Among all enemies of honeybees, driver or army ant is known to cause great harms through initiating aggressiveness, absconding, and destroying the

entire colonies of honeybees (Smith, 1953, Morse and Hooper, 1985, and Crane, 1990). Although, strong bee colony resists for some time, eventually abscond if molested too much and small bee colonies be subjugated shortly (Bechtel, 1988**).** Ant eats or carries off any comb contents honey, pollen and brood (Smith, 1953). Ant *(Dorylus fulvus)* is so long identified as one of the main honeybee enemies causing serious problem on beekeeping sector in Ethiopia (Ayalew, 1983; Amsalu *et al*., 1999, Desalegn, 2001; Desalegn *et al*., 2001, 2005; Nicola, 1988).

In many parts of the world, research is under way to develop means to combat or prevent bee pests. However, bee research in Ethiopia is at its infancy and no detail investigation made on type of honeybee pests, distributions and the actual products lost as a result of bee pest. In this regard, quantified data on the degree of damage caused is much important for intervention and further development plan. Therefore, this study was carried out to assess and quantify the magnitude of ant damage imposed on life of honeybees and their products in West Shewa Zone.

Materials and Methods

Study area

The study was conducted in West and South West Shewa Zone in 2003, representing the central highland of the country. The Zone is characterized by favorable condition for crop and livestock production having relatively better cultivated crops and natural plant coverage (Zerihun *et al*, 1991) which are mainly bee forages. Due to these, the Zone sustains large number of hived bee colonies (104383) from which about 835 tones of crude honey is produced per year (Edessa, 2004).

The Zone receives 813.2mm-1699mm of rain with average range of 22.9-29.9^{0}C temperature. The altitudes ranges from 1500-3000masl.

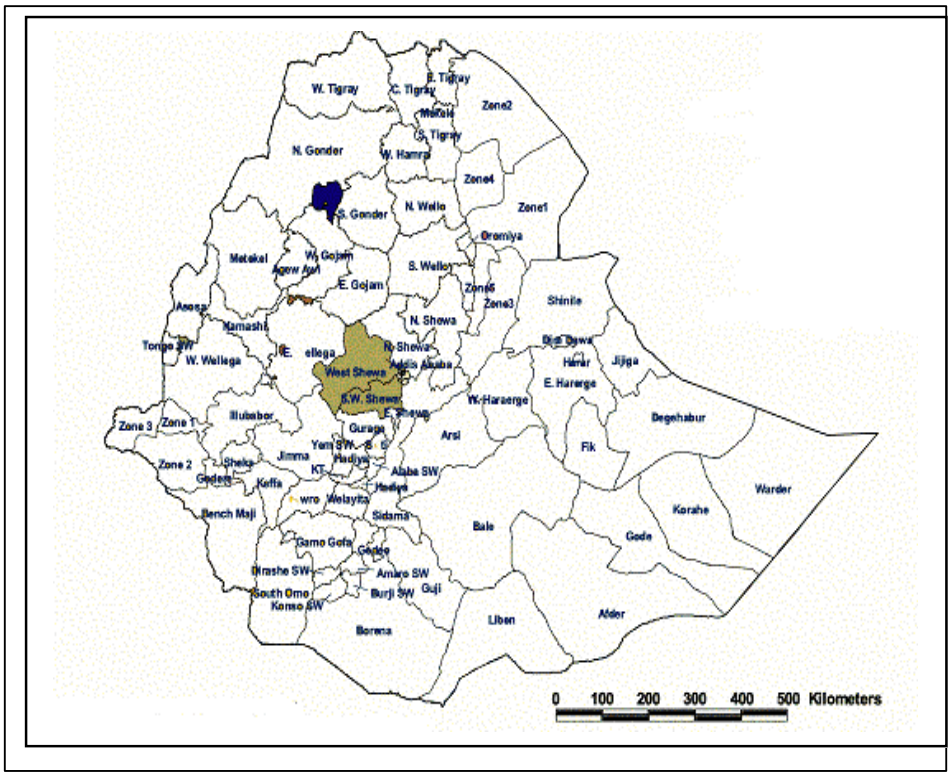

Figure -1 Study area

Methodologies

For this study 7 out of 21 districts of the Zone, were selected based on the agro ecological variability, mainly on the altitude. Based on the traditional ways of altitude classifications, the selected districts were categorized into high, mid and low altitudes. From each district 23-26 beekeepers, totaling 174 beekeepers having 1997 bee colonies were purposely selected. Selection of the beekeepers was performed in cooperation with the local agriculture & rural development office experts working either as beekeeping technician or as an expert of livestock production. Farmers' selection was based on the criterion of their beekeeping experiences & whether they are currently owning bee colonies or not. Pre-tested questionnaires were used to investigate effect of ant on the lives the honeybee colonies and their products. As they help in the effect of ant assessment, the questionnaire has mainly included records of bee colony holdings, type of hive in use, the local price of bee colonies & honey, respondents bee colony holdings, total number of bee colony in the survey

districts, total number of bee colonies in the Zone, honeybee pest types, number of honeybee colonies attacked, died, and absconded by ant per year, price of honey & honeybee colony for each district, price of beeswax at central market, the distinct time at which the ant set attack on honeybees & methods exercised to prevent ant attack. Average price of honeybee colony & honey for the colonies dead & absconded were used to compute the loss occurred due to ant attack in the survey areas.

Due to insignificant number of intermediate and frame hives in most of the surveyed districts, the effect of ant attack was analyzed based only on the data from bee colonies in the traditional beehives and the average honey and beeswax yield obtained form this bee hive type. Average beeswax production obtained from traditional bee hive was taken from the assumption that the wax production in a traditional bee hive is 10% (Moeller, 1982) of the honey yield. The wax price used (25birr) in the calculation was the average pure beeswax price of the central market in 2003. The average bee colonies attacked, absconded and died, the honey yield and beeswax losses are the average value of two years (2001 & 2002) from the surveyed districts. The degree of bee products vulnerable to ant attack was determined based on the reply got from the respondents in the study areas. Finally, loses due to ant effect at Zonal level was extrapolated from the total lose occurred in the surveyed districts.

Results

Colony holdings

From the total 174 beekeepers included in the assessment, the number of bee colony holdings varied from 1-100 with an average of 11.5 bee colonies per individual beekeeper. The majority (69%) of the beekeepers in the assessment possess 1-10 bee colonies and few of them manage more than 10 bee colonies, which in rare cases goes to 100 (Fig.2).

Type of bee hives in use

It is understood that three types of bee hives are in use in the zone. Of the total bee colonies in the survey areas, 95.1%, 0.4% and 4.5% are managed in a traditional, transitional and frame hives respectively and the number of bee colonies managed in a frame hive is relatively high in Welmera district consisting 66.7 % of the total records of frame hive (Fig 3).

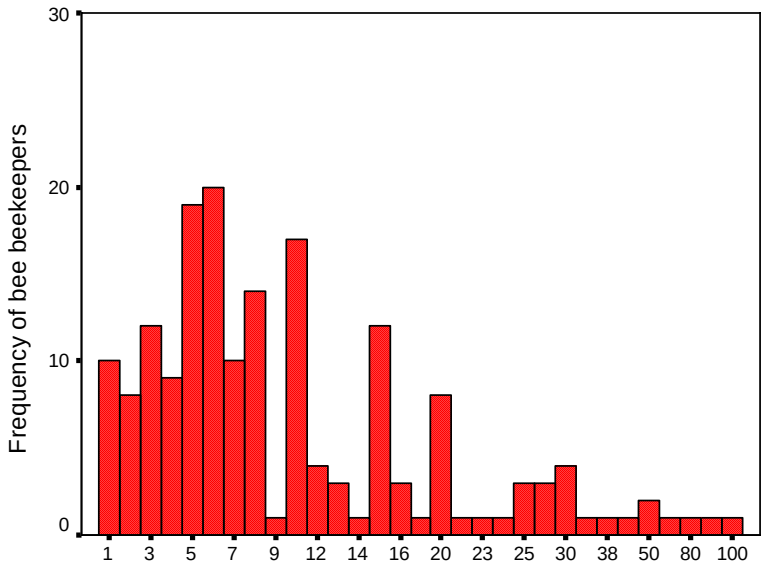

Figure 2. Bee colony holdings

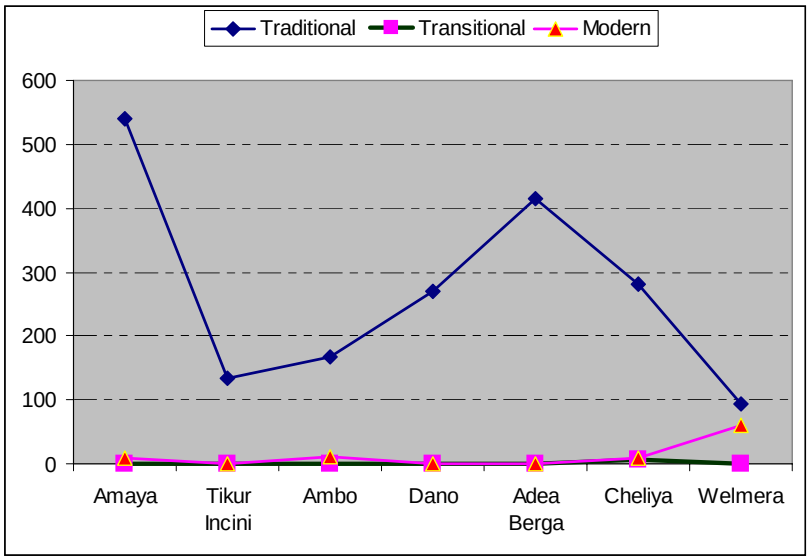

Figure 3. Status of the beekeeping with different beehives by district

Pests observed

Although the damage they create is so small and not recognized by the beekeepers, spiders, birds, and Wax moth, Honey badger (Hama), mice, toads,

snake, preymantis, lizards, bee lice, beetles, death head hawke moth and monkey were reported as bee pest in the study areas. Beekeepers reported that there is time when some of these pests are highly interacting and affecting the bees and their products. For instance, the local honey badger (Hama-local name) has ultimate effect when it attacks the colony.

Ant protection methods exercised

It has been observed that beekeepers use one or combination of methods to combat ant from attacking their bee colonies. Applying ash under the hive stands is considered as reliable and dependable method of ant protection by the beekeepers, when there is no rain. Similarly it has been observed that the beekeepers clean the underneath of the hives & keep their apiary neat as a means of ant protection. The beekeepers & the experienced local beekeeping experts also disclosed that like leaves of eucalyptus & aje (local naming) are traditionally applied as ant deterrents when it appears. Wrapping the hive stands with polytine bag, hunting and killing ant queens are also among the methods exercised by the beekeepers to protect their bee colonies from ant attack. However, it was observed that few beekeepers have developed knowledge of smearing used engine oils on the hive stands as a means of ant protection.

Causes of bee colony abscond

The beekeepers disclosed that the main reason for absconding of bee colonies in the study areas was due to ant. According to 98.3% of the respondents, ants harassed almost all, which eventually resulted into either absconding or to death (Table 1).

Regardless of the variation in altitude among the study areas, the study revealed that there was a distinct periods at which the ant set attack on honeybees. September to December was found to be common period in all the surveyed places where ants exerted attack on honeybee colonies and their products (Fig 4).

Table1. Percentage of respondents to ant attack on honeybee colonies

No	District	Total number of respondents (N)	Number responded (N)	%	Total bee colonies owned by the respondents	Number of bee colonies attacked	% colonies attacked
1	Ameya	23	21	91.3	547	157	29
2	Tikur Inchini	24	24	100	134	22	16
3	Ambo	25	25	100	179	95	53
4	Dano	25	25	100	270	208	77
5	Adeaberga	26	26	100	414	161	39
6	Cheliya	26	25	96.2	298	185	62
7	Welmera	25	25	100	155	56	36
	Total	N=174	N=171	98.3	1997	884	44

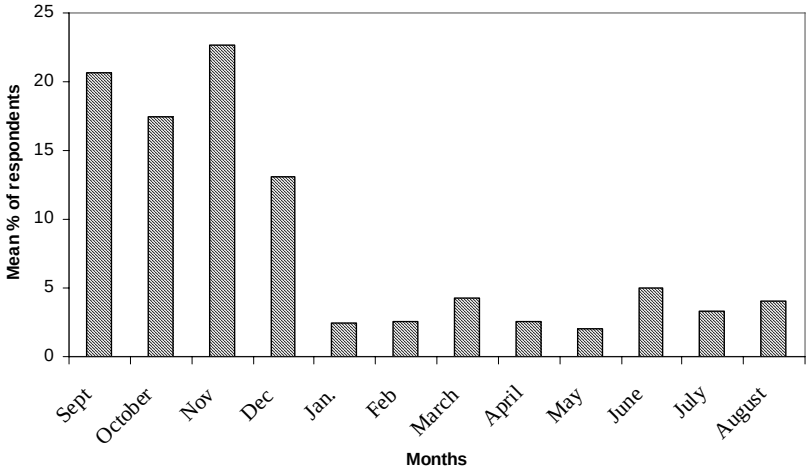

Figure 4. Mean percentages of respondents to ant attack on honeybee colonies in each month

In this study the beekeepers also revealed that other than honeybees, ants also eat different bee products. According to them, once the ant enters the bees' hive, it destroys entire colony and eats bees, honey, brood, beeswax, and pollen. Bees are the first & the most victim of the attack followed by the honey. Although pollen is observed to be taken by the ants, it could be after all the honey & the broods are depleted (Fig 5). Usually after massive attack, pile of crumbled bees & ants can be observed in and beneath the hive

entrance of the victim colony with large number of ants marching into the center of the hive.

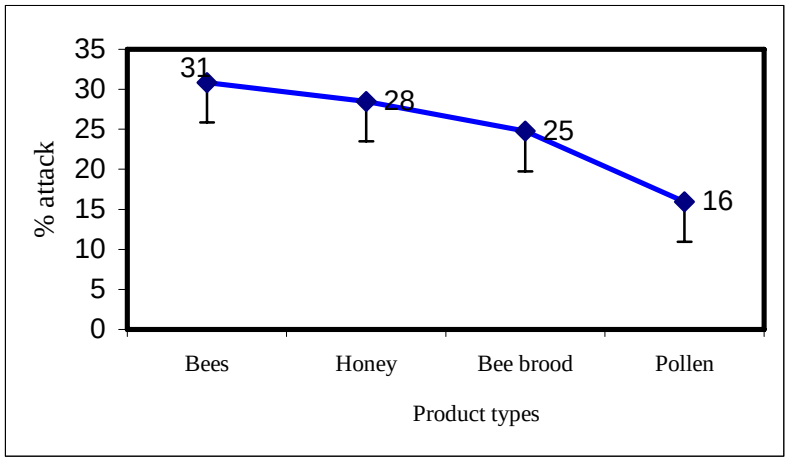

Figure 5. Percentage of bee products type attacked by ant according to the reply from the respondents

Bee colonies and their products losses

From the total 1997 bee colonies owned by the surveyed beekeepers, 884 of them were attacked of which 477 bee colonies absconded, 90 died and 317 remained in the hive after the attack. Extrapolating this result to the Zonal level, from the total of 104383 hived bee colonies in the Zone, 46137 (44.2%) of them were known to be attacked by ants every year, of which 4706 (10.2%) die and 24776 (53.7%) are forced to leave their hive. This results in 29% of the total honey yield lose in the Zone. However, of the total attacked bee colonies, 16,655 (36.1%) remained in their hives either by withstanding the fighting or assisted by the beekeepers. Irrespective of the respondent percentage to ants harassment (Table 1), the actual recorded percentage of bee colonies absconded and died, calculated from the average colony attacked is smaller for Welmera and Chelia, and higher for Tikur Inchini, Amaya and Adea Berga districts (Fig. 6 & Table 2).

Computing the economic loss encountered at rate of 50 and 10 birr (the average price obtained during the survey time) for a bee colony and a kg of honey respectively (Table 3), the total money amounting 65559.2 birr in the survey districts and 3839810 birr in the Zone is being lost annually due to ant attack on honeybee colonies.

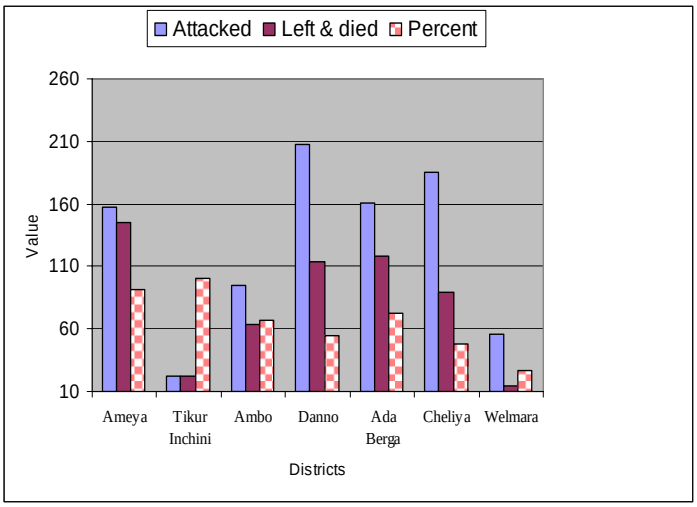

Figure 6. Number of bee colonies left and died & their percentage against the total number of bee colonies attacked.

Comparing the monetary losses in terms of different products, the losses through bee product (honey and beeswax) overweighs the losses produced through the bee colonies themselves (Fig. 7). About 51% & 13% of the losses were recorded through honey & beeswax loses, respectively, which totals to 64%. However, only 36% is lost through death of honeybee colonies.

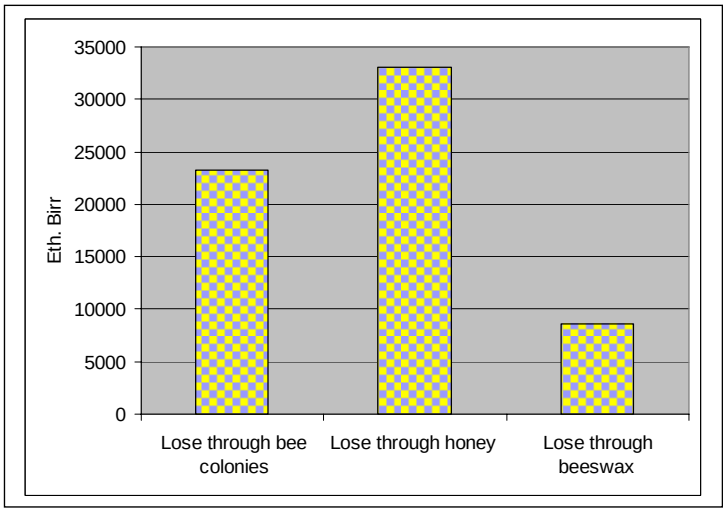

Figure 7. Magnitude of monetary losses in terms of bees & bees' products

Table 2. Status of bee colonies and percentage colonies left and died, across the districts & respondents in 2001 &2002

No	District	N	Bee colony owned by the respondents	Average honey yield per Colony (kg)	Total honey yield (kg)	Average bee colonies attacked A	Average bee colonies absconded B	Average bee colonies died C	Sum of bee colonies absconded & died D (B+C)	Percent bee colonies left & died from the total attacked E(D/A)*100
1	Ameya	23	547	3.00	1641	157	104	41	145	92
2	Tikur Inchini	24	134	8.21	1100.14	22	17	5	22	100
3	Ambo	25	179	10.52	1883.08	95	53	11	64	67
4	Danno	25	270	5.64	1522.8	208	95	19	114	55
5	Ada Berga	26	414	7.38	3055.32	161	109	9	118	73
6	Cheliya	26	298	6.73	2005.54	185	86	3	89	48
7	Welmara	25	155	3.56	551.8	56	13	2	15	27
Total/average		174	1997	45/7=6	11759.68	884	477	90	567	64

Table -3 Losses produced due to ant attack through bee colonies, honey and beeswax across each districts

	Districts	Number of bee colony left & died (A)	Average price of one bee colony (Birr) (B)	Loss due to bee colony left & died (Birr) C=AxB	Average honey yield per Colony (kg) (D)	Total honey yield lost (kg) E=AxD	Average price of one kg honey (F)	Loss through honey from bee colonies left & died (Birr) G=ExF	Loss through beeswax from bee colonies left & died		Loss through bee colonies, honey & beeswax J=C+G+I
									(kg) H=Ex0.1	Average price 25 per kg I=Hx25	
1	Ameya	145	35	4350	3.00	435	8.5	3697.5	43.5	1087.5	9135
2	Tikur Inchini	22	37	814	8.21	181	7.5	1354.65	18.1	452.5	2621.15
3	Ambo	64	42	2688	10.52	673	10	6732.8	67.3	1682.5	11103.3
4	Danno	114	32	3648	5.64	643	8	5143.68	64.3	1607.5	10999.18
5	Ada Berga	118	47	5546	7.38	871	10	8708.4	87.1	2177.5	16431.9
6	Cheliya	89	52	4628	6.73	599	11	6588.67	59.9	1497.5	12714.17
7	Welmara	15	108	1620	3.56	53.4	15	801	5.34	133.5	2554.5
Total /average		567	353/7=50	23294	45/7=6	3455.4	70/7=10	33026.7	345.54	8638.5	65559.2

Discussion

Beekeeping in Ethiopia is very common and is one of the traditional agricultural activities. Besides its cash income & apitherapeutic role, honey and beeswax plays an important role in the cultural and religious life of the people. In addition to its contribution to the national and rural economy, beekeeping is very significant in the food production chain through pollination of fruits, vegetations and cultivated crops.

Many pests are known to affect the life and products of honeybees under local condition of which ant is the most known. Ants harbor in fertile soils beneath tree trunks, small hill soil places and, group and column perdition, periodic nomadism, and constructing soil particle along the column are also an attributes of this ant (*Dorylus fulvus*) (Gotwald (1976). The colour of this ant ranges from brown to black which is by nature high absorbent of radiant energy. Therefore, constructing soil cover along its road (column) & sheltering in hidden places are probably evolutionary adapted mechanisms of the ants to avoid direct heat from sun light.

Ant is one of the economically important pests that cause substantial losses to the beekeepers income through losses of bee colonies and their products (Smith, 1953, Morse and Hooper, 1985, Crane, 1990, and Amsalu *et al*. 1999, Desalegn, 2001, Desalegn *et al*. 2001 & 2005, Nicola, 1988). But to what extent or degree was the question unanswered by those authors. This study additionally determined figuratively that about 29% of the total honey yield losses occurred through bee colonies abscond and death, which accounts for about 51% of the total loss due to ant attack per year in the study areas. However, loss through beeswax from bee colonies left & died & the value of the left & died bee colonies accounted to 13% & 36% of the total loss, respectively. As a result, beekeepers in the Zone losses substantial amount of money through the losses of bee colonies and their products. This is without taking in to account the bees' indirect benefit from pollination services to the cultivated crops and natural vegetation.

The percentage of bee colonies absconded and died from the actual colonies attacked varied among the surveyed districts and is small for Welmara and Cheliya while, it is very much serious for Tikur Inchini followed by Amaya and Adea Berga districts. This is probably due to provision of training and extension services by the Holota Bee Research Centre in Welmara and

Cheliya districts. In these districts Holota Bee Research Centre has demonstrated improved methods and beekeeping technologies and hence, backyard beekeeping is largely exercised to implement different ant protection methods designed at the centre.

The variation among the survey districts in terms of losses through bee colonies, honey & beeswax can be attributed to differences in total number of bee colonies absconded, died, colony productivity, price of bee colonies and price of honey among the districts. The number of colonies kept constant for all districts, the eventual loss due to ant attack on honeybee colonies and their products is so much serious in those districts having better access to road and better market. This is because in these districts, the price of bee colonies and honey is very high compared to the remote districts where the items are less priced. For instance, an impact of 15 bee colonies loss in Welmera district has produced 1620 birr loss, while absconding of 22 bee colonies in Tikur Inchini has brought about only 814 birr loss. Like wise, the loss through honey from bee colonies left & died at Ambo district having less bee colony number (N=64) with high productivity, exceeds Danno district that has high number of bee colonies (N=114) but less productive.

Despite the altitude variation and severity of attack among the study areas, the major period during which the ant attack was common to all districts is between September and December. This time is after the end of heavy rainy season (June-August), at which many grasses and vegetations are in growth and blooming by covering the land surface. This time relative moisture condition coupled with existences of different plant species flower seems to support the life & reproduction of many insect species including honeybee. This period seems an evolutionarily matched season of life to complement the prey and predators. These months are also the time at which the bees rear brood and make honey using the timely existing resources mainly pollen and nectar of different plants. It is also observed that ant appear attracted to the bee's nest through the attraction of the bee brood and the collected nectar in the hive.

Almost all beekeepers in the West Shewa Zone keep bees to generate income through honey sales and for household honey consumption. The results of the present study could well be by the majority of the areas that are from mid to high altitude.

Conclusion

It is recognized that the country has great potential in beekeeping. However, the sector is challenged by heavy loss that occur every year due to effect of ant on honeybee colonies. If the benefit from the sector is to be materialized, the beekeepers and the government should be conscious enough to protect bee colonies from various naturally existing honeybee pests like ants. Thus, improved ant protection methods designed & developed by Holota Bee Research Centre should be scaled-up to mitigate the problem & increase the production & productivity of honeybees in such a way that it benefits the beekeepers & the nation at large.

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Isolation and characterization of tannins tolerant bacteria from rumen fluid of free ranging sheep and goats

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Abstract

Four straight rods and three spherical bacteria were isolated using roll tubes inoculated with rumen fluid from sheep and goats and enriched with tannic acid. The isolates were characterized by morphology, products of fermentation and restriction fragment length polymorphism that indicated the cocci isolates to be Streptococcus while the rods are closely related to recently isolated tannin tolerant bacteria within the Klebsiella genus. All of the isolates were able to grow in 30 g/L tannin extract of Acacia angustissima ground dry leaves except isolates EG 2.1 and EG 1 that grew in 20 g/L of tannic acid.

Key words: tannins tolerance, sheep, goats, ruminants, rumen microbiology, Ethiopia

Introduction

Multi purpose leguminous trees (MPLT) are more reliable feed resource than herbaceous plants as they are able to retain green foliage during the dry seasons and drought periods (Dzowela *et al*., 1997). Additionally, MPLT have high crude protein as compared to mature tropical grasses (Odenyo, *et al*., 1999b) and have high mineral content which improve the environment, leading high intake and improved overall utilization of feed (Osuji *et al*., 1995). Apart from being used as a feed supplement, these trees have economic importance for different uses. Despite their use, MPLT have anti nutritional factors (ANFs) that are toxic and limit their use as feed. Some of the ANFs that are known in MPLT are non-protein amino acids, glycosides, phytohemagglutinins, poly phenolic compounds, alkaloids, triterpenes, and oxalates (Kumar, 1992). Tannins are water-soluble polyphenols, which precipitates proteins from solution (Nelson *et al*., 1995) by forming protein

* Correspondence

tannin complexes (Kumar and Singh, 1984). Tannins are categorized into hydrolysable tannins and condensed tannins called proanthocyanids. Hydrolyzable tannins are esters of one or more gallic acid residues (gallotannins, ellagitannins and taragallotannins) with a sugar moiety (Nelson *et al*., 1995). Gallic acid and pyrogallol are monomeric derivatives of gallotannic acid that are found to be much less toxic than gallotannic acid (Field and Lettinga, 1987). Hydrolysable tannins are more susceptible to enzymatic and non-enzymatic hydrolysis than condensed tannins. The hydrolysis of gallotannins yields gallic acid and glucose while hydrolysis of ellagitannins yields ellagic acid and glucose.

Tannins reduce intake and palatability of feeds by causing an astringent feeling in the mouth (Woodward and Reed, 1989). If animals consume high level of tannins, protein is over-protected and the protein will pass out in the faeces resulting in low retention in the animal. Tannins also reduce the concentration of short chain volatile fatty acid in vitro (Salawu *et al*., 1999). The presence of condensed tannins in feeds of animals has deactivated the ruminal cellulase enzymes (Kumar, 1992). Tannins also affect the normal flora of microorganisms that are important for fermentation of dietary fibers, especially cellulose degrading bacteria like *Ruminococcus flavefaciens* and *Ruminococcus albus* (Odenyo and Osuji, 1998). Scalbert (1991) suggested three mechanisms of tannin toxicity in rumen microorganism: enzyme inhibition, substrate and metal ion deprivation and action on membranes. Tannin in ruminants feed also result in a low milk yield, toxic degenerative changes in the intestine, liver, spleen, and kidney, mucus appearance in the urine, and fatal constipation (Kumar and Singh, 1984).

Various methods have been developed to alleviate the problem of ANFs. Some of the methods, for example, are feeding ANFs containing leaves in mixture with other feeds, harvesting the leaves at times when the concentrations of ANFs are lowest, heating and supplementation with urea and metal ions (Kumar, 1992). The removal of memosine (a type of non-protein amino acid) in Australian ruminants by inoculating bacteria isolated from the rumen fluid of Hawaiian ruminants showed the potential of rumen microbes for alleviating the problem of ANFs (Allison *et al*., 1990). Since then, various rumen bacteria have been isolated to overcome the effect of ANFs (Allison *et al*., 1990; Kumar, 1992; Gupta and Atreja, 1998). This work

was aimed to isolate and characterize tannin tolerant or degrading rumen bacteria from free ranging sheep and goats.

Materials and Methods

Tannin extraction

Leaves of *A. angustissima* were ground to pass through a 0.5 mm sieve. A volume of 100 ml 70% acetone was added to 5 g of each leaf type. The mixtures were incubated in a shaking water bath (130 rpm) at 30°C for 2 h. Samples were centrifuged at 3000 rpm for 20 min at 4°C. The supernatant was collected and the acetone was evaporated by drying an oven at 35°C to a constant weight according to Makkar (1995). The dried samples were diluted in distilled water at the desired concentration (4, 8, 15, 20, and 30 g/L) and were filter-sterilized though a 0.45 um pore-size filter membrane.

Rumen fluid collection

The rumen fluid from goat and sheep were collected from Debre Zeit abattoirs, Ethiopia. The rumen was removed immediately (3 min) after the slaughter, cut open and the contents were mixed before sampling. The rumen fluid was passed through four layers of cheesecloth into CO_2 pregassed flasks, and transported to the laboratory.

Media preparation

All media used were prepared anaerobically according to the procedures of Bryant (1972). Complex medium (Odenyo *et al.,* 1991) enriched with 5 g/100ml *of A. angustissima* leaves were prepared, called enrichment medium according to Bryant (1972). Roll tubes were also prepared according to Hungate (1969) and enriched with 1 ml of tannin extract of *A. angustissima,* or tannic acid (Sigma Chemicals) (0.4 g/L).

The Rumen fluids (5 ml) from the abattoir were separately inoculated into the enrichment medium. Cultures that grew in the enrichment media were transferred in to tubes containing Growth study medium (GSM) (Odenyo and Osuji, 1998) with 4 g/L of tannic acid or tannin extracts of *A. angustissima* leaves. The tubes were incubated at 39°C for two days after which 20 µl of each sample was run on a Thin Layer Chromatography (TLC) to evaluate the ability of the mixed microbes to degrade tannin. The solvent was composed of acetonitrile and toluene in 2:1 ratio. The TLC plates were dried, and sprayed with a solution composed of 0.5 g iodine in 95% ethanol. The presence of pyrogallol spots on the TLC plate indicated hydrolysis of tannin

and tannic acid. Those cultures with the ability to hydrolyze tannic acid and tannin extracts of *A. angustissima* leaves were serially diluted in anaerobic diluent (Hungate 1969). The samples (0.5 ml) of 10^{-6}, 10^{-7}, and 10^{-8} dilutions were then inoculated into roll-tubes and incubated at 39°C for 5 days. Colonies that were formed on the surface of the agar and those colonies that had clear zones around them were picked under CO_2 into complex media and incubated overnight. The cultures purity was examined by a phase contrast microscope (Olympus Opicals Co. Ltd, Tokyo, Japan). Colonies from goats and sheep rumen fluid were designated as 'EG' and 'ES,' respectively, where 'EG' referred to Ethiopian goat and 'ES' to Ethiopian sheep. The cultures were transferred to GSM containing 4 g/l of tannin extracts or tannic acid and incubated at 39°C for 48 h to evaluate their ability to hydrolyze tannins and tannic acid. All stock cultures were stored at -20°C in complex media or GSM containing 2 g/l of tannin extract or tannic acid and 20% glycerol at a ratio of 1:1.

Characterization of tannin tolerant or degrading isolates

Classical characterization

The isolates were characterized by their morphology, gram stain and carbohydrate fermentation capabilities. Morphological character and motility were examined by phase-contrast microscopy. Gram stain was performed to determine the Gram reaction. The carbohydrates used for characterization were L-arabinose, D-cellobiose, dextrin, esculin, D-fructose, D-galactose, D-glucose, α-lactose, D-mannitol, D-maltose, D-raffinose, L-rhamnose, D-sucrose, D-trehalose and D-xylose. The medium containing the specific carbohydrates was inoculated with 0.5 ml of an overnight culture of each isolate. Growth was measured turbudimetrically at 600nm.

Molecular Characterization

Restriction fragment length polymorphism (RFLP)

DNA extraction was performed according to Wilson (1991). The 16S DNA of each DNA template (1 µl) was PCR amplified using 3' 16S universal primers (AAG GAG GTG ATC CAG CC) and 5' 16S universal primers (GAG TTT GAT CCT GGC TCA G) (Wilson, 1991). The PCR product was analyzed using agarose (1.5 %) gel electrophoresis. The gel was stained in ethidium bromide for 30 min to 1 h, visualized with a U. V. Trans illuminator and photographed using CCD camera (Ultra - LÜm, Paramount, CA). The PCR products were digested with different restriction enzymes (*Alu I*, *Dde I*, Msp *I*) (Sambrook *et*

al., 1989). Approximately 10 µl of PCR product of the bacterial isolates were pipetted into eppendorf tube and 10 µl dd H_2O, 1.5 µl of restriction enzyme digestion buffer (Promega), and 0.5 - 1 units of the restriction enzymes were added separately and incubated overnight at 37°C. Approximately 5 µl of gel-loading buffer was mixed with the digested samples and loaded on to a gel (1.5% w/v). A 100 bp marker (Promega) was used. The gel was run at 100 V for 2 hours and stained with ethidium bromide for 1 to 2 hours. The gel was visualized with a U. V. Trans illuminator and photographed using a CCD camera (Ultra - LÜm, Paramount, CA).

Results and Discussions

Mixed cultures of bacteria from rumen fluid of goats and sheep hydrolysed tannin to pyrogallol (Figures 1). Six bacterial isolates from goat rumen fluid were designated as EG 2.1, EG 7.1, EG 9.1, EG 9.2, EG 13 and EG 1. Isolates EG 2.1, EG 9.1, EG 9.2 were Gram negative rods and EG 1 was a Gram positive rod. They occurred in single/chained arrangements and some were highly motile. EG 7.1 and EG 13 were cocci that occurred in singles, pairs and chains. They were Gram positive. Gram positive coccus isolate (ES 5) was picked from roll tubes inoculated with rumen fluid from sheep.

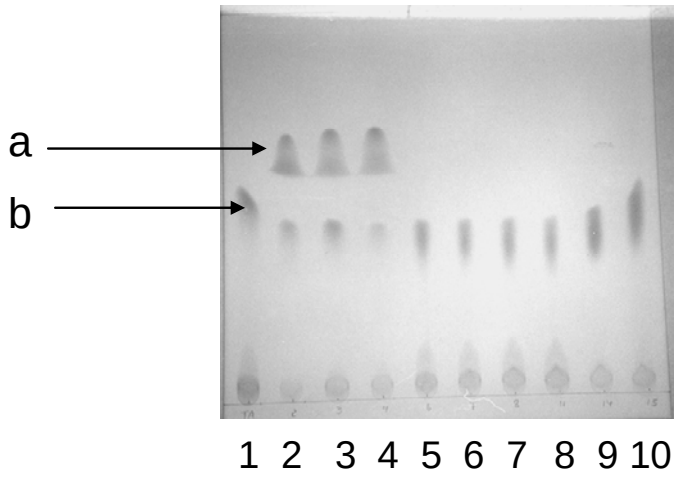

Figure 1: Hydrolysis of tannic acid (4 g/L) (1) by mixed bacterial cultures from rumen fluid of goats (2, 4, 6, 8, 10) and sheep (3, 5, 7, 9) and production of gallic acid (a) and pyrogallol (b).

Characterization of the isolates

Isolates EG 2.1, EG 7.1, EG 13 and ES 5 were able to hydrolyse tannic acid into pyrogallol (Figure 2). All of the isolates from the goats grow on 30 g/L

tannin extract of *A. angustissima*. EG 2.1 and EG 1 tolerated up to 20 g/L tannin acid (Table 2). ES 5 had a poor growth on higher concentrations of tannin acid but was able to grow on 30 g/L of tannin extract from *A. angustissima* leaves (Table 1).

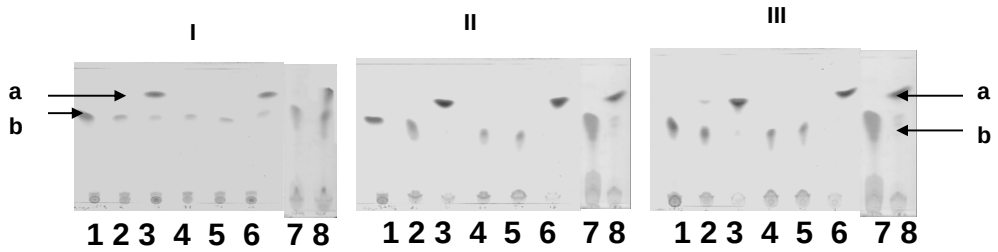

Figure 2: Hydrolysis of tannic acid (4 g/l) (1) by isolates EG 2.1 (2), EG 7.1 (3), EG 9.1 (4), EG 9.2 (5), EG 13 (6), EG 1 (7), ES 5 (8) and production of gallic acid (a) and pyrogallol (b). The cultures were incubated overnight (I), 5 days (II) and 10 days (III) at 39°C.

Table 1: Growth of the isolated bacteria at various concentrations of tannic acid and 70 % acetone extracts of *A. angustissima*.

Notes: Growth was measured turbidimetrically at 600 nm; + = growth with OD reading 0.7 – 0.5 with in 24h; ++ = growth with OD reading

Concentration	EG 2.1	EG 7.1	EG 9.1	EG 9.2	EG 13	EG 1	ES 5
Tannic acid 15 g/l	++	+	++	++	++	++	+
Tannic acid 20 g/l	++	+	+	+	+	++	+
Tannic acid 30 g/l	+	+	+	+	+	+	+
Tannin extracts 15 g/l	++	++	++	++	++	++	++
Tannin extracts 20 g/l	++	++	++	++	++	++	++
Tannin extracts 30 g/l	++	+	++	++	++	++	++

greater than 0.7

Carbohydrate utilization of the isolates

The capability of the isolates to ferment various carbohydrates is depicted in Table 2. The results showed that all of the isolates fermented fructose, glucose, galactose, lactose, maltose, mannitol, raffinose and trehalose. Isolate EG 2.1 did not ferment dextrin. Isolates EG 7.1, EG 13 and ES 5 could not ferment arabinose, rhaminose and xylose however, EG 13 fermented arabinose. Isolates EG 2.1 and EG 1 produced the highest total VFA (25 - 15 μm/ ml) that was more of acetate, propionate and butyrate as a major end product of glucose fermentation. All of the cocci isolates, EG 7.1, EG 13 and ES 5, produced less amount of total VFA as compare to EG 2.1 and EG 1. Their major end products of fermentation were acetate, propionate and isobutyrate.

Molecular characterization of the isolates

Result from the digestion of the 16S rDNA PCR product of the isolates by *Alu I*, *Dde I* and *Msp I* showed that isolates EG 7.1, ES 5, ES 11, and *S. bovis* had similar band patterns (Figure 3). Similarly, isolates EG 2.1, EG 13, EG 1 and ES 14.2 had similar patterns when digested with *Alu I*, *Dde I* and *Msp I* except EG 1 that showed a different pattern with *Alu I*. *S. ruminantium* did not have any similar band patterns with all of the isolates that are digested *Alu I*, *Dde I* and *Msp I*.

Table 2: Carbohydrate fermentation by tannin tolerant isolates

Type of Carbohydrate	EG 2.1	EG 7.1	EG 13	ES 5	EG 1	*S. ruminantium	*S. bovis JB1
Arabinose	+	–	+	–	+	+	(+)
Cellobiose	+	+	+	+	–	+	+
Dextrin	–	+	+	+	–	(+)	+
Esulin	+	+	+	+	–	(+)	+
Fructose	+	+	+	+	+	+	+
Galactose	+	+	+	+	+	+	+
Glucose	+	+	+	+	+	+	+
Lactose	+	+	+	+	+	+	+
Altose	+	+	+	+	+	+	+
Mannitol	+	+	+	+	+	+	(+)
Raffinose	+	+	+	+	(+)	+	–
Rhaminose	(+)	–	(+)	–	(+)	(+)	–
Trehalose	+	+	+	+	+	–	+
Sucrose	+	+	+	+	–	+	+
Xylose	(+)	–	–	–	+	+	+

Notes: Growth was measured turbidimetrically at 600 nm; – = no growth in the period of 10 h; (+) = growth with OD reading of 0.3 – 0.5; + = growth with OD reading greater than 0.6; *

Source: Odenyo and Osuji (1998)

The cocci isolates were all Gram positive and exhibited carbohydrate fermentation patterns similar to *Streptococcus bovis* and the tannin-tolerant isolate (ES 11) (Odenyo *et al*., 2001). Based on the morphology, carbohydrate utilization capabilities and Gram reaction characteristics, these isolates were are *Streptococci*, family Micrococcaceae. Phylogenetic studies of Odenyo *et al*. (2001) isolates showed that their isolate ES 11 was closely

related to *Streptococcus caprinus* (Brooker *et al*., 1994) but not the diplococcal isolated by Nelson *et al*. (1995).

Table 3: Production of acetate, propionate, isobuytric, butyric, isovaleric, valeric and total volatile fatty acids (µm / ml) by tannin tolerant isolates for 48 h

Isolates	Volatile fatty acids						
	Acetate	Propionate	Isobutyric	Butyric	Isovaleric	Valeric	Total VFA
EG 2.1	21.67	1.43	0.24	0.99	0.34	0.38	25.04
EG 7.1	4.18	1.26	0.72	2.85	1.86	0.28	11.15
EG 13	3.70	1.32	0.12	0.76	3.11	0.00	9.01
ES 5	4.20	0.74	0.00	0.62	0.11	0.00	5.67
EG 1	14.88	0.42	0.00	0.28	0.10	0.00	15.68

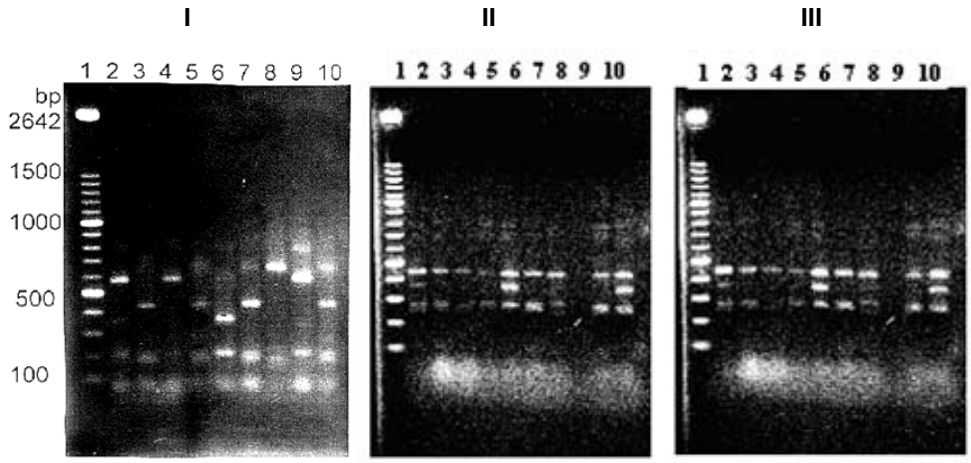

Figure 3. The restriction fragment length polymorphism of the 16 S rDNA PCR product of the tannin tolerant isolates cleaved with *Alu I, Msp* I (II) and *Dde* I (III). Lane 1, marker (100 bp); Lane 2, EG 2.1; Lane 3, EG 7.1; Lane 4, EG 13; Lane 5, ES 5; Lane 6, EG 1; Lane 7, *S. bovis*; Lane 8, *S. ruminantium*; Lane 9, ES 14.2; Lane 10, ES 11.

The RFLP patterns of the *Streptococcus* isolated in this study confirmed that isolate EG 7.1 and ES 5 belong to *Streptococcus bovis*. But isolate EG 13 may not be closely related to *Streptococcus bovis* or with ES 11 (*Streptococcus caprinus*), even through there was approximately 80 % similarity with EG 7.1 and ES 5 when characterized classically. Therefore isolate EG 13 is not related to neither to Odenyo *et al*. (2001) nor Nelson's *et al*. (1995) but it could belong to one of the species of Genus *Streptococcus*. The carbohydrate fermentation of the other isolates EG 2.1 and EG 1 that are rod shaped

revealed their difference to one another and to *S. ruminatium*. Phylogenetic studies of Odenyo *et al*. (2001) isolate ES 14.2 showed that it belongs to the genus *Kelebsiella pneuminiae,* which have similar band patterns to EG 2.1. Based on these similarities, EG 2.1 is a *Kelebsiella,* genus *Eubacterium*. Isolate EG 1 may also belong to genus *Eubacterium* because of similar band patterns to EG 2.1 when digested with *Dde I* and *Msp I* restriction enzymes. A different band pattern of EG 1 to EG 2.1 when digested with *Alu I* could be due to their distinct species type.

The isolated tannin tolerant bacteria could be introduced into ruminants that are feeding on tannin rich MPLT such as *A. angustissima* leaves to alleviate the toxicity of tannin. Even though, tannin tolerant/degrading bacteria have been previously reported (Brooker *et al.,* 1994; Nelson *et al.,* 1995; Odenyo and Osuji, 1998), there is still a need for isolating the best bacteria that can completely degrade tannin efficiently in short period of time. Therefore, further studies are needed to isolate bacteria that can degrade tannin and transfer these bacteria to ruminants that found in tropical areas where tannin rich leaves could be used as a feed supplement.

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Physical and Chemical Properties of Ethiopian Beeswax and Detection of Adulteration

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Abstract

Beeswax is one of highly valuable bee products. Currently, because of its high demand and shortage in the world market, its adulteration with cheaper materials became a challenge for its quality and marketing. The objectives of this work were to analyze the phyisco-chmical properties of local beeswax and to investigate the causes of quality deterioration and also to establish checking standard for animal tallow adulteration. For physicochemical analysis 75 beeswax samples were taken from farm gates and beeswax rendering houses and properties, relevant to beeswax quality like melting point, acid value, ester value, ratio of ester to acid and saponification cloud point were tested based on the protocols of American Beeswax Importers and Refiners Association INC. 1968 and the results were compared with different countries standards. To establish checking standard for detection of animal tallow adulteration, 10 authenticated beeswax samples were taken and mixed with animal tallow in the following proportion: 1%, 2.5%, 5%, 7.5% and 10%, 12.5%, 15%, 17.5%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90% and their melting and saponification cloud points were determined. As control and for comparison, both pure beeswax and animal tallow were tested and recorded. Each test was replicated three times and the average results were used as checking standard for adulteration. Beeswax samples mixed with 1% animal tallow observed to melt and saponify lower by 1°C than pure beeswax. As the proportion of adulteration increases, the melting and saponification cloud points were gradually decreased and approached to 46°C and 44°C respectively. The results of physical and chemical analysis revealed that most of the beeswax samples meet different countries standards; however few samples failed to meet the requirements as a result of adulteration and inappropriate processing. The study indicated that melting point and saponification cloud point could be used to easily detect up to 2% level of animal tallow adulteration. To minimize the alteration of beeswax appropriate processing devices is very important and for that of adulteration strong control mechanisms is needed to halt the existing problems.

Keywords: Beeswax, animal tallow, adulteration, melting point, saponification, Ethiopia, cloud point

Introduction

Beeswax is one of the very valuable bee products and it is also one of the oldest items to be used by mankind. Most of the beeswax of the world comes from developing countries and mainly used for export purpose. In developing countries exportation of beeswax has been considered as inflation-proof against local currencies (Roberts, 1970). Today beeswax is used for more than 300 purposes like in cosmetics, pharmaceuticals and many other industries (Wells, 1977). As a result, the demand for beeswax is very high and it has been never satisfied. Because of its high demand and shortage in the world market, adulteration of beeswax with cheaper materials like animal fats, plant oils and petroleum sprits (paraffin wax) become a challenge for beeswax quality and its marketing (Toulloch, 1980; Anam & Gathuru 1985).

In Ethiopia beeswax is one of the important exportable items since many centuries. Because of its softness and pliability nature, Ethiopian beeswax has been highly demanded and mostly used to blend beeswaxes from other sources. However, today complains are coming from exporters in that, some of the batches of beeswax exported are failing to meet the requirements for beeswax quality. These might be due to either adulteration of the beeswax or damaging of its natural properties while processing. Both factors are very likely to happen and are potential danger of beeswax quality. In other countries adulteration of beeswax with paraffin wax is a major problem. But under local conditions because of availability and cheapness of animal tallow, which is 10 times cheaper than beeswax, it is highly suspected and very likely to be mixed with pure beeswax. However, unlike paraffin wax there is no established checking standard to confirm adulteration of beeswax with animal tallow.

On the other hand the deterioration of beeswax's natural quality and the alteration of its composition as a result of prolonged over heating during rendering have been reported (Tulloch, 1973 & 1980). In Ethiopia deterioration of beeswax quality while processing is highly likely to happen because some of the processing facilities are not suitable to regulate the optimum temperature while processing. So investigation for the causes of beeswax quality deterioration that is to specify whether it is due to

adulteration or inappropriate processing is very essential. The possibilities of detecting adulteration and any alteration of beeswax properties (during processing) through its physical and chemical analysis has been well used (Tulloch, 1980; Anam & Gathura, 1985). So far the physical and chemical properties of local beeswax and the type and extent of adulterations were not determined.

With these backgrounds the objectives of this study were to establish reference data for detection of beeswax adulteration with animal tallow; to analyze the physical and chemical properties of local beeswax and to compare the results with different countries importers, refiners and pharmacopoeia's standards; and to pinpoint the main causes of quality deterioration that is to know whether it is while processing or adulteration.

Materials and methods

This study had two components: one was to collect and analyze the chemical and physical properties of local beeswax, which are relevant to its quality and the second one was to establish reference data or checking standard to detect the adulteration of beeswax with animal tallow. The analysis was carried out at the Laboratory of Holeta Bee Research Center.

To know the properties of pure beeswax secreted from local bees, crude honey samples were taken directly from traditional hives of the center and also from farm gates of nearby beekeepers. The beeswaxes were separated from the honey and then the crude beeswaxes were rendered into pure beeswax. From these authenticated beeswaxes, 10 samples were taken and used to establish reference data for the detection of beeswax adulteration with animal tallow. The samples were melted below 70 ^{o}C and strained in cotton clothes to remove any dirt particles and then allow solidifying. Then from each beeswax type, 10 gm samples were taken and mixed with animal tallow in the following proportion: - 1%, 2.5%, 5%, 7.5% and 10%, 12.5%, 15%, 17.5%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90%. The mixtures were re-melted and allow solidifying. From each mixture sample was taken and their melting point and saponification cloud point were determined based on the protocols of American Beeswax Importers and Refiners Association Inc. (1968). Along with the mixtures, the pure beeswax and pure animal tallow were tested as control and for comparison. Each test was

replicated three times. The obtained average results were used as checking standard for detection of adulteration of beeswax with animal tallow.

The physical and chemical properties of local beeswax were analyzed by taking a total of 75 samples from central, western and south western parts of the country. To identify the possible areas of beeswax quality deterioration, beeswax samples were taken from farm gates, honey mead breweries, intermediary beeswax collectors and exporter stores. The collection sites include different apiaries of Holeta Bee Research Centers like Holeta, Gedo and Suba sub sites, demonstration apiary sites of Ministry of Agriculture like Jimma, Nekemte and Children Amba, some enterprises and private apiaries farm gates). Moreover, samples were taken directly from local honey mead breweries (*tej houses*) from Ilubabor, Jima, Wollega and around Addis Ababa. Besides farm gates and *tej houses*, samples were taken from intermediary beeswax collectors and processors stores in areas mentioned above. Finally, samples were also taken from beeswaxes processed for export purpose at exporter's stores in Addis Ababa.

Before testing, the samples were melted below 70°C and strained in cotton clothes to remove any dirt particles and then allow solidifying. The physical & chemical properties that are relevant to beeswax quality like melting point, sponification cloud point, acid value, ester value and ester to acid ratio were tested based on the protocols of American Beeswax Importers and Refiners Association (INC, 1968). The results were compared with different countries beeswax standards (Table 1). The type of adulterant was specified using the established data of this experiment for animal tallow and for that of paraffin wax data reported by Tulloch (1980) and Anam & Gathuru (1985) were used.

Data Analysis

Data were analyzed using simple statistics procedures of the Statistical Analysis System (SAS, 1999).

Results

Establishing of checking standard

Beeswax samples adulterated with 1% animal tallow were melted at slightly lower temperature at an average of 61°C, which was lower by 1°C than the lower limit of most pure beeswax melting point standards. Beeswax samples mixed with 2.5 -7.5% animal tallow tend to melt at further lower

temperature between 60°C - 59°C. When the adulteration level was above 7.5°C the melting point was further below 59°C and as the proportion of animal tallow increased the melting point approached to 46°C, which is melting point of pure animal tallow Fig. 1.

Table 1. Official specification for beeswax

Pharmacopoeia	Melting Point (°C)	Acid value	Eater value	Ratio of ester to acid	Saponification cloud point (°C)
Pharmacopoée Française VII	62-66	16.8-22.4	72-80	-	
Dautsches Arzneibuch	61-66	17-22	66-82	3.0-4.3	
National Formulary USA XIV	62-65	17.0-23.0	72-77	3.3-4.2	
Pharmacopoeia USSR	63-65	17-20.5	66-76	3.4-3.9	
British Pharmaceutical Codex 1973	62-65	17.0-23.0	70-80	3.3-4.2	
American wax importers and refiners Association	62-65	17.0-24.0	72-79	3.3-4.2	< 65
Ethiopian Standard and quality Authority	61-66	17.0-24.0	70-80	-	

Source: Tulloch (1980)

Similarly the saponification cloud point followed the same trend in which beeswax samples mixed with 1% animal tallow averagely saponified at 60°C and beeswax samples adulterated with 2.5 - 7.5% animal tallow saponified at further lower temperatures between 59°C - 58°C. When the adulteration was above 7.5% the saponification cloud point further gradually fell below 58°C and as the proportion of animal tallow increased the saponification cloud point approached to 44°C, which is the saponification cloud point of pure animal tallow (Fig. 2). The average melting point and saponification cloud point of control, pure beeswax samples were 62°C and 61°C, respectively and the melting point and saponification cloud points of pure animal tallow were 46°C and 44°C, respectively.

The physicochemical properties of collected samples

The melting points of the collected beeswax samples varied from 59.9°C to 65°C with mean of 62.5°C (Table 2). In this test out of 75 samples 71 were found to be within the acceptable range of melting point (61-66°C). The remaining 4 samples were lower than the acceptable range, 59.9 – 60.5°C. The

origins of these samples were 2 from intermediary beeswax collectors and processors and the remaining 2 were from final processors (Table 3).

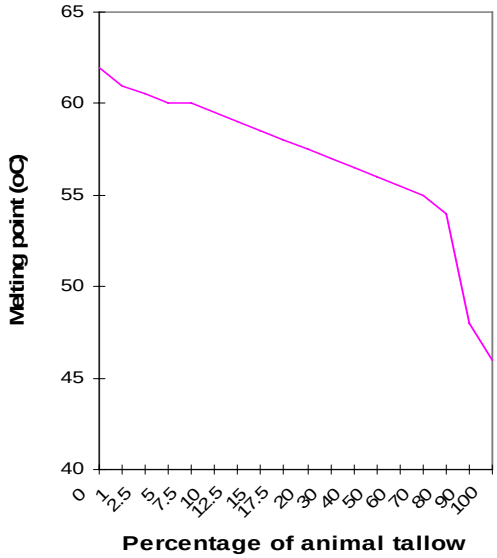

Figure 1. Melting point of adulterated beeswax

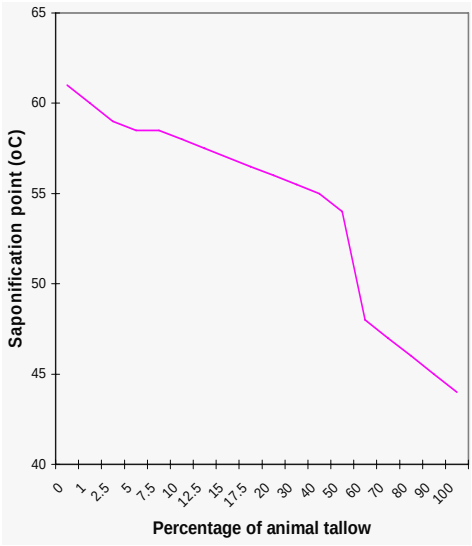

Figure 2. Saponification cloud point of adulterated beeswax

Table 2. Test results of collected samples

Parameters	Minimum	Maximum	Mean ± Std	Variance
Melting point	59.90	65.00	62.50 ± 1.07	1.14
Acid value	14.70	26.18	21.66 ± 2.26	5.09
Ester value	66.38	93.03	77.89 ± 5.99	35.95
ratio of ester to acid value	2.91	6.20	3.64 ± 0.57	0.32
Saponification cloud point	58.00	65.00	61.96 ± 2.02	4.09

The saponification cloud point test results of collected samples varied from 58°C to 65°C with mean of 61.91 (Table 2). Out of 75 samples 6 of them showed saponification cloud point less than 60, which varies from 58.0 –59.9, and these correlate with 2.5% - 7.5% animal tallow adulteration. From the 6 failed samples, 4 of them were from intermediary collectors and the remaining was from final processors. All samples that failed in melting point also failed in saponification cloud point tests (Table 3). Both tests (melting point and saponification cloud point tests) are supporting each other to confirm animal tallow adulteration. Moreover, the sample results indicated

that adulteration mainly occurs at intermediary processors levels and also appear at final processors.

Table 3. Origins, melting and saponification cloud points test results of beeswax samples those failed to meet the standard

Code	Origin of samples	Melting Point (°C)	Saponification cloud point (°C)	Saponification cloud point of beeswax adulterated with paraffin wax (°C)
007	Intermediary collector	59.9	58.0	
018	Intermediary collector	60.0	58.2	
021	Processors & exporter	60.2	58.1	
042	Processors & exporter	60.5	58.0	> 65 **
050	Intermediary collector		58.8	
068	Intermediary collector		59.9	
	Mean	60.15	58.5	
	Range	59.9 -60.5	58.0 -59.9	

** Tulloch, 1980; Anam.O.O. & Gathuru (1985) and American Beeswax importers and Refiners Association Inc. (1968)

The acid values of the tested samples were varied from 14.7 - 26.2 with mean value of 21.66. Out of 75 samples 5 of them showed the acid values below the acceptable range, 14.7 –16.9 and 3 of them were above the acceptable range, 24.6 - 26.2. Out of 8 samples that failed to meet the requirements, 3 of them were from intermediary collectors and the remaining was from final processors.

The ester values of the test results varied from 66.38 to 93.03 with mean value of 77.89 (Table 2). Out of 75 samples 7 of them showed high ester values, ranging from 82.40 - 93.03 which is beyond the acceptable range. Out of the 7 samples that failed to meet the requirements, 3 of them were from intermediary collectors and the remaining was from final processors. Samples that failed to pass the ester value also failed to pass the acid value which is due to un-controlled prolonged heating.

The ratios of ester to acid values also varied from 2.91 – 6.20 with mean of 3.64 (Table 2). In this test, only 4 samples (2 from intermediary collectors and 2 from final processors) showed above the acceptable values, which ranged from 5.13 – 6.20.

Generally, the results indicated that beeswax samples collected from farm gates and honey mead processors have no sign of adulteration and also deterioration of quality as a result of processing. On the other hand both adulteration and deterioration of beeswax quality arises starting from intermediary and final processors.

Discussion

Establishing of checking standard

The deliberate adulterated beeswax samples melting point and saponification cloud point test results indicated the presence of clear differences between pure beeswax and slightly adulterated beeswax with animal tallow. The results also indicated the possibilities of detecting as low as 2% level of animal tallow adulteration of beeswax. Moreover, there is a clear difference in saponification cloud points between beeswaxes adulterated with animal tallow and paraffin wax in which the later reported to saponify at higher temperature > 65°C as a result of the presence of higher number of hydrocarbons (Tulloch, 1980) while the animal tallow mixtures saponify below 60°C (Fig. 2). So saponification cloud point test could be used to specify the adulteration of beeswax with animal tallow or paraffin wax.

The physicochemical properties of collected samples

The low melting point of few beeswax samples could be due to animal tallow adulteration because the presence of paraffin wax adulteration was not supported with saponification cloud point tests. Moreover, samples with low melting point also showed low saponification cloud points 58°C – 59.9°C, which support animal tallow adulteration (Table 3). Beeswax adulterated with paraffin wax because of its high number of hydrocarbons is expected to show a cloud point at higher temperature, even for small amount of paraffin wax adulteration, tend to saponify at 70°C (Tulloch, 1980). But in this saponification cloud point test, beeswax samples with low melting point did not exceed beyond 65°C (Table 3). Therefore, low melting point of these samples could be due to animal tallow adulteration. Locally animal tallow is readily available and also 10 times cheaper than pure beeswax. In addition, the established data from deliberate adulteration of beeswax with animal tallow supports that the results of melting point and saponification cloud points of the samples could be associated with animal tallow adulteration.

The low acid values of few samples could be the declining of free acids and esters as a result of the reaction of free acids and esters with the secondary hydrocarbons under prolonged over heating (Tulloch, 1980). High ester values and high ratio numbers of ester to acid values are also associated with prolonged over heating of the beeswax (Tulloch, 1980).

In general the low acid and high ester values and their high ratio numbers are attributed to inappropriate processing conditions. This can be witnessed in the country where most of the large crude beeswax refiners melt the crude beeswax in 3000 – 5000 kg capacity melting tank continuously for about 12hrs without having thermo-regulatory facilities or water jacketed containers. The same system is used by small-scale beeswax processors who melt the crude beeswax using excessive fuel wood vigorously in the absence of water bath system, all of which would contribute for the alteration of the natural properties of beeswax.

Conclusion

Test results of the study indicated that most of the beeswax samples collected and tested for major beeswax quality parameters met the requirements of beeswax standards. However, the few samples failed to meet the standard, which was mainly due to inappropriate processing and adulteration of the beeswax with animal tallow. Both adulteration and alteration of natural properties were observed in the intermediary and final processors. Therefore, it requires awareness creation on how to render the beeswax and what type of processing devices should be used. Control mechanisms also need to be designed for adulteration. Melting point or/and saponification cloud point can be easily used to detect as small as 2% animal tallow adulteration of beeswax. Saponification cloud point test can be used to specify the adulteration due to animal tallow or paraffin wax.

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Past, Present and Future Perspectives of Animal Sciences Graduate Thesis Research: The Case of Alemaya University

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Abstract

This study was initiated based on the author's experience both as a student and instructor in the Animal Science graduate program of Alemaya University (AU). Masters theses published by graduates of the Department of Animal Sciences of AU from 1981 to 2005 were analyzed in terms of subject area, livestock species, subject area within livestock species, and gender of graduates to assess the type and nature of M.Sc. theses published by Animal Science graduates of AU in the last 25 years and to highlight scope for future livestock research. The number of M.Sc. graduates from the department has increased three-fold from 6 students in 1981 to 19 in 2005. Male and female graduates accounted for 95.6% and 4.4%, respectively of the total graduates. The most studied livestock species was cattle (31%) followed by poultry (17.6%), sheep (13.2%) and goats (9.6%). Camels (4.4%) appeared to be the least studied species indicating that many aspects of camels remain to be investigated. The most researched discipline was animal nutrition (33.1%) followed by animal breeding (19.9%), and characterization of livestock production systems (14%). Processing and preservation of animal products (5.1%), animal health (4.4%), draft animal power (2.2%) and animal physiology (0.74%) were given little attention and hence deserve detailed research in the future. The difference observed in the number of researches conducted in each subject area could be attributed to lack of subject matter specialists and laboratory facilities to conduct specific experiments in some fields of study and also due to inadequate financial resource to conduct theses research in the areas which are not well addressed. Thus, the Department of Animal Sciences needs to revise its human resource development and capacity building plans and strengthen its relationship with different national and international institutions to broaden its research programs through multidisciplinary and multi-institutional collaboration.

Keywords**:** Alemaya University; Department of Animal Sciences; Ethiopia; Livestock species; M.Sc. thesis research

Introduction

Ethiopia possesses 34.5, 22.5, 17, 55.8, 8.6 and 1 million heads of cattle, sheep, goats, chicken, equines and camels, respectively (ILRI, 2000). Despite the huge livestock resources, the contribution of the livestock sector to the national economy is limited. The livestock sector contributes about 18.8% to the total Gross Domestic Product (FAO, 2003) and about 40% to the Agricultural Gross Domestic Product (Getachew Feleke, 2003) of the country while it contributes about 31% of total employment (Getachew Feleke, 2003). The total annual production of meat, milk and eggs in the country was estimated at 653.6, 1197.5 and 75.6 thousand metric tones, respectively in the year 2000 and the annual growth rate of these products was estimated to be 1.3, 2.1 and 0.3%, respectively (FAO, 2003).

Various factors contributed to the under development of the livestock sector in the country one of which is shortage of well-trained professionals in the area of animal sciences. Successful development of the livestock sector in the country calls for highly trained professionals in modern animal husbandry and management techniques. It is, therefore, essential that in countries where the livestock sector is to be developed, manpower requirements need to be assessed at the early stages of development planning and steps should be taken to establish appropriate training facilities. Thus, intensive training programs in animal sciences aimed at producing high caliber, capable and dedicated professionals are of paramount importance in countries with developing animal agriculture.

It was to meet this demand for trained manpower in the livestock sector that the graduate program in Animal Sciences was launched in the then Alemaya College of Agriculture as part of the Addis Ababa University graduate program in 1979 (Tilahun Jiffar, 1987; AU, 2004). Until 2004, the Department of Animal Sciences of Alemaya University (AU) was the only higher learning institution in the country that offers M.Sc. training in Animal Sciences (AU, 2004). The M.Sc. program consists of both course work and research based thesis. Till recently, the Animal Science graduate program has been offered in two fields of study viz., animal production and animal breeding. However, currently with the initiation of two additional programs, animal nutrition and range ecology and management, the M.Sc. programs in the department increased to four (AU, 2004).

Every year increasing number of students join the Animal Sciences graduate program. The author's experience as a student, instructor and member of the Departmental Graduate Council (DGC) shows that graduate students are often confronted with problem of identifying research areas for their M.Sc. thesis work. This is mainly attributed to the absence of systematically organized and well-documented information retrieval systems either in the AU library (Belay Kassa, 2004) or in the Department of Animal Sciences. As a result, students often come up with a topic very similar to an earlier work done by their predecessors. Moreover, because of lack of reference materials, the DGC usually faces problem while approving M.Sc. thesis titles submitted by graduate students.

Assessing and analyzing the nature of M.Sc. theses research published so far by Animal Science graduates of AU would be of paramount importance in examining the type and nature of masters thesis research that has been undertaken, understanding the trends in the direction of research in the various aspects of animal production and helping to develop strategies for future livestock research. It will help students and researchers identify research areas that have been thoroughly studied and those that have been given little attention and it will also highlight future animal science research direction. This in turn will avoid repetition of experiments and will save time wasted in search of new research areas.

Analysis of M.Sc. theses published so far in the livestock sector could also contribute to the documentation system of the AU library in particular and to the livestock research directory of the country in general. Besides, it will facilitate the decision making process of the DGC of the department during thesis proposal approval. This study will also provide feedback information that would help the department to strengthen its graduate program. Other sister institutions which currently launched graduate programs in animal sciences would also benefit in identifying research areas. Moreover, the information generated would be useful in the design of appropriate curriculum for the Animal Science graduate program. The objectives of this study were, therefore, to assess and analyze the type and nature of M.Sc. theses published by Animal Science graduates of AU in the last 25 years and to highlight scope for future livestock research.

Methodology

List of M.Sc. theses published by Animal Science graduates of AU over the last 25 years (1981-2005) was used for this study. In addition, to determine theses published on socio-economic and marketing aspects of the livestock sector, M.Sc. theses published by graduates of Agricultural Economics from 1981-2005 were examined. The data was obtained from the School of Graduate Studies of AU and the M.Sc. theses reserved in the library were referred to verify the specific field of study to which each thesis belongs. To avoid overlap of field of study for some theses, only the major themes of such theses were considered in categorizing these theses by subject areas. Descriptive statistics was used to analyze the data.

Results and Discussions

Masters graduates of the Department of Animal Sciences

Figure 1 presents the number of M.Sc. students graduated from the Department of Animal Sciences from 1981 to 2005. Over the 25 years period, the number of graduates from the department has increased three-fold, from 6 students in 1981 to 19 in 2005 (Appendix 1). The increase in the number of graduates in recent years could be attributed to the change in the education policy of the country. Recently, the minimum grade point average required to join the graduate programs of AU decreased from 2.5 to 2.0. The increased number of graduate students in recent years could also be attributed to the increase in the number of B.Sc. graduates in the field of animal sciences in the country and fierce competition for jobs among the graduates which in turn necessitated graduates to upgrade their qualifications. The initiation of different fields of specializations at a graduate level by the department might also have partly contributed to the increased enrollment of graduate students in the department.

Although the department has played a significant role by training highly qualified livestock professionals for the various stakeholders in the country during the last 25 years, the country's need for trained manpower in the livestock sector is not yet fulfilled. The country's demand for well-trained agricultural professionals is still very high and supply has continuously fallen short of demand (Belay Kassa, 2004). The national demand for M.Sc. degree holders in agricultural sciences was estimated at 445 per year (Belay Kassa, 2004); however, currently the country produces less than 100 graduates per year. In the 2004/2005 academic year, the total number of

students graduated with M.Sc. degree in agricultural sciences from AU was 75 (AU, 2005) and until 2004 AU was the only higher learning institution in the country that offers M.Sc. training in agricultural sciences (AU, 2004). This high demand offers a great opportunity to the department and hence the department needs to strengthen and further diversify its graduate program.

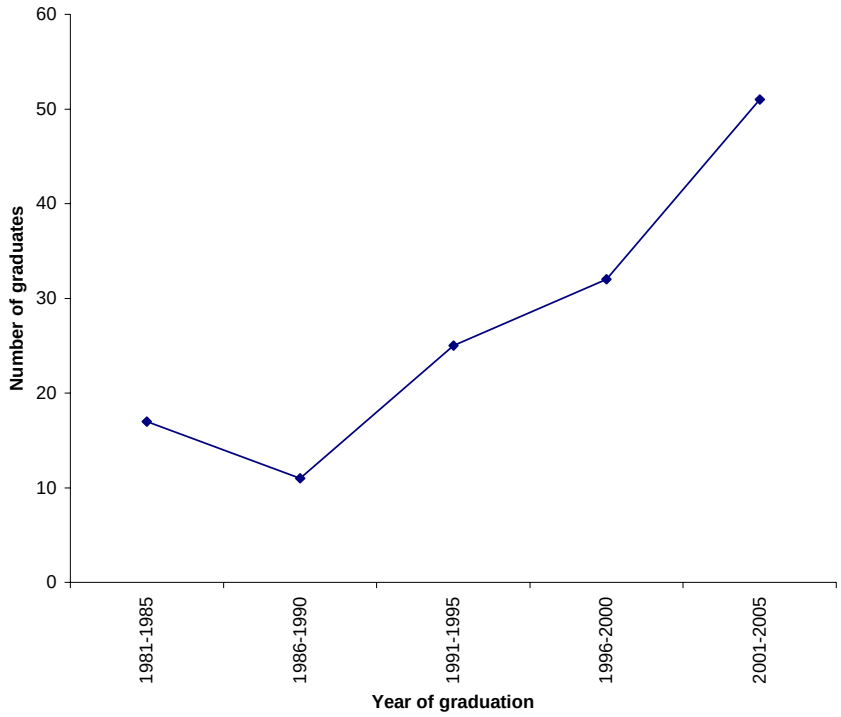

Figure 1. Trends in the number of M.Sc. graduates from the Department of Animal Sciences (AU) from 1981-2005 (N = 136) (AU = Alemaya University)

Distribution of thesis research by livestock species

Figure 2 illustrates distribution of M.Sc. theses published by Animal Science graduates over the last 25 years by livestock species. Among the major livestock species, cattle were the most studied species. This finding is inline with that reported by Azage Tegegne (1998) in which he analyzed the type and nature of research articles published during 1987-1997 in the proceedings of the Ethiopian Society of Animal Production and found that cattle were the most studied (36%) species. Given their large number and high contribution in

the country, the relatively large number of studies on cattle is expected. Although more studies have been conducted on cattle relative to other livestock species, the research done so far is not exhaustive and it hasn't significantly increased the productivity of cattle in the country (Knips, 2004). Thus, more demand-driven and applied research needs to be conducted on cattle in the future.

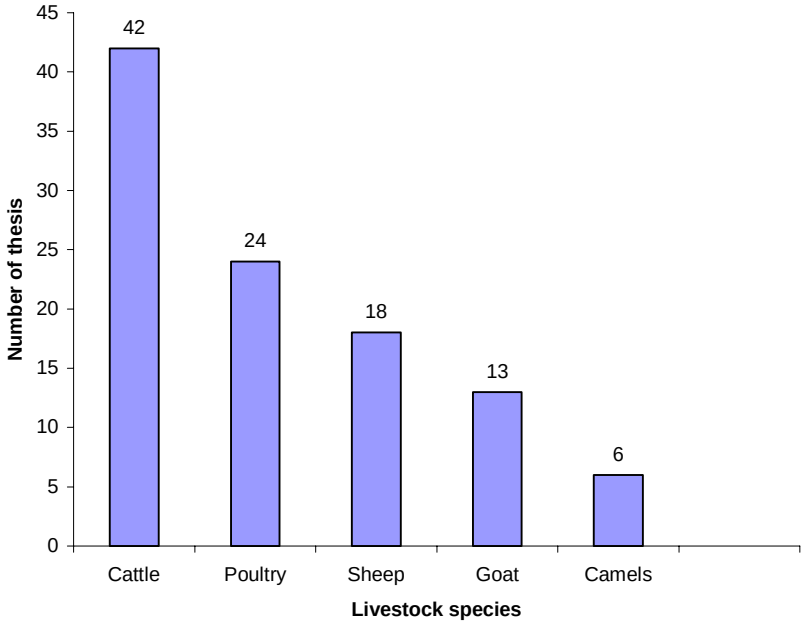

Figure 2. Distribution of M.Sc. theses published by Animal Science graduates over the last 25 years by livestock species

Poultry were the second most studied species after cattle (Fig. 2). In view of their large number and potential contributions especially to the resource-poor farmers, the studies conducted so far on poultry are not exhaustive. Thus, there are still many unstudied aspects that could potentially be addressed by AU graduate students.

For many of the rural poor farmers in the country, small ruminants provide a number of advantages over other livestock species. Although a number of researches have been conducted on small ruminants in the country, in view of the large number and contribution of goats and sheep, still much remains

to be studied. Thus, more and detailed scientific research needs to be conducted on small ruminants and their products in order to exploit their full potential.

Despite the huge potential of the camel in human food production in the arid and semi-arid lowlands of the country, camels are the least explored species and until recently little research and academic attention has been given to this important domestic animal. This calls for an urgent attention to the camel and conduct an in-depth research so as to increase the productivity of camels and to scale-up their contribution towards food self-sufficiency in the country.

Distribution of thesis research by subject areas

Figure 3 presents livestock thesis researches published by AU graduates during the period 1981-2005 by major subject areas. Of the total Animal Science M.Sc. theses published over the last 25 years, 33.1% were on animal nutrition while 20% were on animal breeding and reproduction. The higher number of theses published in the area of animal nutrition in relation to other subject areas is not because animal nutrition is the most pressing problem of the country as compared to other subject areas. A possible reason could probably be the availability of subject matter specialists in the department who could guide and advise graduate students and the relative convenience to conduct nutrition research with the available facilities in the department as compared to other disciplines. The Department of Animal Sciences had PhD holders in animal nutrition since the inception of the graduate program. Currently too, the number of PhD holders in the department in animal nutrition is greater than those with similar qualifications in the other disciplines. In the 2004/2005 academic year, the department had eight PhD holders (AU, 2004) of which 3 (37.5%) were in animal nutrition. On the other hand, the department currently faces a critical shortage of staff in poultry science and animal breeding and genetics (Tessema *et al*., 2004). The foregoing indicates the importance of having qualified academic staff in the various fields of study. Thus, the department needs to make strategic human resource development plan to increase the number of qualified staff in the various fields of study.

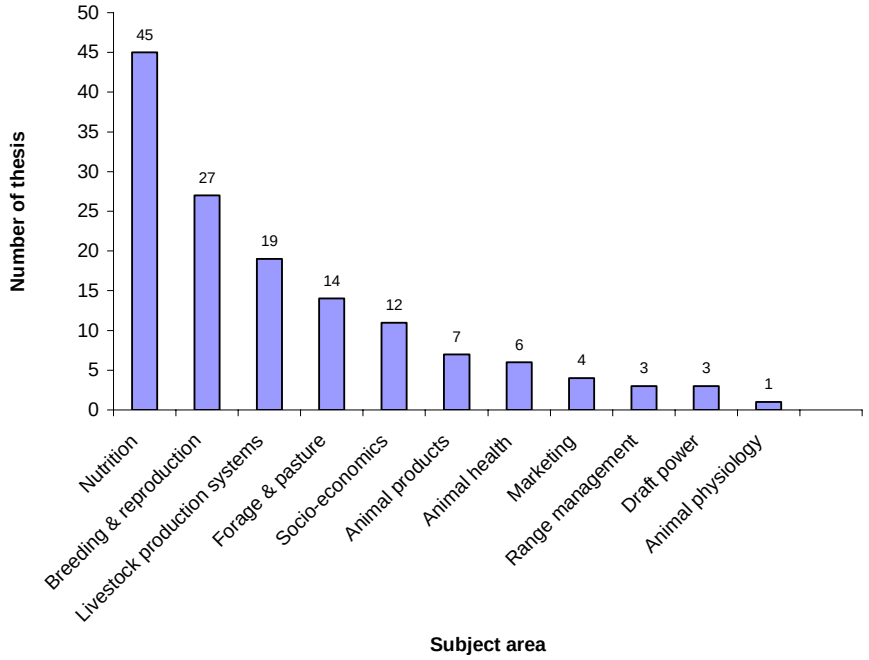

Figure 3. Distribution of livestock theses published by AU graduates over the last 25 years by major subject areas (Theses on socio-economics and marketing were by graduates of the Department of Agricultural Economics)

Following nutrition, breeding was the second most studied area in the department (Fig. 3). Postgraduate program in animal breeding was launched in the 1989/90 academic year (Belay Kassa, 2004) and most of the breeding theses were published since 1992. Expatriate staff mainly from Sweden, were in charge of this program. The theses published so far focused on breed characterization and analysis of secondary data collected over the years in various state farms across the country. No thesis was published in the area of molecular genetics and biotechnology. This could partly be attributed to the lack of trained staff and facilities in the department. Thus, it is high time for the department to seriously think about this and devise a means so as to provide graduate students an opportunity to do their thesis research in this direction.

Mere increase of production of meat, milk and other animal products could hardly bring the desired development in the livestock sector. To bring about a significant progress in the livestock sector, much attention needs to be

given to the production, collection, handling, transportation, preservation and distribution of animal products in the country. Post-harvest losses of animal products are generally high in most African countries. Considering milk alone, 20 to 80% of the milk produced in East and Central Africa is wasted through post-harvest losses (ILRI, 2005). Appropriate processing and preservation techniques could significantly reduce post-harvest losses of animal products. So far, however, little work has been done in the area of animal products processing and preservation by AU graduates (Fig 3). Among the theses published in the area of animal products, four were on dairy products, two were on meat and one was on eggs. In Ethiopia, the export of hides and skins is the second most important source of foreign exchange earnings after coffee (Knips, 2004). However, no research was done on hides and skins by graduate students of the department and so was the case with poultry meat, wools and hairs. The opening of the Department of Food Science and Postharvest Technology in the University (AU, 2004) is a good opportunity to graduate students to conduct their thesis research in the area of animal products processing and preservation because they will get subject matter specialists who will guide them while conducting their thesis research.

Except one work on dairy cattle physiology, no research was done on the physiology of goats, sheep, poultry and camels by Animal Science graduate students (Fig. 3). Although such studies might have been done elsewhere in the country, given the diverse climatic and agro-ecological zones of the country, much remains to be done by AU graduate students.

Among others, disease is an important factor which hinders the productivity of the livestock sector in the country. However, over the last 25 years only five theses were published in the area of animal health (Fig. 3). In fact, one may argue that animal health research is the duty and responsibility of graduates of veterinary science and the mandate of animal science graduates is mainly on the production aspects of domestic animals. In a way this might be true but animal health research should not be left only to veterinary graduates. There is a wide scope for animal science graduates to do research on animal health in relation to various production parameters and this aspect could probably be better handled by animal science graduates than veterinary graduates. Hence, more research needs to be carried out in this direction.

The most common farming system in Ethiopia is smallholder mixed crop-livestock farming (Knips, 2004). Animal traction is the major source of power used for crop cultivation by millions of smallholder farmers in the country and cattle are kept for ploughing (Knips, 2004). However, only three studies have been conducted on draft animals by AU graduate students so far (Fig. 3) indicating that draft power is one of the neglected areas of research and certainly deserves due attention. Similarly, only three studies have been conducted on range management by AU graduates to date (Fig. 3). Since the department launched M.Sc. training on range ecology and management (AU, 2004), more studies on range management are expected to be conducted by AU graduate students in the future.

Studies on socio-economic and marketing aspects of livestock and their products have not been done by Animal Science graduates probably because graduates of the Department of Agricultural Economics do their thesis research on these aspects of the livestock sector and probably because Animal Science graduates lack a strong background to conduct such studies. Examination of M.Sc. theses published by graduates of the Department of Agricultural Economics has shown that very few studies (a total of 16 theses) have been conducted on socio-economic and marketing aspects of livestock and livestock products (Fig. 3). The development of effective and efficient livestock marketing systems is essential to improve and sustain the livelihood of poor livestock producers in the Horn of Africa (Knips, 2004). Thus, there is a pressing need for more and detailed scientific research on socio-economic and marketing aspects of the various livestock species and their products.

Distribution of thesis research by subject area within livestock species

Cattle: Figure 4 shows the distribution of M.Sc. theses by subject area for the major livestock species. In the case of cattle, the most studied field was breeding followed by nutrition. On the contrary, breeding was the least studied area in goats, poultry and camels. The possible reason for more study on cattle breeding could be the availability of breeding data collected over the years in the various state farms across the country.

Though prevalence of disease is one of the major factors affecting the productivity of cattle in the country, it is not given due attention. This is evidenced by the fact that only a single thesis was published in this aspect to

date (Fig. 4). The opening of Faculty of Veterinary Medicine in the University (AU, 2004) is a good opportunity for our graduate students to conduct their thesis research in the area of animal health because they can get subject matter specialists to guide them during their thesis research. Hence, more research needs to be conducted in the area of animal health in the future.

Most of the studies conducted on cattle so far focused mainly on dairy traits and very few on beef. Although meat and milk are the major food products obtained from cattle, only few studies have been conducted on these products. To date, only three studies were conducted on cow milk while no research has been done on quality aspects of cattle meat by AU graduates. Thus, research on milk and meat from cattle need to be given due attention.

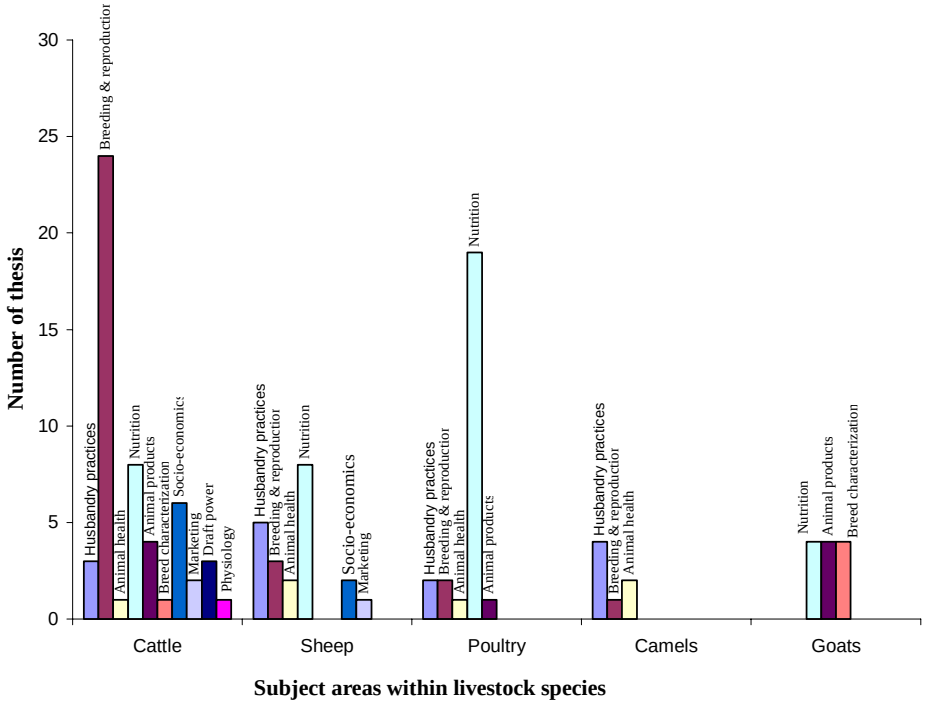

Figure 4. Distribution of M.Sc. theses published by Animal Science graduates over the last 25 years by subject area for the major livestock species (Theses on socio-economics & marketing aspects were published by Agricultural Economics graduates)

Goats and sheep: Except for the few breed characterization studies, no research has been done on goat breeding (Fig. 4). Similarly, no study has

been conducted on goat health problems. Thus, these aspects are potential areas for research. So far, only two studies each were done on goat milk and goat meat. Hence, further and detailed investigations need to be conducted on the processing and preservation of goat products.

To date, few studies have been conducted on sheep breeding and reproduction by AU graduates (Fig. 4). Moreover, very few studies have been conducted on sheep products such as milk, meat and wool in the country. Hence, there is an urgent need to conduct detailed research on quality parameters of products from sheep.

Trends of the last 25 years of thesis in AU indicated that the main research interest so far has been increasing the productivity of small ruminants, while research on marketing and product improvement is lagging behind. The contributions of goat and sheep milk to human nutrition and health have received little research attention. Therefore, research is needed to identify and promote marketing of the unique values of dairy products from goat and sheep milk.

Poultry (Chicken): Nutrition appeared to be the most researched field of study in the case of poultry (Fig. 4) whereas no research has been conducted on poultry breeding and characterization of the indigenous breeds of chicken by AU graduates. Moreover, only one study was conducted each on poultry health and egg quality so far. On the contrary, no study has been conducted on quality parameters of poultry meat indicating that these areas very much deserve detailed investigation.

Camels: By virtue of their unique anatomical and physiological adaptation to the arid and semi- arid environments, camels are the most important domestic animals that determine the survival of millions of pastoralists in the arid and semi-arid lowlands of the country. However, camels are the least explored species. Until recently, no research and development attention has been given to the camel along with development programs of other livestock species in the country. Many aspects of camels remain to be investigated. Very little, if any, research has been done on camel nutrition so far by AU graduates. Similarly, no study has been conducted on processing and preservation of camel milk and milk products and on quality parameters of camel meat and meat products. Even the few studies conducted on husbandry practices, health and breeding (Fig. 4) of camels are far from

adequate. In general, much remains to be done about the camel in the country.

Distribution of thesis research by gender of graduates

Of the total graduates of the department, 95.5% were male, and female graduates accounted for only 4.5% of the total graduates. Due to the current policy reform on gender equity by the Ethiopian Government, the number of female students joining the Animal Science graduate program is increasing in recent years. In the 2004/2005 academic year alone, nine female students joined the Animal Science graduate program. This is a tremendous increment as compared to only six students during the last 25 years. The recent trend of the University to sponsor female graduate students (Belay Kassa, 2004) will encourage more female students to join the graduate program of the department.

Conclusion

Among others, lack of facilities and inadequate financial resource to conduct thesis research are reasons for the less involvement of our graduate students in the areas which are not well addressed. Thus, the University in general and the Department of Animal Sciences in particular need to linkup and strengthen their collaboration with different national and international institutions and scientists to give their graduate students an opportunity to broaden their thesis research area through multidisciplinary and multi-institutional collaboration.

Although almost all of the AU Animal Science MSc theses contain important and publishable results, the information contained in most of these theses has not been published and thus not accessible for use by the scientific community. Hence, the Department of Animal Sciences and the University in general should devise a means and encourage graduate students to publish the results of their thesis research work.

Areas such as processing and preservation of animal products, animal health, draft animal power and animal physiology and animals such as camels were given relatively little attention by our graduate students. Thus, attention should be given to and detailed research needs to be conducted in order to address problems associated with the relatively neglected animal species and/or subject areas.

Some of the students joining our graduate programs are self-sponsored and do not have fund to undertake their thesis research work. As a result, they desperately pickup any topic when they find a potential sponsor. Thus, in an effort to give more emphasis to research areas which have not been given attention, the Government or non-government organizations involved in development work should devise a strategy to provide financial support to graduate students planning to conduct their thesis research in the areas that are not well addressed.

Given the significant role of women in livestock production and management in the country, efforts should be made to increase the enrollment of female students in our graduate programs.

Acknowledgements

The author acknowledges the School of Graduate Studies of Alemaya University for providing the information.

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Appendix 1. List of M.Sc. theses published by Animal Science graduates of AU from 1981 to 2005*

1981

1. **Alemu Yami.** 1981. Laboratory Evaluation of Nutritive Value of Some Feedstuffs in the Alemaya Woreda. 81 pp.

2. **Azage Tegegne.** 1981. Reproductive Performance of Pure Zebu Cattle and their Crosses with Temperate Breeds in Ethiopia. 98 pp.

3. **Gebrekiros Asegede.** 1981. The Study of Ovine Helimenthiasis in Awassa and the Effect of Control with Nilzan. 65 pp.

4. **Maaza Sahle.** 1981. Comparative Laboratory and Animal Evaluation and Estimation of Protein Supplementation Value of Noug (*Guzotia abyssinica*) and Peanut (*Arachis hypogea*) Seed Cake. 71 pp.

5. **Mekonnen Lemma.** 1981. Evaluation of Noug Meal Versus Groundnut Meal as Protein Source in Calf Starter Rations. 46 pp.

* Arranged alphabetically within a year.

6. Tsegaw Belay. 1981. Comparative Laboratory and Animal Evaluation and Estimation of Calcium Supplementation Value of Bone Meal, Egg Shell Meal and Lime Stone. 115 pp.

1982

7. Amanuel Tuku. 1982. The Feeding Value of Sisal Waste for Fattening Borena Steers. 93 pp.

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Economic comparison of Ethiopian Boran cattle and their crosses with Holstein Friesian in central Ethiopia

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Abstract

Economic comparisons among Ethiopian Boran and their crosses with Holstein Friesian were made in the central highlands of Ethiopia. Data collected from experimental dairy cattle herds of the International Livestock Research Institute (ILRI) at the Debre Zeit Research Station, Ethiopia were used. The data of one year (2003 calendar year) were used for calculation of costs and returns. Comparisons of economic performance of the different genetic groups (Ethiopian Boran, 50, 75 and 87.5 per cent Holstein Friesian Inheritances) were made through calculations of profit per day per cow, profit per year per cow and cost per liter of milk production. The results indicated that the cost required to produce a liter of milk was significantly higher ($P<0.01$) for the Ethiopian Boran breed compared to all crosses. Ethiopian Boran cattle required more than double the amount required by the crosses. The costs were estimated at ETB† 3.17, 1.32, 1.39 and 1.17 for Ethiopian Boran, 50%, 75% and 87.5% crosses, respectively. Profit per day per cow and profit per year per cow were also much lower for Ethiopian Boran (ETB1.15 and 45.8, respectively) compared with the crosses (ETB15.3 and 4109.6 for 50%, 17.6 and 4760.6 for 75%, and 21.0 and 5700.7 for 87.5%, respectively) ($P<0.01$). The profit per day and profit per year for the 87.5% crossbreds were higher ($P<0.05$) than the amount for the 50% crossbreds. The 75% crosses did not have a significant ($P>0.05$) difference with 50 and 87.5% exotic blood levels. It was concluded that intensive dairy production with indigenous tropical breeds (Ethiopian Boran) is not economically feasible. Therefore, in such production systems crossbreds should be utilized.

Keywords: Ethiopian Boran; Holstein Friesian; Economic comparison; Central Ethiopia

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† 1 US Dollar= ETB (Ethiopian Birr) 8.67 in December, 2005

Introduction

The livestock sector has a significant contribution to the national economy of Ethiopia. However, the productivity of the livestock is extremely low. The average lactation milk production for the indigenous cows ranges from 494-850 kg under optimum management (EARO, 1999).

To meet the ever-increasing demand for milk and milk products in Ethiopia, genetic improvement of the indigenous cattle has been proposed as one of the options. Genetic improvement of the indigenous cattle, basically focusing on crossbreeding, has been practiced for the last five decades but with little success. Assessment of the overall impact of the crossbreeding work in Ethiopia is limited. Evaluation of the overall benefit of crossbreeding should capture both the biological and economic efficiency of the program. The majority of published studies on cattle crossbreeding in the tropics have focused on comparing biological efficiency of indigenous cattle with their crosses. Comparisons are generally restricted to reproductive and production traits. There have been few economic evaluations of cattle crossbreeding in tropical countries (Madalena, 1989; Kahi *et al.*, 1999; Karugia *et al.,* 2001). Indeed, in some of the studies it was indicated that biological efficiency did not translate into economic efficiency.

In Ethiopia, although some efforts (Kiwuwa *et al.,* 1983; Haile-Mariam *et al.,* 1993; Nigussie *et al.,* 1998; Demeke *et al.,* 2004a,b) were made in studying the biological performance of the crossbreds vis-à-vis the indigenous stock, economic comparisons of the different genetic groups has not been done to the best of our knowledge. This is the demand of the day particularly in light of stimulated global interest for cost effectiveness in breeding programs. Thus, there is a need to collect and analyze the information on the expected overall economic performance of the available breeds and their crosses at specific levels of resource availability and management and in discrete climatic conditions. This paper compares the economic performance of different genetic groups in central Ethiopia.

Materials and Methods

Source of data

Data collected from dairy cattle herds of the International Livestock Research Institute (ILRI) at the Debre Zeit Research Station, Ethiopia were used. The data of one year (2003 calendar year) were used for calculation of costs and returns.

Description of the farm

The Debre Zeit Research Station of the International Livestock Research Institute (ILRI) is located on the outskirts of the town of Debre Zeit, about 50 km south-east of Addis Ababa, in the Ethiopian highlands (8° 44'N and 38° 58'E), at an altitude of about 1850 meters above sea level. Average annual rainfall in the Debre Zeit area is about 866 mm. The annual average temperature is 18.7°C and the average monthly relative humidity is 52.4%.

Animals and management

Animals from four genetic groups were available and used for the study. These were: Ethiopian Boran, 50, 75, and 87.5 per cents of Holstein Friesian inheritance levels. Ethiopian Boran cattle are well adapted to semi-arid tropical conditions. They have a high degree of heat tolerance, are tolerant to many of the diseases prevailing in the tropics and have the ability to survive long periods of feed and water shortage. They are, however, comparatively low milk producers. On the other hand the Holstein Friesians, though less adaptive to the tropical environment have high milk production potential. The intent in crossbreeding is to combine these attributes of the genetic groups in the crossbreds. The cattle were not grazed because of problem of tick infestation. Thus, they were all stall-fed. Recorded amounts of green fodder and silage were provided. The animals were supplemented with concentrate mixture composed of (Wheat bran, noug (*Guizotia abyssinica)* seed cake, and molasses) based on milk production, two times per day. Clean water was provided *ad libitum*. Milking was done manually twice a day (mornings and evenings). Culling was based on productivity (low producers), age (old age) and health problems. Disease control was practiced through combined health management practices that included: vaccination for the important diseases (Black leg, Anthrax, Contagious Bovine Pleuropneumonia, Pasteurelosis and Foot and Mouth Disease), deworming (every six months) and treatment as the disease occurred.

The data

Comparisons of economic performance of the different genetic groups were made through calculations of the following parameters:

4. Profit per day per cow
5. Profit per year per cow; and
6. Total variable cost per liter of milk production.

These calculations demand correct identification of the costs and returns. Costs considered in this analysis include: feed (concentrate, hay and silage) cost, veterinary cost and labor (milking, feed collection, feeding and cleaning) cost.

Sources of income in dairy enterprise could be many and varied. However, because of availability of record and suitability for computation, income from the sale of milk and dung were considered. Dung output from each animal was computed based on results from a study by Tesfaye (2002) which found mean fecal dry matter yield per kg of live weight of 6 grams and 5 grams for crossbred and local Boran cows in Ethiopia. Profit was calculated as the difference between gross revenue (returns) and total variable cost.

The economic comparison was made under the following assumptions/conditions:

7. Herd size of 159 cows was considered;
8. The comparison is made with an intensive dairy enterprise in mind;
9. Indigenous genetic resources have existence, option, cultural and recreation values that are lost when full-scale crossbreeding is undertaken. These non-market values present formidable estimation problems and are not considered in this analysis.

Market price of inputs and outputs

Data on variable costs was collected for partial budgeting. The calculated input cost in local markets for feed, veterinary and labor for each genetic group is detailed in Table 1. Irrespective of the genetic groups, revenue for milk per liter was ETB 3.00, where as dung price per kg was ETB 0.05.

Statistical and financial analyses

Financial analysis was performed by employing partial budgeting method (Hyman, 1989) on each animal in the genetic groups based on data collected on price of variable costs (feed, veterinary and labor) and outputs (milk and dung). Subsequently, statistical differences in profit per day per cow, profit per year per cow and cost incurred to produce a liter of milk for the genetic groups were tested using the Generalized Linear Model (GLM) procedures of SAS (SAS, 2002).

Table 1. Costs and returns used for economic comparisons

Items	**Ethiopian Boran**	**50%**	**75%**	**87.5%**
Fecal out put (kg, dry matter/day)	1.75	2.33	2.36	2.34
Concentrate intake (kg/day/cow)	3.255	5.62	6.37	7.54
Silage intake (kg/day/cow)	6.815	11.76	13.34	15.78
Forage intake (kg/day/cow)	0.83	1.43	1.63	1.92
Costs (ETB/day/cow)				
Veterinary	0.010	0.014	0.036	0.051
Feed (concentrate)	2.54	4.38	4.97	5.88
Feed (silage)	0.75	1.294	1.467	1.736
Feed (forage)	1.154	1.991	2.258	2.671
Labor (ETB)	0.74	1.69	1.69	1.69
Total cost	5.194	9.369	10.421	12.028
Returns (ETB/day/cow)				
Dung	0.09	0.116	0.118	0.118
Milk	6.26	24.55	27.94	32.95
Total return	6.35	24.666	28.058	33.068
Price of milk, ETB/kg	3	3	3	3
Price of dung, ETB/kg	0.05	0.05	0.05	0.05

ETB, Ethiopian Birr

Results

Biological information as basis for economic comparisons

Results of the genetic evaluation of Ethiopian Boran and their crosses with Holstein Friesian are presented elsewhere (Haile, 2006). As basis for the present study, however, brief account of the major results are summarized. Crossbreeding of Ethiopian Boran with Holstein Friesian had improved growth, reproductive and milk production performance of the crossbreds over those of Ethiopian Boran breed. The Ethiopian Boran were consistently lighter than all their crosses with the Holstein-Friesian at birth, weaning, six months, one year, eighteen months and at two years. The Ethiopian Boran breed also had poor reproductive (as judged by calving interval, days open, age at first service, age at first calving and breeding efficiency) and production performance (evaluated based on lactation milk yield, 305 days milk yield, daily milk yield, lactation length and lifetime milk yield) compared to all the crosses.

Comparison among the crosses with different levels of exotic inheritance (50, 75, 87.5 percents) revealed no clear-cut superiority of any of the genetic group for growth and reproductive performance except for calving interval and days open which were shorter for 50% crosses compared to the 75% crosses. Lactation milk yield, 305 days milk yield and daily milk yield showed an increasing trend as exotic inheritance level increased. However, lifetime milk yield was higher in 50% exotic inheritance compared to 75% and 87.5% crosses.

Weight differences during the study period (2003, calendar year) among the genetic groups were marked (Table 2). All the crosses had significantly higher (P<0.01) body weight than the Ethiopian Boran breed. The crosses, however, had no differences (P>0.05) among themselves. Daily milk yield per cow for the study period was also significantly (P<0.01) different among the genetic groups. The Ethiopian Boran breed had the lowest yield amongst all the genetic groups. The 87.5% exotic inheritance crossbred cows had more daily milk yield than the 50% crosses but not significantly so with the 75% blood level.

Table 2. Least square means (±SE) for differences of genetic group on economic comparisons

Effect and level	**Number**	**Body weight (kg)**	**Daily milk yield (kg)**	**Cost per liter (ETB)**	**Profit per day (ETB)**	**Profit per year (ETB)**
Overall	159	380±4.6	7.6±0.28	1.76±0.08	13.8±0.83	3654±254
CV (%)		12.7	37.5	50.2	61.7	70.7
GG		**	**	**	**	**
50	78	388±5.5^{a}	8.2±0.32^{a}	1.32±0.09^{a}	15.3±0.98^{a}	4109.6±300^{a}
75	41	394±7.6^{a}	9.3±0.45^{b}	1.39±0.13^{a}	17.6±1.36^{ab}	4760.6±414^{ab}
87.5	14	389±13.0^{a}	11.0±0.77^{b}	1.17±0.22^{a}	21.0±2.32^{b}	5700.7±709^{b}
Eth. Boran	26	350±9.5^{b}	2.1±0.57^{c}	3.17±0.16^{b}	1.15±1.70^{c}	45.8±520^{c}

**, P<0.01; GG, genetic group

Least squares means with same superscript in the same column indicate non significance

Economic comparisons

Summary of costs and returns used for economic comparisons among the genetic groups are presented in Table 1, whereas, results of the analysis are given in Table 2. When the economic merits of the genetic groups were studied, the cost required to produce a liter of milk was significantly higher (P<0.01) for the Ethiopian Boran breed compared to all crosses. Ethiopian

Boran cattle required more than double the amount required by the crosses. The costs were estimated at ETB* 3.17, 1.32, 1.39 and 1.17 for Ethiopian Boran, 50%, 75% and 87.5% crosses, respectively. Profit per day per cow and profit per year per cow were also much lower for Ethiopian Boran (ETB1.15 and 45.8, respectively) compared with the crosses (ETB15.3 and 4109.6 for 50%, 17.6 and 4760.6 for 75%, and 21.0 and 5700.7 for 87.5%, respectively) (P<0.01). The profit per day and profit per year for the 87.5% crossbreds were higher (P<0.05) than the amount for the 50% crossbreds. The 75% cross did not have a significant (P>0.05) difference with 50 and 87.5% exotic blood levels.

Discussion

It was noticed that as the level of exotic inheritance increased the benefit in terms of profit had substantially increased. However, Madalena *et al*. (1990) used a profit function that, in addition to milk sales, included returns from sales of calves and culled cows and concluded that maximum profit was obtained utilizing F1 (Holstein Friesian x Guzera) females, over a wide range of simulated economic situations, suggesting that organization of continuous F1 heifer replacement programs may have a sound economic basis in Brazil. Kahi *et al.* (1999) compared economic performance utilizing data on accumulated lifetime performance of crosses of Ayrshire, Brown Swiss, Friesian and Sahiwal cattle from a dairy ranch in the lowland tropics of Kenya. There was no significant difference in the additive breed effects of the *Bos taurus* breeds for profitability indicating that greater genetic differences among breeds does not necessarily lead to greater economic benefits. Therefore, it was indicated that breeding decisions aiming to increase herd production efficiency should not solely be based on lactation and reproductive performances of cows but also on their relative economic efficiency.

Many of the studies on economic comparisons have not looked into the different exotic inheritance levels. Rather, they mainly compared local cattle with crossbred at specific blood level. Indeed, many reported the advantages, in financial terms, of the crosses over the local indigenous breeds. For example, Kumar (1999) in a study of economic analysis of technological change on milk production observed that the average cost per liter of milk

* 1 US Dollar= ETB 8.67 in December, 2005; § 1 US Dollar= Rupees (Rs.) 45.70 in June, 2006

production from milch animal was markedly lower in case of crossbred cows (Rs.§ 6.27) as compared to the local cows (Rs. 7.90). Similar results have also been obtained by Ram *et al*. (1981), Sharma and Singh (1985) and Kalra *et al*. (1995). Pandit (2002) carried out a detailed study to find out economic benefits of crossbred cows vis-à-vis locals and indicated that the average cost per kg of milk production was lower in case of crossbred cows (Rs 9.07) compared with that of local cows (Rs. 12.40). Net profit per kg of milk was found to be more (Rs. 2.24) for crossbred while it was negative (Rs. -0.54) for local cow. In the same study it was also indicated that net return per animal was Rs. 16.91 per day for crossbred but negative (Rs. -0.79 per day) for local cows.

The household impacts of smallholder-market-oriented dairying have been analyzed to test whether gains in real income from technical change or commercialization may translate into food consumption of the poor and nutrient intake in a pilot research project implemented in Holeta area (Ethiopia) between 1993 and 1998 (Ahmed *et al.,* 2000; 2002). Within the study area, crossbred cow yield a gross margin of ETB 937/cow/year, or more than seven times the gross margin of a local cow (ETB 120 /cow/year) in 1997. This result mirrors that of a similar study by a smallholder dairy development project in the central highlands of Ethiopia in 1998, which shows gross margin of ETB 865/cow/year for crossbred cow with milk production of 700 liters annually (Ojala, 1998). The gross margins estimated for crosses in these studies are smaller compared to results of the present study. This could be a reflection of differences in profit between on-farm and on-station studies, as the present study is based on records of institutional herds.

Although many studies, including the present one, have revealed the economic advantages of crossbred cattle compared with local in many parts of the tropics, it should be noted that indigenous genetic resources have existence, option, cultural and recreation values that are not considered in classical economic analysis. Although these non-market values present formidable estimation problems, an overall assessment of the economic benefit of a crossbreeding program need to capture these benefits which are indeed lost when full-scale crossbreeding is undertaken. Thus, results of these studies should be examined carefully.

Additionally, it is worth mentioning that the difference, in economic efficiency, between the crosses is not inline with the results of biological variation, where the crosses didn't differ in a consistent manner for the dairy traits studied, although 50% crosses were at advantage for some of the traits. This could possibly be because of two reasons: (1) labor cost that is expected to vary between the crosses is assumed similar because of difficulty in partitioning; (2) the economic assessment focused on milk and manure output only. This leaves out reproduction, growth, longevity etc which could some how affect the computation.

Conclusions

The Ethiopian Boran required more than double the cost required to produce a liter of milk compared to crosses. Profit per day and profit per year were also much lower for Ethiopian Boran. It was also demonstrated that as the level of exotic inheritance increased the benefit in terms of profit has substantially increased. It is concluded that intensive dairy production with indigenous tropical breeds (Ethiopian Boran) is not economically feasible. Therefore, in such production systems crossbreds should be utilized. It is also recommended that such economic evaluation be carried out for the different production systems prevailing in the country, preferably with considerations of non-traded benefits of indigenous cattle.

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On-farm Characterization of Sheko Breed of Cattle in Southwestern Ethiopia

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Abstract

A survey work was carried out in Bench Maji Zone of southwestern Ethiopia to characterize Sheko breed of cattle and their breeding tract. Reconnaissance tour, focus group discussion, semi-structured interview, field observation, secondary data and linear body measurement were used to generate the dataset. Findings of this study indicated as the geographical distribution of Sheko cattle is mainly restricted to Bench Maji Zone (BMZ) and partly in the adjoining parts of Kaffa and Shaka Zones. It was also revealed as Sheko cattle are blocky, predominantly polled (84.8 and 89.9% in male and female population, respectively) and have horizontally-oriented broad and short ear, broad muzzle and reduced type cervico-thoracic hump. They are dominated by glossy-red hair coat. The main identified threats are interbreeding with Zebu cattle, scarcity of feed resources and lack of conservation program and reliable information on the status of the breed. Current population of Sheko cattle is estimated at 4040, which is far low from previous reports. Trypanosomosis and internal parasite are reported as main diseases. However, over two-thirds of the respondents reported that Sheko cattle possess trypanotolerance character. Average age at puberty for male and female population is 41.6 and 42.1 months, respectively. Average age at first calving and mean calving interval is 54.1 and 15.6 month, respectively. Average reproductive lifespan of a cow is 14.7 year with average calf-crop of 8.3. Average age at castration is 5.7 year. Average lactation milk yield is 698.3 liter with associated average lactation length of 9.9 month. Nearly, 22.1 and 7.8 percent of the sampled Sheko cows were reported to produce on average more than 1000 and 1400 liter of milk per lactation, respectively. Sheko oxen on average start draught work at

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3.4±0.81 year and have an average draught work life of 8.5±2.67 year. Moreover, 76 percent of the respondents reported as Sheko oxen surpass their Zebu counterparts in draught stamina and speed.

Keywords: Sheko cattle, on-farm characterization, trypanotolerance, performance, adaptation, taurine, southwestern Ethiopia

Introduction

According to CSA (2004) report, Ethiopia has 40.6 million heads of cattle and considered as home of present-day cattle breeds of East and South Africa (Beyene and Biruke, 1992). It has also endowed with 23 identified breeds of cattle (Workneh *et al*., 2004); even though, this is still far from complete (Takele, 2005). Despite abundant cattle population and diverse animal genetic resources, exploitation of this has rarely gone beyond subsistence efforts of smallholder farmers.

Sheko, the only taurine breed of East Africa region is one of the identified indigenous cattle breeds in Ethiopia. It possesses genetically important attribute- trypanotolerance. Even though, it is endowed with this valuable adaptation trait today the breed is endangered by zebu introgression (DAGRIS, 2003; Takele, 2005). Despite its special qualities and uniqueness, little information is available on Sheko breed and its production environment. This study was, therefore, carried out to characterize Sheko breed of cattle and its breeding tract so as to collate information on special qualities and status.

Materials and Methods

The study area

Bench Maji Zone, the natural breeding tract of Sheko breed of cattle located in the per- humid agro-ecological zone of southwestern Ethiopia. The soil is generally red brown with scattered tracts of red color. The annual average temperature ranged from 20 to 40 ^{o}C with the mean annual rainfall of 1200 to 2000 mm and the main rainy season lasts from June to September (BMZRDMD, 2004). The tract lies 850 to 3000 m.a.s.l, approximately between geographic coordinates of 5°12' and 36°18' N latitude and 34°30' and 36°12' E longitude.

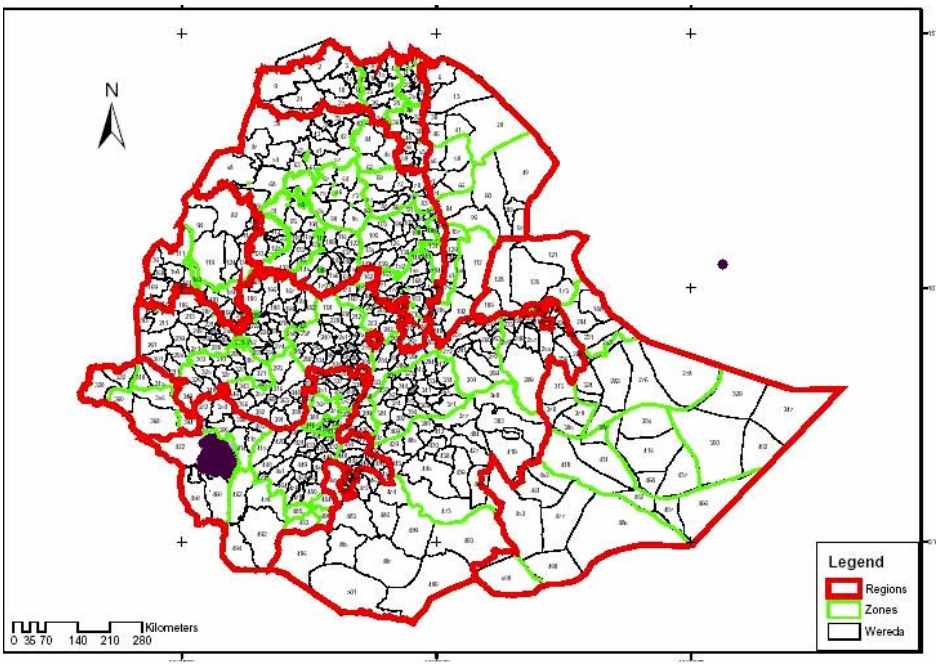

Figure 1. The study area (shaded part)

Methods of sampling and data collection

Reconnaissance and rapid surveys

A reconnaissance survey was made to familiarize with the existing agro-ecological zones and production systems. Information was then gathered using rapid survey encompassing collection of secondary data, wayside informal talks and key informant contacts. The information obtained from rapid survey indicated the heterogeneity of the breeding tract.

Identification and stratification of the study area

Based on the results of the rapid survey three districts were identified as main distribution centers of Sheko cattle. Agro-ecological classification of the study districts was made into lowland (<1500masl) and highland (>1500masl), which constitute 52 and 48 percent of the study area, respectively. Similarly, distribution density of the breed in question was categorized into low (<2%), medium (2 to 5%) and high (>5%) density of Sheko cattle. Based on this information a sampling frame was developed to conduct focus group discussions.

Focus group discussions

Based on the stratification made focus group discussions were held in 10 sites- Miruns, Giz Meret, Selale and Gaizika in Sheko district; Kite, Zozo, Debre Work, Temenja Yazhi and Genja in Bench district and Maha in Shei Bench district. Elders, village leaders and individuals endowed with extensive knowledge on socioeconomic situation and cattle husbandry system were selected by the help of local Agriculture and Rural Development staffs and Peasant Association leaders for group discussions. On average 7 persons (range 3 to 13) were participated in the discussion.

Key informants contact and way side informal talk

Key informants contact and way-side informal talks were made side by side with focus group discussions to substantiate and to cross check ideas forwarded during focus discussion.

Interview

Most of the dataset on phenotypic characteristics of Sheko cattle were gathered by individual interview of 129 Sheko cattle owning households using a pre-tested semi-structured questionnaire.

The nature of the data

The questionnaire was designed based on the information check lists developed by FAO (2000). Both the qualitative and quantitative variables collected on morphological appearance were adapted from the standard breed descriptor list developed by FAO (1986). Linear body measurement was taken using standard measuring tape. Both qualitative and quantitative variables were recorded in pre-coded format.

Data analysis

The data were analyzed using frequency and mean procedures of the descriptive statistics of SAS (1999).

Results

Origin and geographical distribution

No specific information was generated in this study about the origin of Sheko cattle. Sheko breed mainly found in BMZ and partly in the adjoining parts of Kaffa and Shaka Zones. Sheko breed derives its name from Sheko area and its breeder "Sheko ethnic group". It is known under numerous local names *viz* Goda, Tunt, Tunibey, Dello, Mulge, Mugul, Gombel, Semo and Dobe

(all of them literally describe as the breed is either polled or has floating type of horn), with Goda being the most commonly reported synonym.

Distinguishing features

Qualitative traits

The distinguishing features of Sheko cattle are prominent eye, folded type of eyelid, horizontally-oriented broad and short ear, broad muzzle and blocky appearance. Moreover, majority of them are polled (while the rest have stumpy or curved type floating horn) and characterized by having reduced type cervico-thoracic hump. Sheko dominated by glossy-red coat appearance. Plates of Sheko cow and ox in their natural breeding tract are depicted in Figures 2 and 3, respectively.

Figure 2. Sheko cow on communal grazing land

Figure 3. Sheko ox at night enclosure

Quantitative traits

Linear body measurements taken from Sheko cattle are summarized separately for female and male population in Tables 1 and 2, respectively.

Table1. Summary of linear body measurements for female population (cm)

Variable	N	Mean	Std. Dev	Minimum	Maximum
Chest girth	167	136.5	7.51	118.0	164.0
Body length	167	110.2	6.34	97.0	129.0
Height at wither	167	99.4	4.95	87.0	117.0
Pelvic width	167	33.5	2.23	29.0	40.0
Ear length	167	16.6	1.73	12.0	22.0
Teat length	167	3.4	0.75	2.0	6.0
Face length	167	39.5	2.59	31.0	46.0
Canon bone length	167	12.8	1.64	9.0	18.0
Canon bone circumference	167	13.4	0.84	11.5	18.0
Dewlap width	167	12.6	2.76	6.0	21.0
Naval flap width	167	2.7	1.93	0.3	9.0
Neck length	167	29.9	5.47	20.0	47.0
Horn length	17	14.8	9.03	3.0	33.8

Table 2. Summary of linear body measurements for male population (cm)

Variable	N	Mean	Std. Dev	Minimum	Maximum
Chest girth	46	141.2	9.21	120.0	159.5
Body length	46	114.6	7.51	98.0	127.0
Height at wither	46	103.6	5.98	93.0	118.0
Pelvic width	46	32.8	2.11	27.0	36.0
Ear length	46	16.6	1.75	13.6	20.0
Face length	46	40.8	2.46	36.0	49.0
Canon bone length	46	12.1	1.14	9.0	14.0
Canon bone circumference	46	14.8	1.13	13.0	18.0
Dewlap width	46	16.8	3.65	10.0	25.0
Perpetual sheath width	46	7.6	2.68	3.0	15.0
Neck length	46	30.2	5.69	20.0	45.0
Horn length	7	7.6	5.21	3.5	18.5

Threats and current status

Main constraints reported by focus group discussants and key informants in the breeding tract were shortage of feed, shrinkage of grazing land, encroachment of crop farming, indiscriminate interbreeding with local zebu, lack of reliable information on the status of the breed and conservation program, relatively more feed requirement, prevalence of diseases and nuisance from biting flies.

Population statistics and distribution density

The total population of Sheko cattle is estimated at 4040, which constitutes 2788 breeding females, 266 breeding males, 651 working oxen and 335 calves. The ratios of male to female and breeding bull to cow in the sampled herd were 1:2.9 and 1:10.6, respectively. Adult animals over 3 year constitute 91.7 percent of the herd.

In the sampled Peasant Associations (PAs) the minimum and maximum distribution density of Sheko cattle is 0.8 and 13.2 percent of the herd in Shimi and Kersheka PAs of Sheko and Bench districts, respectively. However, proportion obtained from accessed Sheko cattle owning households herd ranges from 8.3 to 100 percent with average value of 25.2 percent. Out of the interviewed 129 Sheko cattle-owning households only 3.1 percent of them keep pure herd of Sheko cattle.

Table 3. Summary of population estimate

District	Sampled PAs	Total cattle	Sheko (%)	Districts' total
Sheko	8	7809	1.6	300
Bench	21	74512	2.2	2130
Shei Bench	6	22637	1.4	1150
Adjacent districts*				310
Adjoining zones**				150
Total				4040

* Meanit Goldia, Meanit Shasha and Gura Ferda

** Kaffa and Shaka

Management practices

Sheko, Bench, Maenit and Kaficho ethnic groups mainly involve in breeding and management of Sheko cattle. The husbandry practice is characterized by low-input low-output system. About 95.3 percent of the owners house their animals at night and part of the day at their home, while the rest keep at night enclosures and open yards. House wives perform milking and cleaning of the yard more frequently while the husband is mainly responsible for sale and purchase of cattle.

Feeds and feeding

Sheko cattle are reared on natural pasture under continuous grazing system. Sheko cattle graze on fallow land, wetland, forest and bush, and bund of farm. Tethering and cut-and-carry are mainly practiced in areas where there is shortage of grazing land and herding labor. The practice of feed conservation is almost non-existent in the entire breeding tract. However, supplementation with non-conventional feed sources such as leftover of "*Chemo*" (a hot drink prepared from green leaf of coffee and spices such as garlic, red paper and ginger for human consumption), taro and grain husk is common. "*Dekin*" a seed collected from forest tree, "*Attela*" a local beverage byproduct, leaves from some trees, shrubs and herbs (*Vernonia amygdalina, Millettia ferruginea, Manilkara butigi, Ricinus communis, Sapium ellipticum and Dracaena steudneri*) also form part of the feed resource base.

Sources of mineral constitute table salt and the blue-green water-like mineral "*Zaa*". In most of the cases animals drink this non-conventional mineral source by themselves. "*Zaa"* constitutes about 21.8 percent of the mineral source in the sampled households.

Disease prevalence and health management

Trypanosomosis and internal parasite were reported as main diseases. Over two-thirds of the respondents reported as Sheko cattle are endowed with trypanotolerance attribute. The reported main reasons for this attribute are summarized as black coat color which is known to attract biting flies is rare in Sheko cattle. They are sturdy, thus, they do not lose their body condition during lean seasons of the year. Moreover, it was reported as having thicker skin which is hard enough for biting flies attack. Sheko cattle are affected less frequently by trypanosomosis even during the main season of trypanosomosis challenge. Even when they are affected they do not need frequent medication and recover without treatment in most of the cases. Death due to trypanosomosis was also reported to be rare.

Milk production

The reported average lactation length and daily milk yield of Sheko cows is presented in Table 4.

Table 4. Reported average lactation length (month) and milk yield (litre) (N=77)

Variable	Mean	Std. Dev	Minimum	Maximum
Lactation length	9.9	4.04	4.0	24
First lactation daily milk yield	3.3	1.45	0.5	9
Second lactation daily milk yield	2.3	1.11	0.3	8
Third lactation daily milk yield	1.3	0.85	0.3	6
Total lactation milk yield	698.3	478.02	40.0	2760

Nearly, 22.1 and 7.8 percent of Sheko cows were reported to produce on average more than 1000 and 1400 liter of milk per lactation, respectively. This is a promising potential to carry out breed conservation and improvement and to utilize this breed for crossbreeding.

Draught capacity

Sheko oxen start ploughing at average age of 3.4±0.81 with a minimum and maximum of 2 and 6 year, respectively. On average they can perform this function for 8.5± 2.67 with a minimum and maximum of 5 and 18 year, respectively (N=126). Seventy six percent of the respondents reported as Sheko oxen surpass their Zebu counterparts in draught capacity. Moreover, it was reported that Sheko oxen have appreciable speed and stamina. Therefore, as it is depicted on Figure 4, rope is usually knotted around the muzzle of Sheko oxen to minimize and thus to balance the draft speed with the accompanying zebu oxen.

Reproductive performance

The reproductive performance of Sheko cattle is detailed in Table 5. Calving takes place year round. Visited households reported no case of multiple births. Natural mating is solely practiced in the entire breeding tract. Abortion as reproductive disorder was reported by 7.8 percent of the respondents.

Table 5. Reported reproductive performance of breedable animals

Variable	N	Mean	Std. Dev	Minimum	Maximum
Age at puberty in male (mo)	129	41.6	11.16	24.0	84.0
Age at puberty in female (mo)	129	42.1	11.52	24.0	96.0
Age at first calving (mo)	129	54.1	11.76	36.0	108.0
Reproductive lifespan of cow (yr)	129	14.7	3.24	6.0	23.0
Lifespan calf crop production (n)	129	8.3	2.08	3.0	13.0
Calving interval (mo)	129	15.6	4.56	12.0	24.0
Reproductive lifespan of bull (yr)	126	6.5	1.63	3.5	12.0
Castration age (yr)	117	5.7	1.40	3.0	10.0

Figure 4. Sheko ox (blocky and polled) on draught operation

Discussions

Origin of the breed

Origin of the breed was quite vague for the respondents. However, Alberro and Haile-Mariam (1982a), DAD-IS (2000) and DAGRIS (2003) reported as Sheko cattle are the only remaining representatives of the *Brachyceros* type and last remnants of original Humpless Shorthorn (*Bos taurus*) cattle in east Africa. Unlike their West African Shorthorn counterparts, which was revealed from extensive review of Rege *et al*. (1994), Sheko are good milk producers and dominated by polledness (84.8 and 89.9% in male and female population, respectively).

Geographical distribution

A similar type of description was made about geographical distribution of Sheko cattle by DAGRIS (2003) and Alberro and Haile-Mariam (1982a). Sheko cattle which are known by few synonyms in the reports of Alberro and Haile-Mariam (1982a); DAD-IS (2000) and DAGRIS (2003) were found to have more synonyms which was substantiated by our study. Surprisingly, none of the study communities were familiar with the name Sheko as describer of this breed. Therefore, it is imperative to know vernaculars of the breed as component of descriptor list development.

Qualitative traits

Similar to our findings red plain coat was reported as dominant coat color by DAGRIS (2003) under *ex situ* on station condition. However, the present finding was not in agreement with what had been described by Alberro and Haile-Mariam (1982a) about coat color of Sheko cattle under *in situ* condition. The phenotypic description made about presence of horn in Sheko cattle disagrees from the reports of both DAGRIS (2003) and Alberro and Haile-Mariam (1982a). According to our findings to be qualified as true-to-type Sheko breed either polledness or having floating type of horn is the required criterion. However, other phenotypic descriptor lists reported by DAGRIS (2003) and Alberro and Haile-Mariam (1982a) are in line with the findings of our study.

Quantitative traits

Even though, few data are available on DAGRIS (2003) since data are taken from very few animals (3 animals only) and under *ex situ* on station condition, they may not reflect the real values of the morphometric measurements. Moreover, even though, Sheko were reported as small-sized breed (Alberro and

Haile-Mariam 1982a), they are quite large in size compared to some breeds of Shorthorn Abyssinia Highland Zebus like Gurage.

Threats and current status

The population of Sheko cattle estimated by this study is far below from the previous estimates of DAD-IS (2000) and DAGRIS (2003). This indicates that Sheko cattle population is decreasing. Even though, according to the criteria set by FAO (2000) which uses the number of breeding animals as indicator to categorize the status of a given breed may not place this breed under endangered category; sparse distribution density of the breed coupled with declining tendency for controlled pure breeding declares an alarming state of affairs on its status (Table 3). Interbreeding with local zebu is still the main threat for endangerment of Sheko breed, which is in agreement with the previous report (DAGRIS, 2003).

Feeds and the feeding practice

Farmers feeding strategies are on gradual shift from herding to tethering and cut-and-carry feeding system as herding requires a significant amount of labor largely provided by school-aged children. Moreover, in agreement with what had been described by UNDP (2003) family labor is predominately devoted to growing food crops. Despite reported feed shortage, feed conservation practice is non-existent in the study area as seasonal inadequacy of feed have rarely been corrected by conservation in developing countries (Makkar, 2002). However, this may be partly compensated by the use of non-conventional feed sources similar to what had been described by Jackson (1980). Thus, better utilization of non-conventional feed resources which do not compete with human food is imperative (Makkar, 2002). In this regard there is still a potential to use non-conventional feed sources to overcome the effect of feed shortage. To achieve this, efforts need to be geared towards developing methods of better utilization of the existing non-conventional feed sources.

Health management

Tsetse fly has infested estimated area of 135,000-220,000 km^2 (Bourn *et al*., 2001) in west and southwest of Ethiopia. Thus, the breeding tract of Sheko cattle, which is found at the fringe of southwestern Ethiopia classified as trypanosomosis endemic area. It was also reported by Lemecha *et al*. (2006) that trypanosomosis is as one of the major impediments to livestock sector development in west and southwest Ethiopia. Moreover, due to warm and humid to per-humid agro-ecological zone (Lemecha *et al*., 2006) internal

parasite infestation is a commonly encountered disease types in the study area.

Even though, the breeding tract is tsetse infested, it was substantiated under *ex situ* on station condition (Lemecha *et al*., 2006) and by on farm studies (Takele, 2005), that Sheko cattle possess trypanotolerance character. Reported indicators about trpanotolerance attribute of Sheko from on farm study go in line with what had been described by van der Waaij (2001). Sheko survives in trypanosomosis endemic area. Furthermore, as taurine allele is probably the oldest one on the continent (Bradley *et al*., 1996; Hanotte *et al*., 2000), this long survival of the taurine Sheko in tsetse infested area may be resulted in the development of trypanotolerance character as a natural mechanism to mitigate the challenge of trypanosomosis. Sheko has genetic relationship with Shorthorn West African cattle (Alberro and Haile-Mariam, 1982a), which are proved to possess this genetic attribute (Murray *et al*., 1984; Roelants, 1986; Maule, 1990).

Milk production

The reported mean lactation yield is higher than what had been described by DAD-IS (2000) for Sheko cattle, Workneh and Rowlands (2004) for Oromiya Region and FAO (2004) for the national average. Moreover, the reported mean lactation length is more than the report of DAD-IS (2000) for Sheko cattle. However, the lactation length found in this study is similar to what had been reported by Yitaye *et al*. (2000) for indigenous cattle in southern Ethiopia.

Draught work

A similar report was described about average of starting draught work in Ethiopia by Watson (1981), even though, as low as 2 year of age was reported for starting of draught work in the case of Sheko. However, age at first plowing is lower than the reports of Alganesh *et al*. (2004) and Chala *et al*. (2005).

Reproductive performance

Averages of age at puberty, age at first calving and mean calving interval in Sheko cattle were found to be less than what had been reported by Alganesh *et al*. (2004) for indigenous cattle of west Wellega and by Zewdu (2004) on Semien, Wogera Sanga and Fogera cattle in Northwestern Ethiopia. Reported average lifetime calf crop production in Sheko cow (Table 5) is higher than what had been reported by Gebregziabher and Mulugeta (2006) as highest for Horro cows (5.2 ± 0.24 calves). Similarly, reproductive lifespan of Sheko cows

also longer from what had been described for Horro (10.1 ± 0.01 year) (Gebregziabher and Mulugeta, 2006).

Conclusion

Sheko breed has special qualities of trypanotolerance and adaptation to terrain stress and warm and humid condition of its breeding tract. It also has a promising potential of milk production and draft power. However, its genetic integrity is highly threatened by zebu introgression. This condition in turn results in genetic dilution and numeric scarcity. To halt this situation and to utilize this unique breed for food and agriculture production there is urgent need of planning a community-driven and government-supported conservation and breed improvement program.

To explore the genetic potential of this unique breed, we recommend an in depth extensive research for development study especially under on-farm condition. Moreover, effective management of major constraints has to be given special attention to utilize the special qualities of this unique breed and to increase its population size.

Acknowledgements

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Information for Contributors

General

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

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

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

Objectives

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

Columns of the Journal

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

Research articles

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

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

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

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

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

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

Frequency of publication
Once a year (May)

Guidelines to Authors

General

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

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

Proofs will be sent to the author. Typeset proofs are not checked for errors. Thus, it is the responsibility of the primary author of each paper to review page proofs carefully for accuracy of

citations, formulae, etc. and to check for omissions in the text. It is imperative that the authors do a prompt, thorough job of reviewing the returned proofs to ensure timely publication. Authors are instructed to return the proofs to the Editorial Office within 15 (fifteen) days of receipt. Senior or corresponding authors will be provided with 25 (twenty-five) offprints free of charge for each published articles.

Format for Manuscripts

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Acknowledgements: Should be briefly stated following the conclusion.

References: Cite references by name and date. The abbreviation *et al s*hould be used in the text where more than two authors are quoted. Personal communications and unpublished work should be cited in the text only, giving the initials, name and date. They should not appear in the list of references. All references should be listed alphabetically. References should be selected based on their relevance and the numbers should be kept to a minimum. Journal names should be abbreviated according to the World list of Scientific Periodicals.

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

(Tesfu Kassa and Azage Tegegne, 1998).

(Alemu Yami and Kebede Abebe, 1992; Alemu Gebre Wold and Azage Tegegne, 1995; Zinash et

al., 1996) – Chronologically

According to Zinash Sileshi and Siyoum Bediye (1995)

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

Examples

Journal article:

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

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

Book

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

Chapter in a Book

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

Paper in Proceedings

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

Papers based on Theses

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

Abbreviations

Follow standard procedures.

Units

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

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

Quantity	Application	Unit	Symbol or expression of unit
Absorption	Balance trials	Grams per day	g d^{-1}
Activity	Enzyme	Micromoles per minute per gram	µmol min^{-1} g^{-1}
Area	Land	Hectare	ha
	Carcass	Square centimetre	cm^2
Backfat	Carcass	Millimetres	Mm
Concentration	Diet	Percent	%
		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 ^{o}C
Volume	Solutions	Litre	L
		Millilitre	ML
Yield	Milk production	Litres per day	L d^{-1}
Radioactivity	Metabolism	Curie or Becquerel	Ci (=37 GBq)

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

Membership to the Ethiopian Society of Animal Production (ESAP)

Membership advantages

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

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

Eligibility for membership

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

Application form for Membership

Application for Membership

Ethiopian Society of Animal Production (ESAP)

Name_____

First Middle Last

Mailing Address:_____

Current Employment:_____

Company/Institution:_____

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Measurements in Pasture and Forage Cropping Systems

Aklilu Mekasha
Alemayehu Mengistu

Technical Manual 18

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