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Estimates of Crossbreeding Parameters for Egg Laying Performance of Crossbreed Chickens at Debre Zeit, Ethiopia

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Abstract

Crossbreeding parameters were estimated for egg production performance of indigenous Ethiopian and White Leghorn chicken and their crosses at Debre Zeit Agricultural Research Centre, Ethiopia. The GLM procedure of SAS (1997) was used to estimate the contribution of additive genetic and heterotic effects in the crossbreds. Results obtained on average monthly egg production indicate that individual breed additive and heterotic effects were large and significant. Breed additive effects of 5, 13, 14 and 13 eggs/chicken, and individual heterotic effects of 5, 6, 4 and 3 eggs/chicken were obtained for the first three, four to six, seven to nine and ten to twelve months of laying periods, respectively. For total egg production breed additive effects of 24, 73, 118 and 118, and individual heterotic effects of 12, 23, 46 and 45 eggs/chicken were obtained for the first three, six, nine and twelve months of laying periods, respectively. Breed additive effect for average daily egg production was estimated to be 0.44 for both first six and twelve months of laying periods and individual heterotic effect of 0.19 eggs for the first 6 months and 0.12 eggs/chickens for the first 12 months of laying periods. Maternal breed additive and heterotic effects were not significant in all cases. In general egg production performance of the crossbred chickens was largely determined by breed additive genetic effect and the contribution of the heterotic effects was small.

Keyword*:* Crossbreeding, Chicken, additive effects, heterotic effects, egg production, Ethiopia.

Introduction

Poultry production in Ethiopia shows a clear distinction between traditional, low input systems and modern, more intensive systems with a relatively improved housing, feeding, breeding, marketing and processing

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(Alemu, 1995). The traditional system of poultry production, which has come to be known as "balanced farming", is characterised by its low input and a corresponding low output (Tadelle *et al.,* 2000). In Ethiopia, the egg laying performance of indigenous chickens is reported to be low under farmers' management conditions. (Bigbee, 1965; MOA, 1980; and Kidane, 1980). However, under improved conditions, a maximum of 100 eggs per chicken per year has been reported (Teketel, 1986, Abebe, 1992 and Negussie, 1999). The major constraints that limit poultry productivity are diseases, poor feeding and management practices, and the low genetic potential of indigenous chicken (Alemu and Tadelle, 1997 and Tadelle *et al.,* 2000).

One way of improving the productivity of indigenous chickens for egg production is through crossbreeding with exotic chickens that are known for higher egg production. Such crossbreeding has widely been used as method to combine the high egg production of exotic breeds with the adaptability of indigenous breeds. Apart from the additive contribution of each breed to meet those requirements, there are also large non additive heterotic effects in egg yield and fertility traits which combine to result in high total productivity of the first generation (F_1) of these crosses (Cunningham and Syrstad, 1987). In study of genetic effect on egg production in diallel mating system of six white Leghorn strains, a marked increase in genetic variance and heterotic effect with environmental variance were observed (Laris-Erik Liljedahal (1994)

Earlier reports on the performance of crossbred chickens for egg production traits showed that crossing with 62.5% indigenous-White Leghorn proportions were found to be superior to other crossbreds (25% and 50% crosses), (DZARC, 1991; Joseph, 1995 and Mekonnen, 1998.) However, information on additive genetic and heterotic effects is lacking.

The objective of this paper was therefore, to estimate the individual and maternal additive genetic and heterotic effects for egg production traits in crossbred chickens and to predict the performance of different breed groups using estimated crossbreeding parameters.

Materials and Methods

Study area

Data used for the present study was obtained from a crossbreeding experiment conducted on indigenous Ethiopian Chickens with White Leghorn breed at Debre Zeit Agricultural Research Centre (DZARC), in central highlands of Ethiopia. The centre is located about 45 km Southeast of Addis Ababa at an altitude of about 1900 meters above see level, with an annual rainfall of 849 mm. The daily mean temperature ranges from 9 to 27 ^{0}C with an overall mean of 19.1^{0}C.

Experimental flock and breeding program

About 2000 day old White Leghorn chicks were purchased from state owned commercial poultry firm in Addis Ababa in 1992. At the same time about 150 indigenous Ethiopian Chickens were bought from Cheffe Donsa market (Central highland of Ethiopia). These were housed in deep litter system of housing and in each house they were provided with waterer and feeder. The study flock was fed on recommended starter, grower and layer rations, and both fed and water was offered *ad libtum*.

In the mating system practised in the centre, the White Leghorn males were mated with indigenous female and indigenous male with Leghorn female to produce F_1 female chickens. The reciprocal produced F_1 female chickens were mated to either pure WLH or indigenous cocks to produce 3/4 WLH and 1/4 WLH crosses, respectively. The 5/8 WLH crosses were produced by either mating 1/4 WLH females to pure White Leghorn males or by mating 3/4 WLH females to F1 males. The 5/8 WLH and 3/8 indigenous were also mated to produce the 50% White Leghorn crosses. The reciprocal crosses were produced to test the difference in performance between reciprocal crosses and indigenous chicken Data was recorded on group basis because there was no egg collection nest for individual chicken at the time of the experiment.

Data analysis

A total of 453 records from 2443 chickens were used to estimate individual and maternal additive genetic and heterotic effects on egg production traits. The General Linear Model (GLM) of SAS (1997) was used for data analysis. Chickens of different breed groups were hatched over five years (1992-1996) and two seasons. For evaluation of the effect of seasons on egg production traits, the months of the year were grouped into two seasons: dry season covering the first part of dry season from October to December and second part of dry season from January to February. The main rainy season is from June to September and the short rainy season falls between March and April.

Some of experimental groups (batches and genotypes) had their production recorded only during the first few months of laying while others had for 12 months. Thus, the number of observations after 6 months of laying period was much smaller. To include as many breed groups and batches within breed groups as possible in the analysis, the egg laying performance over the first three, six, nine and twelve months of laying periods was considered to estimate crossbreeding parameters.

The coefficients of expected breed content and heterozygosity in birds were used as covariant to obtain estimates of the individual and maternal additive and heterotic effects using similar procedure to those of Robison *et al.,* (1980), Hirooka and Bhutyan (1995), and Kahi *et al.,* (1995). Heterozygosity with respect to genes of two breeds was calculated as the expected proportion of genes from the sire and dam. For example, the expected heterozygosity with respect to local (L) and Leghorn (WLH), H^{I}_{WLH} was calculated as (G^{s}_{L} *G^{d}_{WLH}) + (G^{s}_{WLH} *G^{d}_{L}) where the superscript *s* and *d* denote that the genes come from the sire and dam, respectively. Similarly expected heterozygosity with respect to two breeds were calculated for the genotype of the dam of individual and were denoted H^{M}_{WLH} as before (Akbas *et al.*, 1993). Thus the model included effects for G^{I}_{WLH}, H^{I}_{WLH}, G^{M}_{WLH}, H^{M}_{WLH} as well as the environmental effects described above except breed groups. The breed groups and coefficients for expected effects of breed content and heterotic are shown in Table 1. It is assumed that the performance of each breed was affected by individual additive genetic effect (G^{I}_{WLH}), the individual heterotic (H^{I}_{WLHL}), maternal additive genetic effect (G^{M}_{WLH}) and the maternal heterotic effect (H^{M}_{WLHL}). The effect of recombination loss was ignored in this study, because available breed group are limited for all traits and these effects cannot be separated. For evaluation of genetic parameters the following statistical model was used:

$$Y_{ijkl} = M + Y_i + S_j + P_k + G^{I}_{WLH}X_1 + H^{I}X_2 + G^{M}_{WLH}X_3 + H^{M}X_4 + +e_{ijkl}$$

where:

M = intercept (general level of indigenous chickens)

G^{I}_{WLH} = individual genetic effect of White Leghorn as deviation from indigenous chickens.

H^{I}_{WLHL} = individual heterotic effect.

G^{M}_{WLH} = maternal additive genetic effect of White Leghorn as deviation from indigenous chickens.

H^{M}_{WLHL} = maternal heterotic effect.

X_1 = proportion of genes from White Leghorn.

X_2 = proportion of maximum individual heterotic.

X_3 = proportion of genes from White Leghorn in dam.

X_4 = proportion of maximum maternal heterotic.

Y_i = year of hatching

S_j = season of hatching.

P_k = year group of hatching

e_{ijkl} = random error

The proportions of White Leghorn genes, individual and maternal heterotic, effect (X_1 to X_4) was considered as continuous variables. For values of X1 to X4 of the different breed groups is presented in Table 1.

Table 1. Breed groups and coefficients for expected effects of breed groups and heterotic effect

Breed group (Sire) * (Dam)	GL	GWL	HI	GML	GMWL	HM
(L) * (L)	1	0	0	1	0	0
(WL) * (L)	0.5	0.5	1	1	0	0
(L) * (WL)	0.5	0.5	1	0	1	0
(WL) (WL*L)	0.25	0.75	0.5	0.5	0.5	1
(L) (WL* L)	0.75	0.25	0.5	0.5	0.5	1
(WL *L) (WL(WL*L)	0.375	0.625	0.5	0.25	0.75	0.5
(WL) (L(WL* L)	0.375	0.625	0.75	0.75	0.25	0.5
((WL *L) (WL(WL*L)} {(WL *L) (WL(WL*L)}	0.375	0.625	0.46875	0.25	0.75	0.5
{(WL) (L(WL* L)} {(WL) (L(WL* L)}	0.375	0.625	0.46875	0.75	0.25	0.75

L=Local; GL= proportion of genes from indigenous chicken; WL= White Leghorn; GWL= Proportion of genes from White Leghorn; HL= Individual heterotic; GM =proportion of genes from dam; HM =Maternal heterotic

Results and Discussion

Average monthly egg production

Estimates of individual and maternal additive genetic and heterotic effects on average monthly egg production of the four laying cycles (1-3, 4-6, 7-9 and 10-12 months) are presented in Table 2. Breed content effects were large and showed significant ($p < 0.01$) effect on average monthly egg production in the four laying cycles. Estimates of individual heterotic were positive and significant ($p < 0.01$) for all laying cycles. Maternal additive genetic and heterotic effects were not significant in all laying cycles. The non-significant effect of maternal heterotic may imply that recombination loss is not involved (Ahlborn-Breier and Hohenboken, 1991)

Deviation of individual breed additive effect of the White Leghorn breed from local breed were estimated to be 4.6, 13, 14 and 13 eggs per chicken per month for the first 1-3, 4-6, 7-9 and 10-12 months of laying cycles, respectively. The individual heterotic contributions were estimated to be 5, 6, 4 and 4 eggs per chicken per month the first 1-3, 4-6, 7-9 and 10-12 months of laying cycles, respectively. Heterotic effect increased with age of chickens from the 1-3 months to 4-6 months and declined from 4-6 months to 7-9 months of laying cycle and remained constant then after. The result obtained in this regard is in agreement with Joseph (1995), who reported the importance of individual heterotic and its contribution to the egg production of crosses. The declined heterotic effect at the fourth period is attributed to different factors like age and small sample size. The latter might have affected heterosis expression by excluding some of the chickens that had good production potential. This affected the average value and reduced the variation in egg production between breeds and hence reduced the heterotic expression. Both year and season of hatching had no significant effect on all traits over the four laying periods.

Table 2. Estimates of individual and maternal additive genetic and heterotic effects for average monthly egg production over the four cycles of laying periods.

Parameter	Monthly egg production (numbers)			
	First 3 months	4 to 6 months	7 to 9 months	10 to 12 months
Individual additive effect	4.6 ± 2**	13±2**	14±2**	12±1**
Individual heterotic	5.3 ±2**	6±2**	4±1**	3±1**
Maternal additive effect	2.4 ±1NS	-1±2NS	-2±1NS	-3±1*
Maternal heterotic effect	-2.0 ±1NS	1±2NS	2±1NS	2±1NS

*= p< 0.05; **= p< 0.01; NS= Not significant

Total egg production

Estimates of individual and maternal additive genetic and heterotic effects on total egg production over the four cycles of laying periods are presented in Table 3. Results obtained indicate that in all cases individual breed additive effects were significant ($p < 0.05$) and increased from the first three months to the first 9 months of laying periods and remain constant then after. It was estimated that the White Leghorn produced 24, 73, 118 and 118 eggs higher than the local chickens, over the first three, six, nine and twelve months of laying periods, respectively, indicating the large potential differences between the two parental breeds.

Individual heterotic effects on total egg production were found to be non-significant for all laying periods and estimated to be 12, 23, 46 and 45 eggs/chicken for the first 3, 6, 9 and 12 months of laying cycle, respectively. The estimated values increased with age from the first 1-3 months to 7-9 months and slightly declined then after. This is in agreement with the work of Lars-Erik Liledahl *et al.,* (1994) who reported the increased heterotic effect with age of chickens in crosses between different Leghorn strains. The decline in heterotic effect at the later period can be explained by the expected decline in egg production performance with age of chickens. Moreover, the sample sizes at later periods were smaller, which might have affected heterotic expression by excluding some of the chickens that had good production potential at earlier periods. This affects the average value and reduces the variation in egg production between breeds and hence reduces the heterotic expression.

The large standard errors obtained in this study for total egg production (Table 3) are attributed to small number of observations. However, when monthly and average daily egg productions were considered, which had more number of observations, the standard error were less than those obtained for total egg production.

Table 3. Estimates of individual and maternal additive genetic and heterotic effects for total egg production/chicken for the first three, six, nine and twelve months of laying periods

Parameter	Total egg production (Numbers)			
	Three months	Six months	Nine months	Twelve months
Individual additive effect	24±14*	72.7±32*	117.53±48.7*	117.5±57*
Individual heterotic	12±12NS	22.6±29NS	45.6±50NS	45±56NS
Maternal additive effect	6±11NS	-4.3±26NS	-14.9±40NS	-41±45NS
Maternal heterotic	-5±11NS	-9.1±28NS	18±49.6NS	-207±55NS

*= p< 0.05; **= p< 0.01; NS= Not significant

Average daily egg production

The estimated individual and maternal additive genetic and heterotic effects for average daily egg production in the first six and twelve months of laying periods are presented in Table 4. Individual breed additive and individual heterotic effects for average daily egg production over the first six and twelve months of egg production were significant ($p < 0.05$) in explaining variation in average daily egg production. The individual additive genetic effects of average daily egg production of White Leghorn breed as deviation from indigenous chickens were similar for the first six as well as 12 months of laying periods and estimated to be 0.44 ±0.01 eggs/chicken. Estimated individual heterotic effects for average daily egg production was 0.19± 0.06 and 0.12 ± 0.04 eggs/hen for the first six and twelve months of egg production, respectively. The decline in individual heterotic with age is in accordance with production curve whereby egg production decreases as chicken get older. Moreover, the decline in number of observations at latter periods might have affected heterotic expression through reducing variation between breeds.

Table 4. Estimates of individual and maternal additive genetic and heterotic effects for average daily egg production in the first six and twelve months of laying periods

	Average daily egg production (Numbers)	
Parameters	6 months	12 months
Individual additive effect	0.44 ±0.01**	0.44 ±0.05**
Individual heterotic	0.19 ±0.01**	0.12± 0.04**
Maternal additive effect	-0.05 ±0.01NS	-0.11 ±0.04NS
Maternal heterotic effect	0.42 ±0.1NS	0.06 ±0.04NS

*= p< 0.05; **= p< 0.01; NS= Not significant

Hen-day and percentage hen-housed egg production

Estimated individual and maternal additive genetic and heterotic effects for hen-day and percentage hen-housed egg production over the first six and twelve months of laying periods are presented in Table 5. Results from regression analysis showed significant ($p < 0.05$) effects of additive breed difference for hen-day and percentage hen housed egg production over the first six months of laying period. For hen day egg production over the first 12 months breed additive genetic difference was still significant, while there were no significant difference of additive breed difference for percentage hen-housed egg production over the first twelve months of laying period. The heterotic effects were not significant for both hen days and percentage hen housed egg production over the first six and twelve months. The individual additive genetic effect of White Leghorn breed as a deviation from local birds in terms of hen-day egg production were estimated to be 0.57± 0.02 eggs/hen for the first six months and 0.53 ± 0.03 eggs/chicken for the first twelve months of laying periods (Table 5). Individual heterotic effects for hen-day egg production were estimated to be 0.25± 0.01 for the first six months and 0.18 ± 0.01 eggs/hen for the first twelve months of egg production. For percentage hen-housed egg production individual additive genetic effects were estimated to be 38 ± 13 for the first 6 months and 26 ± 13 for the first twelve months of laying periods. Individual heterotic effects were found to be 18 ± 16 for the first 6 months and 16 ±7 for the first twelve months laying periods. Maternal breed additive and heterotic effects were not significant in all cases. Thus, non-significant maternal effect on both traits indicate that recombination losses are not involved. Moreover, in modern poultry production, there is no subsequent connection between progenies and their dam; as a result maternal effect is not important. The large standard error obtained for both traits is attributed to small number of observations as both traits were calculated on the bases of total number of chickens that were presented at the end (hen-day) and start (percentage hen-housed) of laying periods. Both year and seasons of hatching had no significant effect on hen-day and percentage hen-housed egg production.

Table 5. Individual and maternal additive genetic and heterotic effects for Hen day and percentage hen housed egg production over the first 6 and 12 months egg laying periods.

Parameters	Hen-day egg production[1] (Numbers)		Hen-housed egg production[2] (%)	
	First 6 months	First 12 months	First 6 months	First 12 months
Individual additive	0.57 ± 0.02*	0.53 ± 0.03*	38 ±13*	26 ± 13NS
Individual heterotic	0.25± 0.01NS	0.18 ± 0.01NS	18±16	16±7NS
Maternal additive	-0.05±0.02NS	0.03 ±0.02	-5±1	12±1
Maternal heterotic	0.04 ± 0.01NS	0.03 ± 0.1NS	6 ±9	8± 7NS

*= p< 0.05; **= p< 0.01; NS= Not significant

[1] Total number of egg produced divided by the sum total of hen-days, i.e, sum of laying days of all hens.

[2]In the case of percentage hen-housed egg production all the birds that initially started production are considered.

Predicted egg production

The predicted egg production potential of chickens for the first six and 12 months of laying periods with different percentage of White Leghorn blood using estimated genetic parameters from Table 3 and regression coefficients from Table 1 are presented in Table 6. The prediction showed that total egg production in the first 6 months of laying periods increased as the level of White Leghorn inheritance increases up to 50%, decreases from 50 to 75% and increases then after. However, total egg production increases as level of exotic inheritance increases except for slight drops for 62.5% WLH. This prediction is in agreement with 129 eggs per chicken for F1 crosses and 114 eggs per chicken for 3/4 crosses reported by Brannang and pearson (1990) in crossing of indigenous chicken with Yarkon chicken breeds at Assela, Ethiopia. The superiority of the F_1 over the 3/4 crosses is attributed to heterozygosity indicating the importance of heterotic effect in crossbreeding programs.

Table 6. Predicted egg production performance of chickens with different percentage of WLH inheritance

Percentage of WLH inheritance	Predicted total egg production (No)	
	First six months	First 12 months
(Local)	69.9	112
¼ WLH	88.1	107.7
½ WLH	128.8	185.8
5/8 WLH	124.5	155.8
¾ WLH	124.4	166.4
7/8 WLH	131.3	177.5
15/16 WLH	134.8	183.0
WLH	138.2	188.5

Conclusion and Recommendations

Based on the results obtained in this study, egg production performance of crossbred of White Leghorn with indigenous chickens is mainly determined by additive genetic effects and to lesser extent by individual heterotic effects. The non-significant effects of individual heterotic for total egg production, hen-days and percentage hen-housed egg production are attributed to large standard errors and small number of observations as these traits were analysed on total number of eggs, but when the number of observations increased by considering monthly egg production and average daily egg production this non-significant effect disappeared indicating the importance of heterotic effect on egg production.

In general it can be concluded that from this on-station study the opportunity exists for up-grading to higher exotic blood level if optimal feeding and routine management are provided. However, under rural low input system crossbreeding around 50% White Leghorn inheritance seems optimal for smallholder farmers as they can cope up with available feed resource and management conditions. In this regard the decline in heterotic effect after first crosses can be minimised through development and use of new breed or synthetic breeds.

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Phenotypic Characterization of Goat Types in Northwestern Ethiopia

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Abstract

In this study goat types of Benshangul were characterized using multivariate analytical techniques and farmers identification criteria. Phenotypic measurements using FAO standard descriptor list, adopted by FARM Africa, were used on 2076 goats selected through stratified multistage random sampling.

Morphologically five different goat types, namely Felata, Arab, Gumuz, Oromo and Agew were identified. The dominant goat types found in semi-arid part were Felata, Arab and Gumuz goats. Agew and Oromo goat types were found in sub-humid parts of the region. The reported trypanotolerant attribute of Felata, Arab and Gumuz goat types might be the reason for their abundance in the region. Felata, Arab and Gumuz goats are used for milk production. The Oromo and Agew goats weigh on average 41.5 kg and 42.3 kg, respectively. They are used for meat production. The Arab and Gumuz goat types are considered as a dual-purpose type. In order to complete and confirm this phenotypic characterization, genetic and molecular breed characterizations are recommended.

Keywords: indigenous goats, breed types, Benishangul, phenotypic characterization, multivariate analysis.

Introduction

Ethiopia is endowed with varied ecological zones and possesses diverse animal genetic resources. There is a long history of trade with Arab countries across the Red Sea, with Sudan in the West and Kenya and Somalia in the southern and southeast. The waves of trade and physical movement of people and animals must have influenced the genetic make up of domestic livestock, including goats (Workneh, 1992). Goat might have gone through a continuous change in genetic structure through natural selection. Therefore, it is necessary to characterize and identify individuals, families, groups, types and

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breeds of animals and environments to which such species or breed populations are adapted or known to be adapted.

Goat types of Ethiopia were characterized using their physical feature and 14 different goat types were identified of which some have been reasonably documented (FARM-Africa, 1996). The Northwestern Ethiopia goat types were characterized as Northwestern lowland goat types (Nigatu, 1994). According to the 1997 annual report of the Benshangul-Gumuz Region Agricultural Bureau, taking advantage of extensive area of bushes and woodlands, which accounts for 60 percent of the total area and their capacity to live in harsh environments, different types of goats form an integral part of the farming systems in the northwestern parts of the country. In addition to the above the 1994 annual report of the Benishangul Bureau of Agriculture has reported that the Region also has other breed types. Therefore, this study was designed to characterize major breed types of goats in Benshangul-Gumuz Region, northwestern Ethiopia.

Materials and Methods

Study area

This study covered the whole of the Benshangul-Gumuz Regional State, which is located in the northwestern Ethiopia, bounded by Sudan in the west, Amhara Region in the north and northeast, Oromia in the east and southeast and Gambela in the south. According to the 1995 annual report of the Benshangul-Gumuz Region Agricultural Bureau, the Region covers a total area of 250,000 km^2 and is located between geographical coordinates 90^0 30'N to 110^0 39'N latitude and 340^0 20'E to 360^0 30'E longitude. The region is divided into 3 administrative zones and 2 special woredas (districts). The 3 zones are further divided into 18 woredas to form a total of 20 woredas. Each woreda is further classified into Kebeles (lowest administrative unit of Ethiopia) and form a total of 633 Kebeles. The region has 8 major ethnic groups and 3 farming system namely Sedentary, Agro-pastoral and Nomadic.

Sampling method

The study considered the whole 20 woredas within 3 zones and 2 special woredas. Out of a total of 633 Kebeles about 10 percent of them were sampled. The Kebele within the stratum constitutes the first unit and the farmer within the Kebele the second unit. The Kebeles were selected in such a way that they were equally distributed among the woredas.

In the first stage, woredas were considered on the basis of identified ethnic groups and geographic locations and secondly Kebeles were taken into account. Further stratification within some woredas based on the production system was found to be important as if farmers could provide at least 30 adult non-pregnant female goats. Thus, the sampling method used was stratified multistage random sampling (Gomez and Gomez, 1976). Once Kebeles were selected, they were checked with local authorities and agricultural extension staff for their goat type and number that resulted to 59 Kebeles to be used for sampling. Four out of the 63 Kebeles were excluded due to few goat populations available.

Survey design

In each of the 59 selected Kebeles, scientific surveys by following sampling designs and suitable formats, descriptors and questionnaires for collecting all possible information for particular goat type residing in a defined area were used. A one-time visit survey (Workneh, 1992, Peacock, 1996) was employed in the Kebeles to the randomly selected goats for physical measurements. Key informant farmers were chosen and interviewed.

Identification of goat types

Physical measurements were taken on goats to assess breed types. Both continuous (5) and discrete (41) phenotypic breed descriptor variables (Nigatu, 1994; FARM-Africa, 1996) from 2076 goats of 59 sample sites were taken for the breed characterization (Table 1).

Stage of maturity of goats was determined at the stage where bone development was assumed to cease. This was done after identifying matured female goats through linear measurements of ear, horn, height at withers, heart girth and body weight of 100 goats of different age group from each goat type. Height at withers stops increasing at an increasing rate earlier than body weight and chest girth, which verifies the stage where the animal is mature (Figure 1) and further bone development stops (Makhenzie, 1976).

Females of greater than 14-19 month of estimated age as judged by their dentition classes (add a foot note explaining the dentition classes), with fully spread apart milk teeth or start to wear down and with erupted and growing first pair of incisors, were sampled for phenotypic characterization. As Nigatu (1994) reported earlier, such goats represents the center of population in the flock age structure.

Data analysis

Multivariate analysis was used to analyze the multiple measurements of subjects to reduce the data dimension and to assign observations to groups (Minitab, 1998).

Principal component analysis

Phenotypic measurements of both continuous and discrete variables from goats of 59 sample sites of 2076 goats each with 46 variables were taken. Principal Component (PC) analysis was used to explore the underlying data structure and form a smaller number of un-correlated components. Only the first five most important PCs were selected for further analysis and classification using Scree plot diagram of the Principal component analysis. The relative importance of the PC was observed from their eigenvalues and their contribution in explaining the overall variance. The eigenvector and loading value identifies how each variable influences its corresponding PC.

Clustering of observations

The procedure used for clustering of observation into groups was sequential, agglomerate, hierarchical and non-overlapping (SAHN) (Workneh, 1992; Alemayehu, 1993; Nigatu, 1994). Average linkage method was found to be appropriate for the data as it suits the clustering technique employed. The within-cluster sum of squares, average distance from centroid, maximum distance from centroid and the squared distance between clusters of goats was calculated to determine the clusters.

Discriminant analysis

Using discriminant analysis, the data were repeatedly analyzed to classify the observations into identified breed groups and identify misclassified goat types.

Results

Principal components (PC)

Based on their associated eigenvalue eight variables from PC one, six from PC two then five, four and three from PC three, four and five, respectively were selected (Table 2). This reduces the variables numbers from 46 to 26 and these were quite satisfactory for the analysis (Sneath and Sokal, 1973; Pimental, 1979). The first five PCs (Table 3) that display weight on the Scree plot profile (Figure 2) and explained 54 percent of the total variation were selected for classification.

PC one was most strongly influenced by ear length, convex head, pendulous ear form, bodies weight, height at withers, hairiness, brown and gray coat color. Principal component 2 was most strongly associated with coat pattern like short smooth hair and coarse hair. Chest length, slightly concave facial profile, presence of wattle and beard were also concerned by PC 2. Principal component 3 was closely related to horn orientation, which was upward and backward orientation with scurs horn shape. Principal component 4 was highly related with polledness, erect ear and straight horn shape. Principal component 5 was associated with lateral horn orientation, hair on toughs and white coat color (Table 3).

Cluster analysis

The amalgamation steps that run before identifying the final clustering showed that five clusters appeared to be more meaningful for the final partition. Because, the similarity level dropped from 59 of cluster six to 54 of cluster five. This 5% abrupt reduction of the similarity level compared to the one to two percent observed at other levels, decision was made to take this as the cut off point (Figure 3). At similarity level of 54 the 59 adult female goats was likely to be grouped into five distinct types of goats (Table 4). After considering the group standard error with in cluster similarity level reveals that cluster 5 representing Agew goat type was more similar than others (Table 5). The squared distance matrix (Table 6) explains that cluster 2 representing Felata goat is exceptionally different than the rest goat types.

Based on farmer's identification criteria (Table 7) five goat types were identified which differed in their phenotypic characteristics and production system they inhabit. The last cluster analysis identifies Cluster 1, the Arab goats (Figure 5). They are mainly characterized by straight head (53%) profile and smooth hair pattern (69%). Cluster 2, Felata goat’s (Figure 6) convex facial profile (86%) and pendulous ear form (88%) differentiate it from other goat types. Oromo goat type (Figure 7) is characterized in cluster 3 and is identified by erect ear form (64%) and the presence of beard (59%). The fourth cluster is Gumuz goat (Figure 8), which differs from other goat types by erect ear form (57%) and short smooth hair (80%). The last cluster (Cluster 5, Agew goat (Figure 9)) is mainly characterized by a concave facial profile (75%) and plain coat pattern (68%) (Table 8, 9).

Discussion

A cluster with a small sum of squares is more compact than one with a large sum of squares with equal number of observations (Minitab, 1998). For unequal number of observations standard error was calculated and used for comparison (Rangaswamy, 1995; Minitab, 1998). Cluster 5 had the lowest standard error and was considered as highly compact while cluster 3, with the highest standard error (Table 5) exhibited the slackness of the cluster. The relatively large size of standard error (13.3) of the Oromo goats indicated higher heterogeneity within the breed type. Similarly, the intra-cluster similarity level of Oromo goat type with other clusters, as indicated by the squared distance matrix was lowest (Table 6). This indicated that Oromo goat share some phenotypic characters with other goat types.

The large standard error associated with the Gumuz goat population (Cluster 4) also indicates relatively large within-cluster variability compared to the other goat types. Furthermore, this cluster had the maximum distance (74.9) from the group centroid (Table 5). The average distance from centroid is maximum for cluster one (Arab) depicts that this cluster is more distinct than the other clusters. But the low standard error for the within cluster sum of square indicated that the similarity level within this cluster is higher than those with higher standard error.

Similarity level among Oromo, Arab and Gumuz clusters compared to the similarity noticed with Agew and Felata was lowest. They were not grouped into one cluster, as they were not similar at 54 percent similarity level and their geographical detachment (Metekel and part of Kamashi zones for Gumuz goats, Assosa and part of Kamashi for Arab and Oromo goats). Besides, the dominant production system for each goat type was different. Oromo goats were raised in sedentary agriculturalist areas of the sub-humid zones of the region; Gumuz goats were confined around the agro-pastoral area of dry to sub-humid zones and the Arabs dominated in sedentary to agro-pastoral areas.

The biometrics result of grouping was compared with the result obtained using subjective clustering technique of the farmer. According to farmer's identification criteria sites 25-29 (where Gumuz people dominate) and site 30 (where Mao and Como people dominate) were miss-classified as compared to the clustering technique. Looking at their phenotypic similarity, geographical area and proximity of the area to where Arab goats dominate, it was decided to give the three local names of the aforementioned sites, as identified by the farmer (Arab, Gumuz and Oromo) in cluster 1, as Arab goat types. This result was subjected to subsequent discriminate analysis and proved that they are of the same group.

The name of each goat was given after the dominant tribe that generally owns the particular goat type. The indigenous goats were usually named after specific ethnic groups or geographic location. In addition to this the classification of the major types was largely based on morphological or physical characteristics (Mohammed *et al*, 1999). The name of the cluster representing different goat types followed the most common name used by the farmer to that group (Table 4).

The phenotypic similarity reveals the functional or adaptation similarity of types (Sneath and Sokal, 1973). Differences may be due to the different evolution paths of goats adapted to different ecology along with human interference in selection for breeding. In this study the Arab, Oromo and Gumuz goat types with less squared distance matrix (Table 6) compared to the rest of goats in Benshangul can be grouped in one main group. This grouping was relatively similar to the grouping made by Nigatu (1994) who described goats with such character as coastal goats under Small East African Family. The similarity among these three goat types could also be speculated from the functional and adaptations similarity (Table 8) in lowlands.

The largest distance between two clusters was observed when cluster 2, representing Felata goats, was compared with the remaining cluster (Table 6). The high variation was also observed on the Dendrogram (Figure 3). In view of the geographical location (the drier part of Benshangul-Gumuz region) and the production system within which it resides (mainly pastoral systems), Felata goat is separated from other goat types. This could be strengthened by an abrupt reduction of similarity level from 47 of cluster 2 to 9 of cluster 1 (Figure 3). Therefore, this breed could be grouped as one major group. In support of this Nigatu (1994) identified this type with the same phenotypic characteristics as the Nubian goat type.

Agew goat similarity level was more compact than the rest goat types (Table 5). The similarity distance of this group with the other goat types was also higher, coming after Felata goat type (Table 6). In addition, its geographical location (sub-humid zones of Benshangul-Gumuz region) and the production system it dominates (sedentary agriculturists) isolate this type from other goat types. The Agew goat that forms distinct phenotypic feature with that of Gumuz goats within the same locality forms another goat type in Benshangul. It is dominant in the sub-humid part of Metekel zones where sedentary agriculturist dominates. Nigatu (1994) characterized the same goat type with the same phenotypic feature and geographical area as Northwestern highland goat.

Conclusion

In Benshangul-Gumuz region, five goat types were identified based on the multivariate analytical technique and farmers identification criteria. These five types could be grouped into two major families on the basis of their phenotypic similarity level identified earlier (FARM-Africa, 1996):

Nubian family:

- Its typical Roman-nosed facial profile and lobbed ear form characterize this breed type. It is known for its good milking ability (FARM-Africa, 1996). Since the characteristics feature of Felata goat type, as reported by FARM-Africa (1996), is similar to the Nubian family and the squared distance matrix result of this finding separate it from other goat types of the region it is grouped under Nubian family.

Small East African family:

- This family includes the other four goat types of the region: Arab, Oromo, Gumuz and Agew goat types, with mainly concave and straight facial profile. It incorporates a large heterogeneous population of goats in the region.

This phenotypic characterization is only the beginning of breed evaluation studies, and hence it should be followed by molecular genetic studies to verify breed identities. Breed performance levels should also be evaluation under standardized on-station evaluation studies.

Acknowledgement

We would like to acknowledge the Benishangul Bureau of Agriculture for assisting data collection and the Ethiopian Science and Technology Commission for financial assistance. The valuable comments of Ato Alemayhu Reda, Ato Ephrem Getahun and Ato Gemechu Degefu are duly acknowledged.

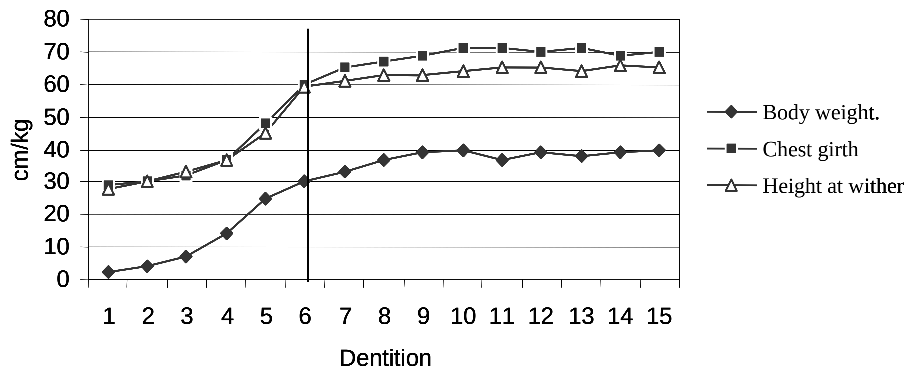

Figure 1. Some body measurements of goats based on their dentition for selected variables

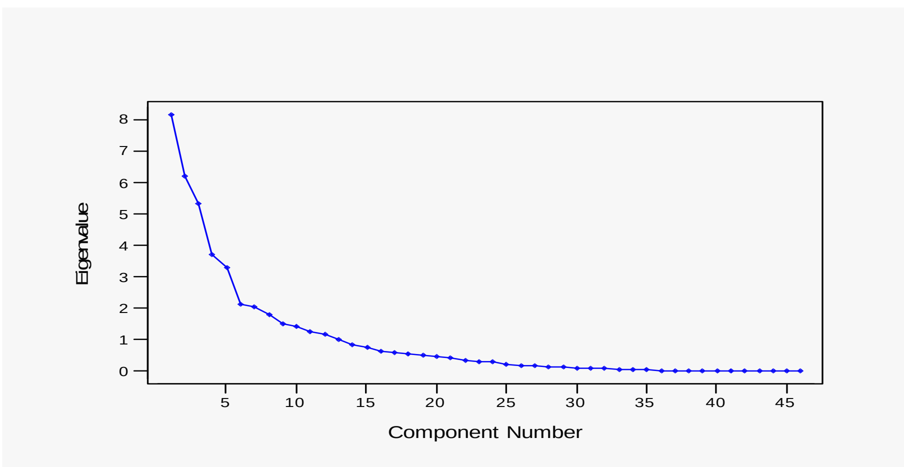

Figure 2. Screen plot of eigenvalue to component number

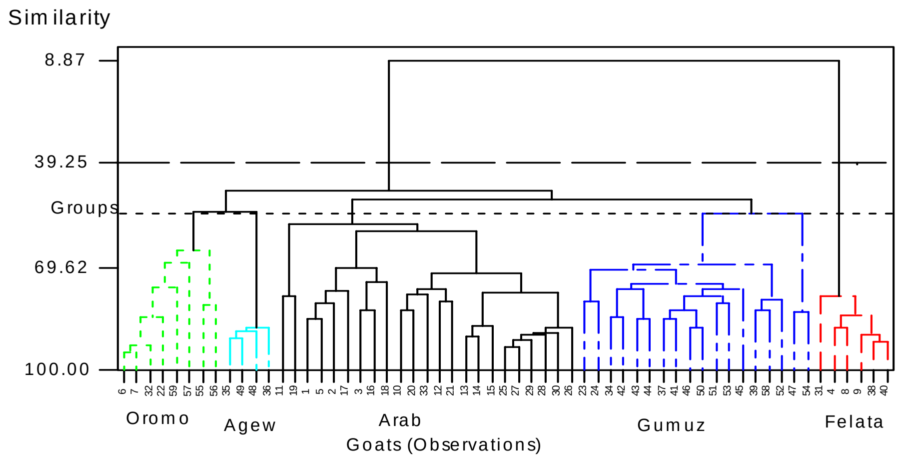

Figure 3. Dendrogram based on average linkage method

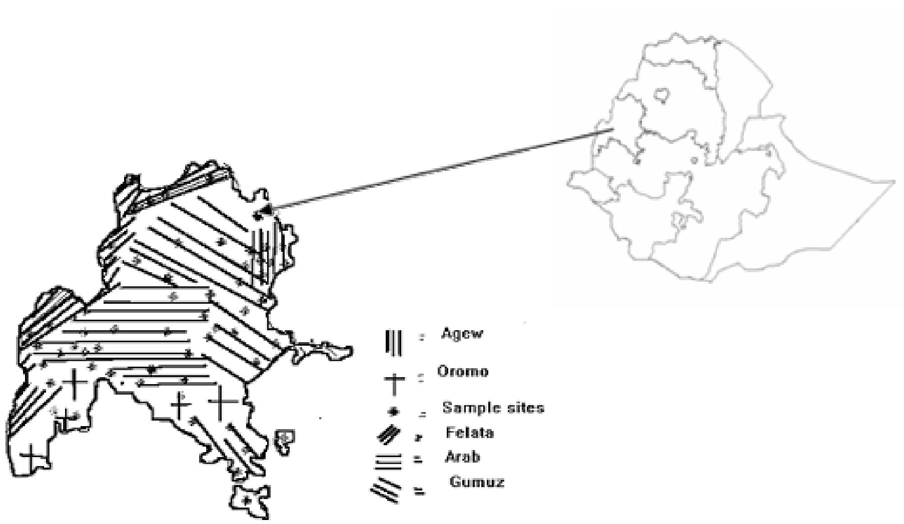

Figure 4. Benshangul Gumuz National regional state, sample sites and distribution of goat types in the region. (Source of the map, Benshangul-Gumuz Agriculture Bureau, 2001)

Figure 5. Arab female goat

Figure 6. Felata female goat

Figure 7. Oromo female goat

Figure 8. Gumuz female goat

Figure 9. Agew female goat

Table 1. Five standard principal component scores representing 58.3 percent of the variance from the original 46 goat characteristics

Variable	PC1	PC2	PC3	PC4	PC5
Ear length	-0.261	0.035	-0.046	-0.144	-0.153
Horn Length	0.030	-0.076	-0.007	-0.071	-0.099
Chest length	-0.195	0.222	0.082	-0.121	-0.083
Body weight	0.218	0.147	0.074	-0.098	0.008
Height at withers	-0.204	0.216	0.101	-0.091	-0.077
Head profile					
Straight	0.175	0.130	-0.256	-0.062	0.190
Convex	-0.329	0.040	0.038	-0.022	-0.057
Slt. Convx	-0.141	0.028	-0.035	-0.193	0.011
Slt. Concave	0.178	-0.279	-0.035	-0.053	-0.125
Concave	0.149	0.056	0.266	0.190	-0.003
Ear form					
Erect ear	0.210	-0.048	0.225	-0.247	-0.018
Horizontal	0.169	0.001	-0.258	0.263	0.080
Pendulous	-0.330	0.041	0.028	-0.013	-0.054

Table 1. Continued

Variable	PC1	PC2	PC3	PC4	PC5
Horn shape					
Polled	0.110	-0.094	0.076	-0.340	-0.081
Scurs	0.038	0.200	-0.241	-0.050	-0.260
Straight	-0.052	0.253	0.047	0.282	0.185
Curved	-0.033	-0.189	-0.115	-0.067	0.112
Spiral	0.042	-0.230	0.025	-0.211	-0.228
Horn orientation					
Lateral	0.146	0.083	-0.205	-0.124	0.266
Upward	-0.142	0.056	-0.248	0.146	-0.176
Backward	-0.010	-0.054	0.353	0.122	0.031
Polled	0.091	-0.087	0.011	-0.392	-0.070
Coat pattern					
Plain cot	0.111	-0.001	0.171	0.163	-0.104
Patchy	-0.111	0.006	-0.168	-0.135	0.123
Spotted	-0.001	-0.016	-0.012	-0.098	-0.061
Hair type					
Short smooth	0.051	-0.227	-0.017	0.136	-0.227
Coarse	-0.051	0.227	0.017	-0.136	0.227
Presence					
Hair on tough	0.076	0.076	0.248	0.044	-0.244
Hair on abdomen	-0.070	0.128	0.145	0.156	-0.186
Hairy	-0.094	0.013	0.132	0.069	-0.186
Ruff	0.110	0.011	0.167	-0.104	-0.041
Wattle	0.071	0.304	0.126	-0.076	-0.069
Beard	0.152	0.220	0.092	0.017	0.195
Coat color					
White	0.191	0.075	-0.056	0.131	-0.239
Black	0.172	0.090	-0.120	-0.004	-0.231
Fawn	-0.133	-0.060	0.094	0.111	0.112
Red	-0.059	0.166	0.067	-0.210	0.136
Brown	-0.247	-0.121	0.093	0.012	0.098
Gray	-0.194	-0.219	-0.061	-0.003	0.105
Roan	-0.037	0.229	-0.108	-0.087	-0.245
White & black	0.193	-0.015	0.015	0.027	0.024
White & fawn	0.024	-0.225	-0.000	0.023	0.169
Black & red	0.070	0.031	0.255	-0.066	0.135
Black & fawn	0.065	0.088	0.189	-0.113	0.164
White, black & brown	0.105	0.250	-0.205	-0.079	-0.088
Other	0.076	0.030	-0.019	0.182	-0.008

Table 2. Eigenvalues, proportion of variability and the cumulative variability explained by the first five principal components

Principals	**PC 1**	**PC 2**	**PC 3**	**PC 4**	**PC 5**
Eigenvalues	8.2737	6.1966	5.3145	3.7099	3.3000
Proportion	0.180	0.135	0.116	0.081	0.072
Cumulative	0.180	0.315	0.430	0.511	0.583

Table 3. Principal components and their corresponding contributing variables

PC 1	**PC 2**	**PC 3**	**PC 4**	**PC 5**
Ear length	Short Smooth hair	Upward horn orientation	Polledness	Lateral horn orientation
Convex head	Coarse hair	Backward horn orientation	Erect ear form	Hair on toughs
Pendulous ear form	Chest length	Scurs horn shape.	Straight horn shape	White coat color.
Body weight	Slightly concave facial profile	Concave facial profile	Horizontally lobed ear form	
Height at withers	Presence of wattle	Straight head		
Hairiness	Presence of beard.			
Brown coat color				

Table 4. Classification of sample sites into the five homogeneous clusters

Cluster	**Number of sites in a cluster**	**Site Number**	**Given name**	**Local name**
1	23	1, 2, 5, 3, 11, 10, 13, 12, 14, 15, 16, 17, 18, 19, 20, 21, 25, 26, 27, 28, 29, 30, 33	Arab	Arab/ Gumuz/ Oromo
2	6	4, 8, 9, 31, 38, 40	Felata	Felata
3	8	6, 7, 22, 32, 55, 56, 57, 59	Oromo	Oromo
4	18	23, 24, 34, 37, 39, 41, 42, 43, 44, 45, 46, 47, 50, 51, 52, 53, 54, 58	Gumuz	Arab/ Gumuz
5	4	35, 36, 48, 49	Agew	Agew

Table 5. Clusters, within cluster sums of squares and average and maximum distances from centroids

Clusters	№	Within cluster sum of squares	Standard error	Average distance from centroid	Maximum distance from centroid
1	23	45793.391	9.5	43.235	65.881
2	6	2463.833	9.1	19.679	30.357
3	8	9937.375	13.3	33.768	47.898
4	18	29654.667	9.8	38.385	74.870
5	4	696.750	7.6	13.127	14.784

№ = Number of observations

Table 6. Squared distances between clusters

Cluster	Arab	Felata	Oromo	Gumuz	Agew
Arab	0.00				
Felata	5213.99	0.00			
Oromo	83.58	5214.03	0.00		
Gumuz	122.10	5361.56	79.37	0.00	
Agew	259.36	5578.09	144.30	163.01	0.00

Table 7. Goats as identified by farmers and their major identification criteria

Goat type	Ear form	Facial Profile	Height at withers	Ethnic group	Place of origin	General body size	Belly Condition
Agew			*	*	*		
Oromo					*		
Arab				*	*	*	
Felata	*	*					
Gumuz			*	*		*	*

* Indicate the farmer's major identification criteria

Table. 8. Habitat and physical attributes of the five goat types

Goat types	**Climate of Habitat**	**Attributes**		
		Physical (Percent of types)	**Functional**	**Others**
Feleta	Semi arid	Head: Convex facial profile (86%), pendulous ear (88%), Horn: Straight (39%) or curved (31%), back ward (45%), up ward (43%), Coat: patchy pattern (69%) Hair: smooth (58%) or coarse (62%) Wattle: present (30%) Beard: present (30%)	Milk	*Trypanotolerant
Arab	Semi arid	Head: Straight (53%) or straight concave (29%), Ear: horizontal and lobbed, Horn: straight (36%) or curved (31%) or spiral (23%) oriented up ward (40%) or back ward (34%) Coat: patchy pattern (56%), hairs smooth (69%), white (14%) or black (11%). Beard: present (42%) Wattle: present (30%)	Meat and milk	
Oromo	Sub humid	Head: straight (53%), curved (26%) Ear: Erect (64 %) Horn: straight (40%), back ward (47%), Coat: patchy (54%) Hair: short smooth (53%), coarse (47%), white and black (23%) or roam (11%) Beard: present (59%) Wattle: (56%)	Meat	
Gumuz	Semi arid	Head: concave (51%) Ear: Erect (57%), Horn: spiral (41%), curved (33%), back ward (47%), up ward (28%) Coat: patchy (49%) or plain (47%) Hair: short smooth (80%), white and black or gray (22%)	Meat and milk	*Trypanotolerant
Agew	Sub humid	Head: concave facial profile (75%) Ear: horizontal (56%) erect (58%) coat: plain (68%) Hair: smooth (61%) white (20%) or fawn (18%) or combination of white and black 18%)	Meat	

*The trypanotolerant attribute of the breed types is not proven, but goat owners it is true.

Table 9. Average linear body measurements of the five goat types (N= 2076)

Name of the goat types	Ear length (cm)	Horn length (cm)	Chest girth (cm)	Body weight (kg)	Height at wither (cm)
Arab	13.4	10.7	70.9	37.9	68.2
Felata	23.8	10.6	81.6	27.8	78.4
Oromo	13.5	10.8	73.6	41.5	70.5
Gumuz	13.3	12.1	69.7	37.8	67.2
Agew	11.0	10.3	74.0	42.3	71.0

Table 10. Sex composition of adult goats in study flocks by breed type (%)

Goat types	Number	Percentage			
		Among males		Out of total	
		Intact	Castrated	Male	Female
Agew	583	56	44	37	61
Feleta	714	73	27	26	74
Arab	3199	67	32	28	71
Oromo	505	56	39	34	66
Gumuz	1963	68	32	31	69

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Mortality and Reported Clinical Signs in Horro Sheep at Smallholder Farms in East Wollega and West Shoa Zones, Ethiopia

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Abstract

A survey was conducted for a year (2001/2002) in eastern Wollega and parts of western Shoa zone, Ethiopia, to investigate the mortality rate of Horro sheep reared under farmers condition, identify major clinical signs for sheep mortality, study the seasonality of sheep mortality and compare with mortality of sheep flock at Bako Agricultural Research Center. The average survival rates were 95.1%, 97.3% and 86.5% for sheep younger than 3-month, older than 3-month but younger than 12-month and older than 12-month of age, respectively. Survival rate was lowest in adults older than 12-months of age. Survival was significantly affected (at least at $p<0.05$) by season, flock size and sex of animals. Agro-ecology did not have significant ($p>0.05$) influence on survival rate of animals. Nevertheless, survival rate tended to be highest in mid-altitude areas as compared to highland and lowland areas for animals younger than 3-month and older than 12-month of age. The major reported clinical signs were coughing (23.8 %), diarrhea (23.5 %), swelling under the neck (23.5 %), circling movement (14.6 %), emaciation (8.5 %), orf (4.0 %) and others (2.1 %). Identification of the diseases associated with these clinical signs is a priority research area to design appropriate control measures.

Keywords: Clinical signs, Horro, sheep, smallholder farmers, survival rate

Introduction

Sheep productivity is the most important criteria for the evaluation of total profitability in sheep enterprises. High productivity is achieved through optimization of reproduction of ewes as well as survival and growth of lambs (Boujenane *et al.*, 1998). Snyman *et al.,* (1998) reported that among others, reproduction and survival rates are traits that are universally important in any environment or livestock production system. Other traits vary in

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importance and can, in some situations, be of little or no value. According to RSA (1995), animal production research in resource poor communities should focus on conception, birth rate and survival, rather than on rates of growth as in more conventional research. Therefore, to produce more effective results, research should focus on reproduction and survival rates.

Sheep survival is of primary economic importance to sheep producers, in that low survival rate results in income losses because fewer animals are available for market and for replacement. Nevertheless, sheep research in the Bako Agricultural Research Center is facing serious constraint of mortality. Though, no in depth identification of causes of death was done due to various reasons (lack of facility at the center, inability to deliver samples timely to other laboratories, high turnover of veterinary staff to follow and collect results of samples sent etc.), mortality rates before yearling age as high as 20% (Solomon and Gemeda, 2000) to 37% (Solomon *et al.*, 1995) have been reported for Horro sheep maintained in the center. Identification of causes of mortality and reduction or elimination of these would increase output from the breed. Sheep in the Western region are totally raised under traditional husbandry system where sheep graze and breed under uncontrolled environments. Prior to any further effort towards finding solution to the mortality problem, it requires verification if the problem faced in the research center is also common under farm condition. The current study was carried out to investigate the mortality rate of Horro sheep on smallholder farms, identify the major clinical signs associated with mortality and study the seasonality of sheep mortality, and to compare these with on station information from Bako Agricultural Research Center.

Materials and Methods

The survey was conducted by way of personal interview with farmers in east Wollega and some parts of west Shoa zone of western Oromia. Those farmers who own one or more heads of sheep were interviewed. All together, 120 farmers owning 3338 heads of sheep (2503 females and 835 males) participated in the study, two of which were omitted during analysis as they provided incomplete information. A reconnaissance study was conducted with the objective of locating accessible sites representing different agro-ecologies to conduct the study. Based on the information from the reconnaissance study villages located in lowland (14.7%), mid-altitude (23.8%) and highland (61.5%) areas were identified. Low land, mid-altitude and high land areas dominantly represent areas with altitude of below 1600, 1600-2000, and above 2000 m.a.s.l., respectively.

Secondary data on population, crop and livestock production and meteorological variables were collected from offices of agriculture in the area. The climate of the study area was characterized by a uni-modal rainfall of which more than 80% falls in the months of May to September. Annual average rainfall is higher than 1100ml. Total area of the survey sites ranges from 20.5 to 147.4 thousand hectares.

A structured questionnaire was used for data collection during the different seasons of a year (2001/2002). Visits were made in four different seasons of the year i.e. in Season 1 (December to February), Season 2 (March to May), Season 3 (June to August) and Season 4 (September to November). All information related to deaths and causes of deaths were collected. The information later transcribed for data analysis. The questions were posed in afan Oromo, except for Anger Gutin areas of east Wollega zone where non-afan Oromo speakers (settlers) were interviewed in Amharic.

Data were analysed using CATMOD procedures (SAS, 1996) and sub class proportions were calculated and their standard errors were estimated using the LOGMLVAR procedure of Rege and Sherington (1996) as implemented by Rege (1997). Survival was studied at three different age classes ($X \leq 3$ month, 557 males and 565 females; $3 < X \leq 12$ month, 221 males and 280 females; and $X > 12$ month, 57 males and 1658 females). Survival was defined as "1" if the animals were alive at the three different ages described above and as "0" otherwise. The model included fixed effects of season, agro ecology (lowland, mid-altitude and highland), flock size category (categories 1 = 1 to 5 head of sheep, 2 = 6 to 10 head of sheep, 3 = 11 to 15 head of sheep, 4 = 16 to 20 head of sheep, and 5 = 21 and above head of sheep) and sex (male, female). For purposes of these analyses, flock size was categorised into discrete classes, as CATMOD is not designed optimally for continuous model effects. In addition to the fixed effects mentioned, the major clinical signs before death identified by the respondents were computed using frequency analysis.

Results and Discussion

Sources of variation considered and the associated probability levels are presented in Table 1, while predicted probabilities of survival rates at different ages are presented in Table 2. The survey showed that 20.5% of the respondents own less than 5 heads of sheep while only 6.8% own more than 21 heads of sheep. In the current study, males and females constituted 25.0% and 75.0% of the flock, respectively. Breeding females above one year of age constitute about 49.7% of the total flock. Only about 2.0% of the sheep flocks were breeding rams above a year of age. The relatively fewer mature rams as compared to breeding females may reflect that male animals are sold or consumed early in life while the opposite sex is retained for breeding.

The average flock survival rates were 95.1%, 97.3% and 86.5% for animals younger than 3-month, older than 3-month but younger than 12-month and older than 12-month of age, respectively. Survival rate was lowest in sheep older than 12-month of age. This could be due to the inclusion of all aged animals in this age group. Comparable on-farm results were not found in the literature. Nevertheless, survival rates obtained in the current study were higher than those reported for Horro sheep maintained at Bako Research Center (Solomon *et al.*, 1995; Yohannes *et al.*, 1995; Solomon and Gemeda, 2000). Very high stocking rate, herding large number of sheep (sometimes more than 120 heads of sheep) together, deterioration of the grazing area, and disease build up with time might have contributed to the high death losses of the flock maintained in the Center (Solomon and Gemeda, 2000). From the difference observed in survival rate between the on-station and on-farm flocks it appears that there exists potential to improve survival rate of Horro flock maintained at Bako Research Center to the level observed on farm by identifying the factor(s) lacking in the center.

Survival rate was significantly ($p<0.001$) affected by season (Table 1). It was lowest in season 2 and 4 for animals older than 12 month of age. For those younger than 3-month of age survival was lowest in season 3 and 4 (Table 2). This is probably due to a decline in the condition of their dams as a result of parasitic burden in these seasons, leading to lowered milk production, coupled with parasitic infestation of the lambs themselves. Survival rate was highest in season 1 for all age classes. Solomon *et al.,* (1995) also reported that survival rate was higher during the dry season (November to February) as compared to the long rainy season (June to October) for Horro flock maintained at Bako Research Center. Despite the poor grazing condition in the dry season (seasons 1 & 2), the high parasite infestations of the pasture during the wet season (Muktar *et al.*, 1993) and the low minimum temperature which predisposes the animals to pneumonia (Solomon *et al.*, 1995) might have contributed to higher death losses in seasons 3 and 4.

Agro-ecology did not have significant ($p>0.05$) influence on survival rate of animals. Nevertheless, survival rate was relatively high in mid-altitude areas as compared to highland and lowland areas especially, for lambs younger than 3-month and for those older than 12-month of age (Table 2).

Survival rate of lambs younger than 3 months of age and of those older than 12-months of age was significantly (at least $p<0.05$) affected by flock size. It was lowest for large flock size as compared to small flock size, especially for those animals younger than 3-month and older than 12-month of age (Table 2). Flock size had no significant difference on survival rate for those older than 3-month but younger than 12-month of age. The cause for the difference of survival rate between flock sizes could not be explained, but it could probably be related to the unavailability of feeds to fill their larger gut and differences in owner's management practices. Being kept in larger flock size might have hindered the flocks to forage enough feeds to fill their larger gut. Study conducted at ILRI Debre Berhan Research Station (Ewnetu *et al.*, 1998) showed that the digesta (weight of digestive content) of Horro sheep is larger by 0.7 kg than that of the Menz sheep, which lends support to the above speculation. In addition to this, in the study areas although water and grazing land are theoretically available to all on an equal basis, regular attention to watering by the owner was rarely practiced. Many owners also keep their animals penned until late in the morning and animals could not graze for longer hours.

In general, grazing management was different for the dry and rainy seasons. During the dry season, the majority of owners released their animals to roam freely. In contrast, animals were either herded or tethered during rainy season to protect crop fields. Supplementary feeding of animals was not common in the study areas, except for leftover kitchen refusals. There are some improved management practices reported earlier by Gemeda *et al.,* (2002b), which could improve survival rates. These include ensuring that the young suckle their dam at birth and subsequently, attention to cleanliness of night bedding by regular removal of feces, removal of external parasites (especially ticks by hand) and supplementary feeding of household scraps and crop residues.

In the current study, the sex effect, over which least control can be exerted, significantly ($p<0.001$) influenced survival rate. Mortality rate was higher in males than females (Table 2). The sex differences obtained for animals younger than 3 months of age is in agreement with results reported in the literature (Gama *et al.*, 1991; Schwulst and Martin, 1993; Gemeda *et al.*, 2002a). Furthermore, in Horro flock maintained at Bako Research Center male lambs had a higher mortality rate than female lambs to yearling age (Solomon *et al.*, 1995; Solomon and Gemeda, 2000).

The clinical signs in sick animals identified by the respondents were coughing (23.8%), diarrhea (23.5%), swelling under the neck (23.5%), circling movement (14.6%), emaciation (8.5%), orf (4.0%) and others (2.1%) (Table 3). Association of the clinical signs with specific diseases may help in designing management practices and veterinary care directed towards reduction of mortality. According to respondents control measures for these major health problems are hampered by inadequate veterinary service caused either by absence of veterinary service in their vicinity or shortage of medicaments or inability of farmers to pay for it. In majority of the cases, sick animals were treated by farmers themselves using traditional herbal remedies. Almost all of the respondents attributed lack of veterinary services in their vicinity for not practicing modern health care. In the surveyed areas, health care in terms of vaccination, anthelmintic and other treatments are only available for large ruminants despite some of the farmers expressed willingness to pay for treating small ruminants.

Conclusion

The current study revealed that on-farm survival rate of Horro sheep was affected by season. Despite the poor grazing condition in the dry season (season 1 & 2), survival rate was higher as compared to the wet season (season 3 & 4) in lambs and sheep older than one year of age. Differences between seasons could be due to the high parasite infestations of the pasture during the wet season and the low minimum temperature that may predispose the animals to pneumonia. Thus, major parasites that could predispose the animals to diseases during the wet season should be looked into. The choice of particular lambing season and use of strategic supplementary feeding should also be considered.

In the present study, the most common clinical signs investigated as major causes of mortality were coughing, diarrhea, swelling under the neck, circling movement, emaciation, orf and others. Identification of the diseases associated with these clinical signs is a priority area for research. It was also investigated that farmers themselves treat sick animals traditionally with herbs. Thus, further study is warranted to verify the efficacy of the traditional veterinary practices of the farmers.

Comparing with the center's information, higher survival rate was observed for sheep maintained under the smallholder management condition. The reasons for the low survival rate of Horro sheep at the center may be the large flock size, because herding up to 120 head of sheep per flock is a usual practice of the farm. Thus, to alleviate problems related to flock size, determination of optimum flock size (heads of sheep tended together) that could improve production, reproduction and survival rate of sheep maintained under a specific grazing condition is warranted.

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Table 1. Maximum-Likelihood analysis of variance of survival rate at different ages

Source	Degree of freedom (df), chi-square and significance levels for:					
	$X \leq 3$ month		$3 < X \leq 12$ month		$X > 12$ month	
	df	chi-square	df	chi-square	df	chi-square
Intercept	1	488.64***	1	166.23***	1	93.27***
Season	3	32.20***	3	25.33***	3	35.90***
Ecology	2	2.32^{NS}	2	2.05^{NS}	2	1.62^{NS}
Flock size category	4	11.05*	4	2.93^{NS}	4	14.06***
Sex	1	38.73***	1	37.48***	1	7.44**
Likelihood ratio	79	121.82***	73	82.40^{NS}	61	82.45*

* = p < 0.05; ** = p < 0.01; ***= p < 0.001; NS = p > 0.05

Table 2. Predicted probabilities of survival rate at different ages

Effect	Predicted probability and standard errors for:		
	X ≤ 3 month	3 < X ≤ 12 month	X > 12 month
Overall	95.1 ± 0.99	97.3 ± 0.99	86.5 ± 0.98
Season			
1	98.3 ± 0.99	98.8 ± 0.99	95.0 ± 0.99
2	95.1 ± 0.99	92.2 ± 0.98	82.5 ± 0.97
3	91.7 ± 0.99	98.5 ± 0.99	85.4 ± 0.97
4	92.0 ± 0.99	96.2 ± 0.99	76.7 ± 0.96
Agro-ecology[1]			
Lowland	94.2 ± 0.99	97.7 ± 0.99	86.3 ± 0.97
Medium Altitude	96.1 ± 0.99	96.4 ± 0.99	88.3 ± 0.97
Highland	94.8 ± 0.99	97.6 ± 0.99	84.7 ± 0.97
Flock size			
1 to 5	96.2 ± 0.99	96.0 ± 0.99	89.6 ± 0.97
6 to 10	96.0 ± 0.99	97.5 ± 0.99	88.7 ± 0.98
11 to 15	93.2 ± 0.99	96.6 ± 0.99	88.1 ± 0.97
16 to 20	96.2 ± 0.99	98.5 ± 0.99	87.5 ± 0.97
> 21	92.9 ± 0.98	97.2 ± 0.98	75.8 ± 0.94
Sex			
Male	92.0 ± 0.99	93.1 ± 0.98	80.4 ± 0.95
Female	97.1 ± 1.00	99.0 ± 1.00	91.0 ± 0.99

[1] Lowland = less than 1600 m asl Medium Altitude = 1600 to 2000 m asl Highland = above 2000m asl

Table 3. Clinical signs observed in sick animals

Clinical signs	Major clinical signs reported	
	Number	Percentage
Coughing	78	23.8
Diarrhea	77	23.5
Swelling under neck	77	23.5
Circling movement	48	14.6
Emaciation	28	8.5
Orf	13	4.0
Others	7	2.1

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Age and Season Related Changes in Semen Quality of Horro Bulls

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Abstract

With the overall objective of selection and evaluation of bulls based on their actual fertility performances, a total of 119 semen ejaculates were collected for seven months from 19 Horro bulls, aged between 36 and 74 months. The bulls were divided into two age groups (36-51and 61-74 months). Depending on the availability of feeds, the experimental period (August- February) was also classified into two seasons, viz wet season (August-November) and dry season (December-February). The semen ejaculates were collected monthly using artificial vagina (A.V.) method and were subjected to evaluation by inspection and microscopic examination. Data were analysed by General Linear Model Procedure (SAS, 1996) using fixed effect model. Simple correlation analysis was used to determine the interrelationship of age and the seminal traits considered. The seasonal differences in most of the semen traits were statistically not significant except in mass motility ($p<0.05$). But the differences due to age were statistically significant in ejaculate volume ($p<0.01$) and mass motility ($p<0.05$). There was positive correlation between age and volume ($r=0.37$; $p<0.001$) and age and live sperm counts ($r=0.36$; $p<0.001$). Higher volume of semen was positively and significantly related with mass motility ($p<0.001$), concentration ($p<0.05$) and total sperm production ($p<0.001$). There is also significant correlation between sperm motility and concentration and total sperm production ($p<0.001$). This study revealed that the bulls' actual fertility performances are of paramount importance in selection and evaluation programme of breeding bulls. However, as the study was not exhaustive across all seasons and age future research should include these and other factors that likely affect semen quality.

Keywords: semen quality, reproduction, age, season, and Horro bulls

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Introduction

The process of selection and use of breeding bulls is very important if optimum fertility is to be obtained and depends on whether they are intended for natural mating or artificial insemination (A.I.). In all cases, however, breeding bulls must be superior not only in their genetic potential, but also in their semen qualities (Perera, 1999). This is because the quality of semen reflects the actual performance of the bull and the efficiency of breeding herd. The major portion of progress in genetic improvement is currently made through selection of appropriate breeding bulls, because sires have more offspring than cows and their breeding value can be more accurately determined. Bulls with high genetic merit and high fertility will enhance genetic progress and improve cowherd fertility. On the other hand, the male with reduced fertility poses serious problems and causes economic losses to breeders and the artificial insemination industry.

Attempts made to develop an accurate and objective test for assessing the potential fertility of a bull on the basis of some specific characteristics of a given semen sample have not been successful (Raja and Rao, 1983). The consensus of opinion prevailed was that a combination of semen characteristics such as ejaculate volume, mass motility, concentration and liveability of spermatozoa and the magnitude of incidence of spermatozoa abnormality will serve the purpose of a single sure test to select bulls of high fertility from a mixed farm (Maule, 1962; Raja and Rao, 1983). There are different views on the effects of season and temperature on semen quality and fertility of a bull. Several workers (Sane *et al*., 1982; Sekoni *et al*., 1988; Juinudeen and Hafez, 2000) reported seasonal differences in sperm quality and fertilizing ability of semen. Working on Sahiwal bull semen, Ulfina, (2002) noted significant age differences in some of the semen characteristics. Since semen characteristics are known to vary, it is essential to determine the normal values for each breed or genotype. Therefore, this study was carried out to assess the effect of age and season on the semen characteristics of indigenous Horro bulls.

Materials and Methods

The study was carried out at Bako Agricultural Research Centre, western Oromia, Ethiopia from August 2001 to February 2002. The centre is situated at an altitude of 1650 m above sea level and located at 9^0 07' North and $37^0$05'

East. The rainfall pattern of the farm is uni-modal amounting to 1200 mm and extends from March to October. The mean annual temperature is 21° C.

Nineteen Horro bulls kept for breeding purpose (aged between 36 and 74 months) were used. They were allowed to graze together on natural pasture during the day (9:00AM-5:00PM) and received concentrate supplements in-group feeding pen during the night, at the rate of 2 kg/head/day. The formulation of the concentrate supplementation was noug (*Guizotia abssynica*) seed cake (49%), maize grain (49%), common salt (1%) and bone meal (1%). After a preliminary period of training the bulls, semen was collected by artificial vagina (A.V.) method from the bulls at monthly intervals over a period of 7 months. A total of 119 ejaculates for colour and volume and 112 ejaculates for mass motility, concentration and total sperm production were examined. The following semen traits were assessed.

Colour and consistency, ejaculate volume and mass motility

The scoring method of Hafez and Hafez (2000) was used for the physical appearance of semen and a 1 to 5 scoring was given by judging as clear (watery), milky, thin creamy, creamy or thick creamy, respectively. The volume of ejaculate semen was read to the nearest 0.1ml directly from the graduated collecting tube. Mass motility was evaluated as per method described by Tomar *et al.,* (1996). Briefly, a drop of thick layer of neat semen was placed on a clean slide and examined under low power (10X) objective microscope. Normal bull semen exhibits a wave like motion when viewed in reflected light. On the basis of swirling current, semen was rated into eleven categories and numerical grading from 0 to 5 was given accordingly.

Sperm concentration and total sperm production per ejaculate

The concentration of spermatozoa was determined by Haemocytometer method. Sperm concentration estimate by using Haemocytometer was made by diluting semen samples 1000 times with 4 % (NaCl) saline solution, in serial dilution method. A pinch of eosin dust (0.05%) was added to the saline solution to give background to spermatozoa. A Haemocytometer cover slip was placed over the ruled field of Neubar's chamber and a drop of diluted semen was allowed to run under the cover slip without floating and allowed to settle for one minute. The spermatozoa in four corner and one middle secondary squares, i.e. 80 tertiary squares were counted under 400 X magnification using a phase contrast microscope. The sperm concentration is expressed in million per millilitre of semen. Total sperm production per ejaculate is a product of sperm concentration and volume of ejaculates. This figure gives the total number of cows that could be inseminated per breeding bull per year.

Live sperm counts and abnormality of spermatozoa

Percentage of live sperms was determined from eosinophilic reaction using eosin-nigrosin stain. Eosin-nigrosin stain was prepared by the method described by Bloom (1950) and Hancock (1951). The composition of the stain was; 100 mg eosin (B), 500 mg nigrosin and 10 ml distilled water. One drop of semen sample was mixed with 2 to 3 drops of eosin-nigrosin stain on a clean slide. About 200 spermatozoa were assessed in different fields. Live spermatozoa appear unstained and dead stain pink against a brownish purple background. Percentage of live spermatozoa was calculated as:

$$\text{Live \%} = \text{No. of unstained spermatozoa} / \text{Total No. of spermatozoa}$$

The type of abnormal sperm and their incidence was estimated from the slides prepared with eosin-nigrosin stains for eosinophilic sperm counts. The types of abnormality (head, mid piece and tail) were summed up and reported as total abnormality of spermatozoa.

Statistical analysis

The data on different semen characteristics were analysed by GLM Procedure (SAS, 1996) using fixed effect model taking season and age group as fixed effects. Simple correlation analysis was used to determine the interrelationship between age and the seminal traits considered.

Table 1. Least squares means (±SE) for semen characteristics of Horro bulls in different seasons and age groups

Effects	**Color and consistency**	**Volume (ml)**	**Mass motility**	**Concentration (million)**	**Total sperm production (million)**
N	119	119	112	112	112
Overall	3.53±0.22	4.23±0.12	4.01±0.11	714.65±38.72	3199.87±230.20
Season	NS	NS	*	NS	NS
Wet season (Aug-Nov)	3.48±0.12	4.35±0.24	3.82±0.18	781.32±57.12	3647.25±338.96
Dry season (Dec- Feb)	3.76±0.43	4.19±0.26	4.16±0.19	628.83±59.14	2742.23±351.90
Age group	NS	**	*	NS	NS
G_1 (36-51 month)	3.64±0.18	3.66±0.24	4.31±0.18	781.80±55.31	3071.22±330.13
G_2 (52-74 month)	3.32±0.20	4.87±0.26	3.67±0.19	628.35±60.77	3318.26±361.31

*=p<0.05; **=p<0.01, **=p<0.001; NS = not significant

Results

Least squares means, analysis of variance and correlation coefficients of semen characteristics of Horro bulls are presented in Tables 1, 2 and 3, respectively.

Colour and consistency, ejaculate volume and mass motility

Horro bulls were found to produce watery, yellowish, milky and creamy semen. On average, the bulls gave milky to creamy colour with the mean value of 3.5±0.22. The overall mean volume of semen per ejaculate was 4.23±0.12 ml. The seasonal difference in volume of semen was not significant. But the mean value recorded for age group 2 was significantly higher ($P<0.01$) than bulls in-group 1. The mean mass motility recorded was 4.01±0.11. A significant ($p<0.05$) difference in mass motility was observed between both the two age groups and season of collection.

Sperm concentration and total sperm production per ejaculate

The average sperm concentration in the current study was 714.65±38.72 million per ml of semen. No significant variation in sperm concentration was observed either between seasons or age groups. The mean value of total sperm production was found to be 3199.88±230.20 million per ejaculate of semen. As this is essentially the same trait with sperm concentration, there was no significant variation observed in both seasons and age groups. Although not significant, it was evident from the result of correlation analysis that the total sperm production per ejaculation was higher in older bulls ($r=0.09$).

Table 2. Analysis of variance and level of significance of semen characteristics of Horro bulls

Source	df	Color and consistency	Ejaculate volume	Mass motility	Sperm concentration	Total Sperm Production
Age group	1	1.6090	43.1637**	3.33550*	6.49×10^{18}	1.24×10^{19}
Season	1	3.1295	0.80735	11.2829*	6.53×10^{18}	6.64×10^{18}
Error		0.9164	3.9406	2.0099	1.88×10^{17}	6.647×10^{18}
Error df		116	116	109	109	109

*=P<0.05, **=p<0.01

Live sperm count and sperm abnormality

The mean percentage of live sperm in the ejaculate was 92.0 % (range from 78 to 100%). The average percentage of sperm abnormality was 22.6% (range from 10 to 35%). Neither age nor season of collection was found to exert significant effect on the occurrence of abnormalities of spermatozoa in the ejaculate. Similarly the correlation analysis showed positive and non-significant relation between age and abnormality of spermatozoa.

Table 3. Pearson correlation coefficients of semen quality traits in Horro bulls

	1	2	3	4	5	6	7
Age =1	-						
Vol =2	0.37***	-					
Mot =3	-	0.25**	-				
Conc =4	-	0.19*	0.50***	-			
Tsp =5	-	0.65***	0.39***	0.79***	-		
Live =6	0.36***	-	-	-	-	-	
Tabp =7	0.006 NS	-	-	-	-	-0.64***	-

Vol=volume, Mot=motility, Conc=concentration, TSP=total sperm production, Live=live sperm counts, Tabp=percentage of total abnormalities, cons = consistency

*=p<0.05, **=p<0.01, **=p<0.001, NS = not significant (p>0.05)

Discussion

Colour and consistency, ejaculate volume and mass motility

The physical appearance of semen at the time of collection has due importance in judging the quality of semen because it is the number of sperm cells in a given volume of semen that affects its appearance. Horro bulls were found to produce watery, yellow, milky and creamy semen. On average the bulls were giving milky to creamy colour with the mean value of 3.9±0.23. Neither seasonal nor age group differences were significant. Similar results were reported on Indian Sahiwal bulls (Ulfina, 2002).

The overall mean volume of semen per ejaculate (4.23±0.12 ml) reported in this study is higher than the value reported by Raja and Rao (1983) and Mathew (1974) for crossbred bulls and Ulfina (2002) for both indigenous Indian Sahiwal and crossbred bulls. The seasonal difference in volume of semen was not significant (P>0.05). But the mean value recorded for age group 2 was significantly higher (P<0.01) than bulls in-group 1. This is in agreement with earlier report by Ulfina (2002) who found significantly higher values of ejaculate volume for older age group than the younger bulls.

Mass motility has been considered essential to provide spermatozoa transport through the female reproductive tract and is essential for fertilization. Normal bull semen exhibits a wave like motion when viewed in reflected light. This activity is observed when a thick layer of neat semen is viewed on a microscopic slide without a cover slide. The mean mass motility recorded in this study was 4.01±0.11. A significant ($p<0.05$) difference observed between the two age groups in mass motility is in agreement with the report of Ulfina (2002) for Indian Sahiwal bulls. The mass motility of spermatozoa was significantly influenced by season of collection, which is at variance with earlier observation by Rao and Rao (1978) in crossbred bulls. According to Tomer *et al.,* (1966), humid hot season does not appear to be conducive for the production of semen with high mass motility. But the humidity of Bako Agricultural Research Center was moderate throughout the experimental period, as it excludes the peak months of dry and rainy season, and this might be the reason for the production of semen with high mass motility inboth season.

Sperm concentration and total sperm production

Accurate determination of the number of spermatozoa per milliliter of semen is extremely important, as it is a highly variable semen characteristic. The number of sperms per unit volume of semen varies from zero in complete azoospermia to over three billion sperms per ml in occasional very dense samples. When combined with volume of the ejaculate, this quantity of the spermatozoa determines how many females can be inseminated, each with the optimal number of sperm cells. The average sperm concentration recorded in this study was (714.65±38.72 million per ml of semen) lower than most of the reports available in this regard (Mathur *et al.*, 2002; Shanmugavel and Singh, 2002; Ulfina, 2002) for Friswal and Sahiwal Indian bulls, but higher than the reports of Madrid *et al.,* (1993) and Usmani *et al.,* (1993) in crossbred and Holstein Friesian bulls, respectively. No significant variation in sperm concentration was observed either between seasons or age groups. Different to our findings, Ulfina (2002) noted a significantly higher sperm concentration for older age groups for Indian Sahiwal bulls.

The mean value of total sperm production was found to be 3199.88±230.20 per ejaculate of semen. As this is essentially the same trait with sperm concentration, there was no significant variation observed in both seasons and age groups. Although not significant, it was evident from the result of correlation analysis that the total sperm production per ejaculation was higher in older bulls ($r=0.09$).

Live sperm count and sperm abnormality

The mean percentage of live sperm in the ejaculate was 92.0 % (range from 78 to 100%). This is higher than the values reported by Raja and Rao (1983) and Ulfina (2002) for Friswal and Sahiwal bulls, respectively. The average percentage of sperm abnormality was 22.6% (range from 10 to 35%). This value is by far higher than the sperm abnormality reported by Raja and Rao (1983). Hafez and Hafez (2000) reported a typical decline in fertility when abnormal sperm cells exceed 20%. Since there was variation between bulls, it requires a systematic evaluation and selection of bulls before using them for breeding purposes. Neither age nor season of collection was found to exert significant effect on the occurrence of abnormalities of spermatozoa in the ejaculate. This inference is in agreement with that of Rao and Rao (1978) in crossbred bulls. But the correlation analysis showed positive and non-significant relation (r=0.006) between age and abnormality of spermatozoa.

Conclusion

In general, the overall values founf in the present study indicate that most of the semen traits considered are in agreement with the standard fertility parameters in the literature. Significant age and season variation was observed in some semen characteristics of Horro bulls. Hence it can be evident from the study that the bulls' actual fertility performances are of paramount importance in selection and evaluation programme of bulls for breeding purpose. However, as the study was not exhaustive across all seasons and age groups future reserach should include these and other factors that likely affect semen quality.

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Effect of Two Types of Housing and Levels of Feeding on Voluntary Feed and Water Intakes, and Associated Changes in Body Weight and Body Measurements of Crossbred Female Calves in Winter Season♣

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Abstract

The effect of two housing systems (loose house vs. conventional barn) and two levels of protein feeding (80 vs. 100% NRC, 1988) on feed and water intake and, associated changes in body weight and body measurements of twenty crossbred female calves that had an average body weight of about 85 .6±2.18 kg and age of 6-10 months was studied in 2x2 factorial experiment over a period of 98 days in the winter season. The average daily dry matter intake per head and intake per unit of metabolic body weight were significantly ($p<0.001$) affected by level of protein. The differences in these parameters between housing systems were not significant. Average voluntary water intake per head and intake per kg dry matter consumed and per kg $w^{0.75}$ were not significant. Housing system and level of protein did not significantly influence average final body weight and daily body weight gain. The average monthly increases in body measurements (body length, height, heart girth, abdominal girth and hip width) were not significantly influenced by housing system. Abdominal girth was however, significantly ($p<0.001$) affected by level of protein. It was higher for the 100% than 80% level of feeding.

Keywords: Body weight, crossbred calves, feed intake, water intake, housing system

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♣ The paper is based on the MSc Thesis of Yibarh Yacob (2002) on Effect of Housing and Level of Feeding on Performance of Crossbred Female Calves in Winter Season. CCS, Haryana Agricultural University, Hisar, India

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Introduction

Exotic breeds of dairy cattle have been introduced in many tropical and sub-tropical countries to meet growing demand of milk and milk products. As a result, a large number of crossbred populations have become available with the farmers. A farmer expects his cows to produce more milk and calve early with minimum inputs. Unfortunately, the above-mentioned targets are not realized in view of a number of constraints such as poor nutrition, disease and climatic stress. It has been well recognized that feed and climate affects the growth, production and reproduction at large.

Feed shortages, low nutritive value of existing feed resources and nutritional imbalance limit animal production and retard the onset of puberty. Provision of adequate nutrients in the diet of ruminants is of primary importance for the expression of their full genetic potential for growth and reproduction. On the other hand, adverse climate is another constraint for efficient livestock production systems. High or extremely low temperatures; high humidity and high solar radiation that characterized tropical environments are associated with lower livestock performance. These factors have led livestock owners in many parts of the tropics and sub-tropics to provide shelter for their animals. The purpose of housing dairy cattle like other farm animals is to reduce climatic stress on the animals that hinder production, reproduction and proper growth and development. Results of several trials conducted under a variety of conditions suggest that shelter is more beneficial in winter than in summer (Curtis, 1983). Winters are severe enough in most of the tropics and young calves are more susceptible to cold stress due to less adaptation ability to environmental stress. Severe cold weather not only reduces the feed efficiency but also causes to decrease resistance and suppresses growth and future development of the animal (Hahn, 1981 and Collier *et al*, 1982). This effect is more pronounced in crossbred cattle as compare to native breeds.

As indicated earlier, adverse climate make the raising of crossbred calves and maintenance of dairy cattle a difficult task under prevailing feed shortages (Jain *et al,* 1996). Although a number of studies have been conducted to reduce the deleterious effect of climate and feed on growth and production of different species (Dattilo and Congiu, 1979; Charles, 1994; Singh and Singh, 1994; Chauhan *et al,* 1999; Poudel, 2001), no comprehensive study appears to have been conducted to study the associative effect of housing and level of feeding on performance of growing crossbred female calves. Hence, the present investigation has been planned to study the effect of two housing systems and two levels of protein feeding on dry matter and water intakes, body weight gain and body measurements of crossbred female calves in winter season.

Materials and Methods

Study area

The study was conducted at the dairy farm of the College of Animal Sciences, Chaudhary Charan Singh (CCS) Haryana Agricultural University in Hisar, India for 98 days (from December 1, 2000 to March 10, 2001) during winter season. Hisar is located at 29^0 to 10' North latitude and 75^0 to 45' East longitude. The maximum daily temperature during the summer (hot season) varies between 40 and 46 degree Celsius. During winter (cold season) it ranges from 1.5 degree to 4 degree Celsius.

Allocation of treatments

Twenty crossbred female calves of 6 to 10 months of age that had an average body weight of about 85.6± 2.18 kg that varies from 68 to 100 kg were selected from the cattle herd. The crossbred female calves were of Indian zebu × European dairy breeds. All calves were treated against internal and external parasites. After a preliminary adjustment period of 10 days, all the calves were divided into four groups of five animals each according to age and body weight. Animals in each group were randomly assigned to one of the following housing and feeding treatments: Loose housing system +80% feeding as per NRC (1988) recommendations (T_1); Loose housing system +100% feeding as per NRC (1988) recommendations (T_2); Conventional barn system + 80% feeding as per NRC (1988) recommendations (T_3) and Conventional barn system + 100% feeding as per NRC (1988) recommendations (T_4).

Management of animals

Two types of housing systems were used to house the calves as described by Heizer *et al.* (1953). Calves in T_1 and T_2 were sheltered in loose house that employed an open lot free-stall system that permits freedom of movement. The open lot has a shelter (partially protected shed) on one side where animals can retire during time of excessive heat, cold or rain. The other two groups of calves (T_3 and T_4) were housed in a conventional barn that is also known as closed barn or tie barn or stanchion barn. In this system animals are confined by stanchions or tie stalls on a lightly bedded hard surface floor. The barn is completely roofed and the wall is also complete with windows and ventilators located at suitable places. During the experimental period the average daily internal house temperature ranged from 12.4 to 20.4 °C in the loose house and 14 to 22.3 °C in the conventional barn. The overall mean values of maximum and minimum temperatures recorded in both the housing systems were 25 and 8.0 °C in loose house and 22.3 and 12.7 °C in conventional barn respectively. The maximum temperatures in loose house and conventional barn varied from 17.3 to 30.4 °C and 16.8 to 28.7 respectively, while the minimum temperature varied from 5.3 to 11.4 °C in loose house and 9.5 to 15.9 °C in conventional barn respectively. The calves in both house types were fed and treated individually. Both shelters were cleaned daily and fresh drinking water was continuously available in each shed.

Percent ingredient composition of the concentrate mixture fed to the experimental calves is given in Table 1. The amount of concentrate offered to the calves in each treatment group was fixed in such a way that T_1 and T_3 received 20 per cent below the normal NRC (1988) recommended level while T_2 and T_4 were fed on normal NRC (1988) recommended level of crude protein per head per day. An equal and weighed amount of seasonally available green fodder was fed to all the calves daily and its crude protein content was taken into consideration while fixing the allowance of concentrate feed for each group. Calves in each group were offered wheat straw *ad libitum*. The ration of each calf was adjusted in proportion to its body weight change in each fortnight.

Table 1. Ingredient composition (%) of concentrate mixture fed to experimental

Feed ingredients	**Proportion of mixture**
Maize	13
Wheat	19
Barley	14
Rice polish	20
Mustard cake	15
Groundnut cake	16
Common salt	01
Mineral mixture	02

The feed intake during the experimental period was determined on the basis of weighing the concentrate, green fodder and wheat straw offered and left over in a fortnight. Representative samples of concentrate mixture, wheat straw, maize and mustard green chops were taken and were kept in hot air-oven for determination of dry matter content. These samples were then analyzed for proximate principles according to AOAC (1980). Calves were weighed at the beginning of the experiment and fortnightly then after. The weights were recorded in the morning before providing water and feed. Body measurements such as body length, height, heart girth, abdominal girth and hip width were taken at the beginning and monthly then after. The water intake of individual calves was recorded for three consecutive days in a fortnight during the experimental period and the mean was taken for calculation. A measured quantity of fresh water was offered ad libitum individually to each calf by placing a graduated bucket full of water in front of the calves twice a day. The leftover was also measured to find out the actual voluntary water intake.

Statistical analyses

Data on dry matter and water intakes, body weight and body measurements were analyzed based on housing and feeding effects in a 2 x 2 factorial arrangement as per the standard statistical procedure recommended by Snedecor and Cochran (1980). The Least significant difference (LSD) was used to locate treatment means that were significantly different

Results and Discussion

Dry matter intake

The proximate composition of feeds and fodder on dry matter basis is presented in Table 2.

Table 2. Proximate composition (%) of feeds

Feed components	DM	Expressed as percent of dry matter				
		CP	CF	NFE	EE	Ash
Concentrate	90.00	20.00	8.96	62.73	4.24	5.65
Maize green	12.35	8.94	25.11	52.93	1.26	11.75
Mustard green	12.83	8.50	19.94	56.41	3.24	9.90
Wheat straw	90.08	3.53	31.13	53.04	1.81	10.47

The data for daily dry matter intake and intake per kg metabolic body weight are presented in Table 3. On an average the daily dry matter intake and intake per kg metabolic body weight in the two housing systems were 2.89$\pm$ 0.086, 2.96$\pm$0.092 kg and 84$\pm$0.002 and 85$\pm$0.002g in loose house and conventional barn respectively. These differences were not statistically significant (p>0.05). This supported the earlier findings by researchers (Martin, 1971; chakrabarti, 1991; Fiems *et al*, 1998; Chauhan et al, 1999 and Poudel, 2001) on cattle and buffalo calves in winter under similar housing conditions.

Table 3. Average daily dry matter intake of crossbred calves

Variables	**Number of animal**	**Average DM Intake (kg) (Mean ±SE)**	**Dry matter intake / kg Metabolic body weight (g) (Mean ±SE)**
Overall mean	20	2.93±0.06	85±0.001
A. Housing			
Loose House (LH)	10	2.89±0.09	84±0.002
Conventional Barn (CB)	10	2.96±0.09	85±0.002
B. Level of feeding			
1. 80% NRC (F_1)	10	2.71^b±0.08	79^b±0.002
2. 100 % NRC (F_2)	10	3.14^a±0.09	90^a±0.002
C. House x Feed			
1. LH x F1	5	2.71±0.12	80±0.003
2. LH x F_2	5	3.07±0.12	88±0.002
3. CB x F_1	5	2.71±0.12	79±0.002
4. CB x F_2	5	3.20±0.13	91±0.002

Within variables means in the same column without a common superscript differ significantly (p<0.001)

The average values for daily dry matter intake and intake per kg metabolic body weight under two levels of proteins were 2.71±0.084, 3.14 ±0.087 kg and 79 ±0.002 and 90 ±0.002 g in 80 and 100% NRC levels of protein feeding respectively. These differences were statistically significant (P<0.001). It was higher for the 100% than the 80% level. This may be due to the 20% additional concentrate intake by calves of this group than calves of other group fed on 80% level. Similarly Taparia *et al*. (1983), Mai and Kurar (1990b), Singh *et al.* (1991) and Shenu (2000) reported that there was significant increase in feed intake in crossbred calves that were fed higher levels of crude protein. On the contrary, Gupta and Saba (1983), Krishna and Ranjhan (1985) and Sampath *et al*. (1983) did not find significant effect on dry matter intake in crossbred calves reared on different levels of protein. The interaction between housing systems and level of feeding was not significant.

Table 4. Average daily voluntary water intake of crossbred calves

Variables	**Number of animals**	**Voluntary water intake/ h/d(Liters) (Mean ± SE)**	**Voluntary water intake / kg DM consumed (Liters) (Mean ± SE)**	**Voluntary water intake/ kg metabolic body weight (ml) (Mean ± SE)**
Overall mean	20	6.00±0.16	2.13±0.069	174±0.004
A. Housing				
1. *Loose House (LH)*	10	5.70±0.22	2.07±0.11	166±0.006
2. *Conventional Barn (CB)*	10	6.30±0.24	2.18±0.09	181±0.006
B. Level of feeding				
1. 80% NRC (F_1)	10	5.74±0.22	2.25±0.12	168±0.006
2. 100 % NRC (F_2)	10	6.26±0.24	2.01±0.07	179±0.006
C. House x Feed				
1. LH x F1	5	5.63±0.31	2.23±18	166±0.008
2. LH x F_2	5	5.77±0.32	1.92±0.10	165±0.007
3. CB x F_1	5	5.85±0.30	2.27±0.14	170±0.008
4. CB x F_2	5	6.74±0.35	2.09±0.11	192±0.008

Voluntary water intake

The data for daily voluntary water intake and intake per kg metabolic body size by experimental animals are presented in Table 4. The daily voluntary water intake and ratio of water to dry matter intake were 5.70 ± 0.22, 6.30 ± 0.24 liter and 2.07± 0.11 and 2.18± 0.09 liter in loose house and conventional barn respectively and intake per kg metabolic body weight were 166 ±0.006 and 181 ±0.006 ml in loose house & conventional barn respectively. These differences were not statistically significant (p>0.05). However the trend was clearly in favor of the conventionally housed group. This may be due to the higher internal temperature observed in the conventional barn, (17.5 vs. 16.5 °c) which initiated the calves of this house group to consume more water than the calves in loose house. Chakrabarti (1991) and Poudel (2001) reported similar findings on buffalo calves under similar housing systems in winter.

The analysis of variance indicated no significant difference in voluntary water intake between the two levels of protein, which is in agreement with earlier reports. For instance, Mudgal and Sivaiah (1982) and Sivaiah and Mudgal (1984) observed non-significant difference in voluntary water intake per unit of dry matter consumed between different levels of feeding. Shenu (2000) reported non-significant difference in voluntary water intake at 100 and 125% level of feeding and Poudel (2001) observed non-significant difference in voluntary water intake per kg dry matter consumed and intake per kg metabolic body weight at 80 and 100 % levels of protein. The interaction between housing system and level of protein feeding was not significant.

Body weight changes

The data for body weight changes of calves under the two housing and two levels of protein feeding are presented in table 5. Average daily body weight gain under two housing systems and two levels of protein feeding was 535 $\pm$0.03 and 540 $\pm$0.04 g and 525 $\pm$0.03 and 553 $\pm$0.03g in loose house, conventional barn, 80 and 100% NRC feeding respectively. The analysis of variance revealed that housing system and level of protein of the diet and the interact between housing system and level of protein had no significant influence ($p>0.05$) on final body weight, total weight gain and daily body weight gain of crossbred females calves. The results indicated that for a dry land environment like Hisar during a cold winter season housing of crossbred female calves in a conventional barn had no advantage in respect to growth of the calves over the loose house. Murely and Calvahouse (1958) reported no significant variation in growth of calves between conventional barn open shed or portable pens. Similarly, significant difference was not reported in body weight gain of beef cattle due to closed building and open front pole barn during winter (Hillickson *et al,* 1972). Chakrabarti (1991) observed better growth in conventional barn housed calves than the calves hosed in the other housing systems. On the contrary Saseendranath *et al.* (1983) and Poudel (2001) reported significantly higher weight gains in crossbred and buffalo calves housed in conventional barn as compared to loose house in winter.

Values for the level of feeding were slightly higher in 100% than the 80% level. This trend was clearly in favor of the 100% level however, the higher dry matter recorded by calves fed on 100% NRC level was not reflected in their body weight gain. This may be due to the fact that the difference in protein level between the two levels may not be large enough to detect a significant difference in body weight gain of crossbred calves. This could also be due to the facts that diet containing 80% protein might be optimum for crossbred calves to attain their maximum genetic potential for growth. Similar findings were reported earlier by many workers (Rathee and

Yadava, 1970, Krishna and Ranjhan, 1982, Singh *et al,* 1991, Sampath *et al.* 1993, Loerch and Fluharty, 1998 and Shenu 2000) who observed similar body weight gain (p>0.05) between different levels of feeding on crossbred and buffalo calves. However, on the contrary Hassan *et al,* (1991), Song *et al,* (1998) and Poudel (2001) reported significant difference in growth rates of calves between different protein levels.

Table 5. Average body weight changes of crossbred calves during the experimental period

Source of variation	**Number of animals**	**Average initial body weight (Kg) (Mean ± SE)**	**Average final body weight (Kg) (Mean ± SE)**	**Average total weight gain (kg) (Mean ± SE)**	**Average daily weight gain (g) (Mean ± SE)**
Overall mean	20	85.60±2.18	138.30±5.10	52.7±1.07	539±0.024
A. Housing					
1. Loose House (LH)	10	85.30±2.89	137.60±5.09	52.30±1.05	535±0.031
2. Conventional Barn (CB)	10	85.90±3.38	139.00±5.69	53.10±1.10	540±0.037
B. Level of feeding					
1. 80% NRC (F_1)	10	85.50±3.29	134.30±4.44	51.30±0.05	525±0.033
2. 100 % NRC (F_2)	10	85.70±3.008	139.80±6.09	54.10±0.10	553±0.036
C. House x Feed					
1. LH x F_1	5	85.20±3.75	136.20±4.09	51.00±1.22	520±0.041
2. LH x F_2	5	85.40±4.68	139.00±9.43	53.60±1.27	550±0.048
3. CB x F_1	5	85.80±5.72	137.40±8.20	51.60±1.08	530±0.051
4. CB x F_2	5	86.00±4.34	140.60±8.80	54.60±1.14	557±0.053

Body measurements

The monthly changes in average body length and average body height during the experimental period were 245 ±0.025 and 200 ±0.019 mm, respectively, in loose house and 256 ±0.022 and 185 ±0.013 in the conventional barn, respectively. The corresponding values for the other body measurements for the two housing systems were 209 ±0.026 and 189 ± 0.012 mm for heart girth 210 ±0.027 and 225 ± 0.016 mm for abdominal girth, and 100 ±0.006 and 115±0.008 mm for hip width, respectively. The corresponding values between the two housing systems were not statistically different. Similar results reported earlier by Erb and Murdock (1951), Jorgenson *et al.* (1970), Macualay *et al.* (1995) and Poudel (2001) were in line with the findings in the present investigation.

The monthly average increases in body measurements (mm) of calves under the two levels of protein feeding were 253 ±0.022 and 249 ±0.025 (length), 185 ±0.014 and 200 ±0.017 (height) in 80 and 100% feeding levels respectively. The values for heart girth, abdominal girth and hip width were 175 ±0.011 and 223 ±0.026 mm, 179 ±0.016 and 256 ±0.025 mm, 104 ±0.008 and 112 ±0.007 mm in both protein levels respectively. Statistical analysis revealed no significant differences in body length, height, heart girth and hip width between the two levels of feeding. Though Significantly ($p<0.001$) higher value of abdominal girth was observed in calves fed higher level of protein. This may be due to more concentrate intake observed by calves of this group. The findings of Mudgal and Ray (1965) and Sreenivasa *et al.* (1986) who reported no significant difference in heart girth, body height and body length and a significant difference in abdominal girth of calves between different levels of feeding on protein support the present results. However, Awate *et al.* (1975) observed significant differences in chest girth, posterior girth and height at withers of calves due to different levels of feeding, while Sarma (1991), Shenu (2000) and Poudel (2001) did not observe significant differences in body length, height, heart girth abdominal girth and hip width of calves between different levels of feeding on protein. The interaction between housing systems and level of feeding in the present study was not significant.

Feed conversion efficiency

The data for dry matter intake per kg body weight gain of crossbred calves are presented in Table 6. The average dry matter intakes per kg body weight gains under the two housing systems were 8.19±0.097 and 8.99 ±1.17 kg in loose house and conventional barn respectively. Statistical analysis indicated that dry matter intake per kg body weight gain was not significantly ($P>0.05$) influenced by housing systems. Chakrabarti (1991) also did not observe significant effect on DM intake due to housing systems. However, Poudel (2001) reported significantly higher values in DM intake per kg body weight gain in calves housed in conventional barn as compared to calves in loose house.

The values for DM intake per kg body weight gain under two levels of protein feeding were 8.75 ±1.14 and 8.43 ±0.01kg in 80% and 100% respectively. Level of feeding did not influence ($p>0.05$) dry matter intake per kg body weight gain. The present results are in agreement with those of earlier workers who also did not observe any significant difference in DM intake per kg body weight gain on crossbred and buffalo calves fed different levels of protein (Shenu, 2000 and Poudel, 2001). On the contrary Mai and kurar (1990a) observed a significant difference in DM intake per kg body weight gain in crossbred calves fed different protein and energy levels. The interaction between housing systems and levels of protein was not significant (P>0.05).

Table 6. Daily Average dry matter intake (kg) per kg body weight gain of crossbred calves

	Level of feeding		
	80% NRC	100%NRC	Mean
Housing system:			
Loose house	8.18 ± 1.33	8.20 ± 1.43	8.19 ± 0.97
Conventional barn	9.33 ± 1.86	8.65 ± 1.43	8.99 ± 1.17
Mean	8.75 ± 1.14	8.43 ± 1.01	

Conclusion

Findings of the present study confirmed that type of housing and level of protein in a diet had no significant influence in body weight, body measurements, water intake and dry matter intake per kg body weight gain of crossbred females calves in winter. However the significant effect of level of protein observed on dry matter intake of the calves was not reflected in their body weight gain. Thus these results suggest that in cold winter season crossbred females calves can be economically reared in loose house with 80% NRC protein feedings.

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Comparative Feeding Values of *Leucaena Pallida* and Noug Cake (*G. Abyssinica*) for Fattening Horro Steers

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Abstract

A study on comparative feeding value of *Leucaena pallida* and noug cake(*G.abyssinca*) for fattening Horro steers was made at the Bako Agricultural Research Center. Thirty Horro steers weighing 173.1±6.85 kg were randomly grouped into the following 5 treatments: grazing on native grass(T1), T_1+1.5kg noug cake/head/day(T2), T_1+1.5kg noug cake+1.5kg ground maize/head/day(T3), T_1+1.8kg *Leucaena pallida* hay/head/day(T4) and T_1+1.8kg *Leucaena pallida* hay+1.5 kg ground maize/head/day(T5). Final body weight(kg), total body weight gain(kg), average daily body weight gain(kg) and average daily feed intake(kg) of the animals were considered as dependent variables and analysed using the GLM procedure of the Statistical Analysis System. Partial budget and dominance analysis were employed to evaluate profitability of the supplemented feeds. Except control groups, all treatments had significant (P<0.01) effect on final body weight, total body weight gain, average daily body weight gain and average daily feed intake. There was a significant (P<0.01) difference between supplemented groups and the un supplemented group. Total body weight gain was significantly (P<0.01) highest (29.4±2.72) for steers in T3 and lowest for T1 (8.6±2.72). Similar trends were observed for final body weight and average daily body weight gain. Average daily feed intake of the steers was significantly (P<0.01) different among supplemented treatments. Feed intake was highest (2.4±0.02) for steers in T5 and lowest(1.0±0.02) for steers in T2. L*eucaena pallida* intake with maize was highest as compared to noug cake with maize or without maize. Even though, steers supplemented with noug cake and maize performed better than the other groups due to high fermentation of noug cake and maize in the rumen than *Leucaena pallida* supplemented groups as a sole feed supplement or with maize, there was no significant difference between noug cake and *Leucaena pallida* as sole feed supplements to steers. Marginal analysis indicated that supplementing Horro

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steers with 1.5kg noug cake and 1.5kg maize could increase net return by 171.70%. Alternatively, the return could increase by 110.02% when Horro steers supplemented with *Leucaena pallida* alone. From this study it can be suggested that in the areas where noug cake is available at price like in this experiments, supplementation of Horro steers with 1.5kg noug cake and 1.5kg maize/head/day is most economical. Alternatively, where there is shortage of noug cake, fattening Horro cattle on *Leucaena pallida* alone is economically feasible. So it can be concluded that one can use *Leucaena pallida* as a protein source in the place where there is shortage of noug cake especially where the farmers can easily grow *Leucaena pallida.* Where as noug cake as protein source is recommendable for fattening when it is easily obtained.

Keywords: Feed intake, Horro steers, Leucaena pallida, noug cake, weight gain

Introduction

Despite the relatively high cattle population in sub humid tropical climate of western Ethiopia, beef production and return obtained is low mainly due to poor nutrition. There are no cattle, which are solely kept for beef production (Alemu, 1987; Tesfaye, 1991; Tesfaye and Abule, 1991). Beef is produced mostly in the traditional system where cattle are kept mainly for ploughing. Cattle are usually sold for slaughter when they are too old for ploughing and milk production or cash shortage forces the farmers to sell their animals with out any further finishing. As a result, there is low beef production in quality and quantity in the area. In addition, poor feeding and management aggravate the problems.

Improvement of traditional beef production by introducing better feeding and management techniques is very important to increase beef production in the area. Finishing Horro cattle based on concentrate improved body weight performance of the animals (Mulugeta *et al*., 1995). Several studies made have shown supplementation of protein from forage source improved growth performance of animals (O'Donovan *et al*., 1978; O'Donovan, 1979). The demand for high quality animal protein along with subsistence production of cereal grains calls for supplementation using improved forages and/or by-products which offer the best supplement so that the productivity of cattle may be improved (Melese *et al*., 2001).

Livestock fattening is one of the best ways for farmers to quickly realise returns on improved forage production investment (Alemayehu, 2002).

Protein in *Leucaena* is of high nutritional quality and contains amino acids in well balanced proportions, much like alfalfa (Tesfaye *et al.*, 1988). Thus, this study was initiated with an objective of studying the comparative feeding value of *Leucaena pallida* and noug cake for finishing Horro steers.

Materials and Methods

Location

Bako Agricultural Research Center is located at 260 km west of Addis Ababa. It is situated at 9 ^{o} 07' N longitudes and 37 ^{o} 05' East latitudes. Long term meteorological data indicate that the center receives annual rainfall of 1196 mm with minimum and maximum temperature of 14 ^{o}c and 28 ^{o}c respectively. The altitude of the area is 1650 meters above sea level.

Animals and feeding management

Thirty Horro steers with initial body weight of 173.1 ± 6.85 were used for the experiment. They were randomly assigned into 5 treatments. The experiment was executed in a completely randomised design (CRD) with 6 replications. The Treatments were

T1=Grazing alone

T2= Grazing + 1.5 kg noug cake/animal/day

T3=Grazing + 1.5 kg noug cake + 1.5 kg ground maize/animal/day

T4=Grazing + 1.8 kg *Leucaena pallida* hay/animal/day

T5=Grazing + 1.8 kg *Leucaena pallida* hay + 1.5 kg ground maize/animal/day

After an adaptation period of 15 days, the experimental animals were offered the Treatment diets for 84 days of experimental period. The steers were grazing for about 8 hours (9 AM to 5 PM) on native grass and kept in individual pen during the night and supplemented with the respective treatment feed except the control group. Over night fasted body weight was recorded fortnightly.

Noug cake was purchased from near by small oil industries. While *Leucaena pallida* hay and maize were prepared in the center. The steers had access to water twice daily. The amount of feed offered and refusals were measured and recorded daily which was used to calculate daily feed intake of the animals.

Data analysis

The general linear model of Statistical Analysis System (SAS, 1996) was used to analyse body weight and feed intake data of the steers. In the model initial body weight and Treatment were considered as class variables, while final body weight, total body weight gain, average daily body weight gain and feed intake were considered as dependent variables.

At the end of the experimental period, a team consisting of local market dealers and experts estimated the market value of the steers and the average estimated market price was used for analysis. Partial budget and dominance analysis were employed to evaluate the profitability of supplementing noug cake, maize and *Leucaena pallida* in the strive to increase self production from Horro steers across 5 treatments. Three years average maize price was taken for the purpose, which was converted to field price by reducing beyond farm costs such as harvesting, shelling and transporting costs that the farmers may incur. The same procedure was used for *Leucaena pallida.* However, because of the fact that noug cake is not uniformly obtained at farm gate, average market price was used. Finally sensitivity analysis was done to define recommendation dominance input prices to determine the profitability index of this business activity.

Results and Discussion

Body weight

Initial body weight (kg), final body weight (kg), total body weight gain (kg), average daily body weight gain (kg) and feed intake (kg) are indicated in Table 1. Treatments had significant ($P<0.01$) effect on final body weight, total body weight gain and average daily body weight gain. Total body weight gain was significantly ($P<0.01$) higher for the supplemented groups than the control group. Similar trends were observed for final body weight and average daily body weight gain. These results were similar with the work of Melese *et al*. (2001) where the average daily gain of Horro bulls fed on different proportion of forage hay and concentrate feed performed better than the group fed on *Chloris gayana* alone (control Treatment). Also they indicated that improved forage with energy sources provide ration balanced for protein-energy.

Supplementation with concentrates and/or forage hay in the present study significantly ($P<0.05$) increased body weight performance over the un supplemented (control) group. Total body weight gain was highest (29.4 ± 2.72) for steers in T3 followed by T5 (15.8 ± 2.72), T2 (12.0 ± 2.72), T4 (11.3 ±

2.72) and lowest for steers in T1 (8.6 ± 2.72). The same trends were true for final body weight and daily body weight gain. The highest total body weight change for steers in T3 can be attributed to high rate of fermentation of noug cake with maze in the steers' rumen. Comparison of total body weight gain for T4 (11.3 ± 2.72) and T2 (12.0 ± 2.72) indicated that there was no significant (P>0.05) difference between the two groups in all body weight performance parameters studied. From this it can be said that there was no significant (P>0.05) difference between noug cake and *Leucaena pallida* on total body weight gain of steers as a sole protein supplement. Similar trends were observed for final body weight and average daily body weight gain.

Feed intake

Daily feed intake of the steers was significantly (P<0.01) different among supplemented animals (T2 to T5). Feed intake was significantly (P<0.05) highest (2.4 ± 0.02) for steers in T5 and followed by T3 (2.1 ± 0.09), T4 (1.1 ± 0.11) and lowest (1.0 ± 0.02) for steers in T2. This report is similar to the work of Hennessy *et al.* (1990) in which they found high forage intake for Hereford and crossbred Hereford steers.

The other reason might also be due to high digestibility of forages in general and Leucaena *pallida* in particular as compared to the by-product feed, which can facilitate animals feed intake. This is again similar to the report of Hennessy *et al.* (1990) in which they found high digestibility of forages for Hereford and crossbred Hereford steers.

The experiment was conducted during the wet season when the animals can get maintenance level from the grazing (Gebregziabher and Mulugeta, 1995; Tesfaye *et al*., 1999). Due to this reason the left over of supplemented feed was high. Otherwise, if the experiment had been conducted during the dry season, high feed intake can be expected, because animals cannot fulfil the required feed for maintenance from grazing (Tesfaye *et al*., 2000). Similar results were reported by Melese *et al*. (2001) in which they indicated that feed intake of bulls was higher for forage hay supplemented animals than un supplemented ones.

In general, *Leucaena pallida* supplementation for Horro steers as a sole supplement and as supplement with ground maize promoted better performance as compared to noug cake as a sole supplement. The feed intake was also higher for *Leucaena pallida* supplemented groups than noug cake supplemented groups. Similar results were reported from previous studies

(O'Donovan *et al.,* 1978; O'Donovan, 1979). All of them indicated that cattle and sheep have shown good performance by supplementing improved forage. Melese *et al.* (2001) reported similar results in which they indicated the demand for high quality animal protein along with the substitute production of cereal grains calls for improved forages which offer the best supplement so that the productivity of animals may be improved.

Table 1. Least squares mean ± SE of initial weight, final weight, total gain, average daily gain and feed intake of Horro steers as affected by different treatments.

Trait	Significance test for treatment effect	Treatments				
		1	2	3	4	5
Experimental period (days)		84	84	84	84	84
No. of animals		6	6	6	6	6
Initial weigh (kg)	NS	171.9 ± 6.85	172.8 ± 6.85	173.9 ± 6.85	173.5 ± 6.85	173.3 ± 6.85
Final weight (kg)	*	180.5 ± 7.17[c]	184.7±7.17[ab]	203.3 ± 7.17[a]	184.8 ± 7.17[ab]	189.8 ± 7.17[ab]
Total gain (kg)	**	8.6 ± 2.72[c]	12.0 ± 2.72[b]	29.4 ± 2.72[a]	11.3 ± 2.72[b]	15.8 ± 2.72[b]
Average daily gain (kg)	**	0.1 ± 0.03[c]	0.2 ± 0.03[b]	0.4 ± 0.03[a]	0.2 ± 0.03[b]	0.2 ± 0.03[b]
Supplement intake (kg/h/day)	**	-----	1.0 ± 0.02[cd]	2.1 ± 0.09[b]	1.1 ± 0.11[c]	2.4 ± 0.02[a]

N.B. Within rows, least squares means with different subscript letters are significantly different at least at p<0.05. *=P<0.05, **=P<0.01, NS=non significant

Economic analysis

Partial budget analysis, dominance and marginal analysis of supplementing Horro steers with different feeding levels were presented in Table 2 and 3. The partial budget analysis indicated that Horro steers supplemented with 1.5kg noug cake and 1.5kg maize gave a net return of birr 663.30. Steers supplemented with *Leucaena pallida* gave net return of birr 561.02. Dominance analysis clearly indicted that steers supplemented with noug cake alone and *Leucaena pallida* with maize were highly dominated to the third and fourth Treatment levels. Marginal analysis also indicated that the movement from the first Treatment (only grazing) to the third Treatment (grazing + 1.5 kg noug cake + 1.5 maize) was found to increase net return by 171.70%. This showed that one birr invested on supplementary feeding of

Horro steers with the main motive of increasing beef production could cover the investment cost and increase the return by 171.70%. On the other hand, the movement from T1 to T4 increased the return by 110.02% signifying that one birr invested could cover the investment cost and increase the profit by 110.02%. In all other cases, the movement from T1 lead to a marginal increase of less than 50%.

Therefore, it can be said that in areas where noug cake is available at required time, quantity and reasonable price, where maize production is high, supplementation of Horro steers with 1.5kg noug cake and 1.5kg maize per head per day is economical. Alternately, where noug cake is available, and production of *Leucaena pallida* at reasonable cost is possible, increasing beef production from steers by supplementing *Leucaena pallida* is economically feasible.

Recommendation made above can hold both for small scale and commercial farmers because in both cases the marginal rate of return was greater than 100%. This recommendation, however, is oscillating up to a limited range for existence non-decision or predetermined variables like prices of maize, noug cake and *Leucaena pallida.*

Table: 2. Partial Budget, dominance and marginal analysis of noug cake and *Leucaena pallida* for fattening Horro steers.

Parameters	**Treatments**				
	1	**2**	**3**	**4**	**5**
Average body weight	181.45	184.70	203.29	184.75	189.80
Adjusted weight gain	179.64	182.85	201.26	182.99	187.90
Gross benefit	544.31	575.90	732.59	576.14	610.67
Costs that vary					
Leucaena pallida (1.8kg/h/d)	0	0	0	15.12	15.12
Noug cake (1.5kg /h/d)	0	18.90	18.90	0	0
Maize (1.5kg/h/d)	0	0	50.40	0	50.40
Total cost vary (birr)	0	18.90	69.30	15.12	65.52
Net benefit (birr)	544.31	557.00	663.29	561.02	545.15
Dominance analysis		D	ND	D	D
Marginal analysis (%)		-	171.70%	110.52	-

N.B MARR (Marginal Rate of Return)= 50%. Average maize price =birr 40/qt. Estimated cost of *Leucaena pallida* = birr 10/qt.
D = Dominated treatment. ND = non dominated treatment

Sensitivity analysis verified that for this recommendation to hold true, the price of noug cake, maize and *Leucaena pallida* should not exceed, birr 30, 69 and 15 per quintal respectively. Simultaneously and opposite changes in price of Horro steers and inputs may also sustain the validity of the recommendation.

Table 3. Sensitivity analysis of recommendation of noug cake and *Leucaena pallida* in increasing beef production from Horro steers.

Item	Treatment				
	1	2	3	4	5
Average price of Horro steers[1] (Birr/kg)	3.03	3.15	3.64	3.15	3.25
Average price of noug cake[2] (Birr/kg)	-	-	0.30	-	-
Average price of *Leucaena pallida* (Birr/kg)	-	-	-	0.15	-
Average price of maize (Birr/kg)	-	-	0.69	-	-

N.B.

[1]=changes more than indicated figures are accepted

[2]=changes less than indicated figures are accepted

Conclusion

Leucaena pallida intake with maize is highest as compared to noug cake with maize or with out maize. Even though steers supplemented with noug cake and maize performed better than other groups due to high fermentation of noug cake and maize in the rumen than *Leucaena pallida* as a sole feed supplement or with maize, there is no significant difference between noug cake and *Leucaena pallida* as a sole feed supplement to steers. Marginal analysis indicated that supplementing Horro steers with 1.5kg noug cake and 1.5kg maize could increase net return by 171.70%. Alternatively, the return could increase by 110.02% when Horro steers were supplemented with *Leucaena pallida* alone. It was suggested from this study that in areas where noug cake is available at required time, quantity and price, supplementation of Horro steers with 1.5kg noug cake and 1.5kg maize/head/day is economical. Alternatively, where noug cake is available, fattening Horro steers on *Leucaena pallida* alone is economically feasible. So it can be concluded that one can use *Leucaena pallida* as a protein source in the place where there is shortage of noug cake especially where the farmers can easily grow *Leucaena pallida*. In case of commercial farmers when they can easily get noug cake, fattening Horro steers using a combination of noug cake and ground maize can bring higher benefits due to high fermentation in the rumen.

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Days To First Service, Conception Rate And Service Period Of Indigenous And Crossbred Cows In Relation To Postpartum Body Weight Change At Bako, Ethiopia

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Abstract

Days to first service (DFS), conception rate to first service and service period of indigenous and crossbred cows were studied using data from Bako Agricultural Research Center. The overall least square mean DFS was 150.3 ± 3.41 days and was significantly (at least $P < 0.05$) influenced by cow genotype, calving year, cow parity, calving weight and postpartum body weight gain. The effect of age on DFS was not significant ($P > 0.05$). Boran (192.7 ± 17.55 days) and Boran x Simmental crosses (200.1 ± 16.84 days) and first parity cows (202.0 ± 11.77 days) had significantly the longest DFS. DFS among the calving years ranged from 102.9 to 254.3 days. DFS was linearly related to calving weight of the cow ($b = -0.39 \pm 4.21$) and postpartum body weight gain ($b = -0.03 \pm 2.81$). The overall predicted probability of conception to first service was 0.7 ± 0.03. It was significantly influenced by mating weight ($P < 0.01$) and age of the cow ($P < 0.001$). The highest probability of conception was recorded for heavier cows (>400kg) at mating (0.8 ± 0.07) and youngest (<4 years) cows (0.8 ± 0.04) at calving compared to the other weight and age groups. A service period of zero was observed in 69.6% of the cows while 22.2% of the cows had very long service period (>48 days). From this study it can be recommended that from the DFS contributed the highest share to the prolonged days open in the center. A mating weight of 251-300 kg resulted in a drastic change in conception rate. Thus, attaining this target mating weight through proper postpartum feeding management and culling of old cows and repeated breeders could improve all traits considered in this study.

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Introduction

The main determinant of calving interval in individual cows is the days open, which is a function of the interval from parturition to first insemination (days to first service) and service period. Days to first service is an indirect measure of the estrus detection efficiency. With effective estrus detection program days to first breeding should be 20 to 28 days past the voluntary waiting period (Radostities *et al.*, 1994). A cow after calving needs some rest period for the uterus to involutes and normal cycle to take place. For this reason, a voluntary waiting period (VWP) ranging from 45 to 60 days is allowed before the cow is inseminated or bred. This prolongs the days to first service. Days to first service has low heritability (Batra *et al.*, 1986), which indicates that the trait is mainly influenced by non-genetic factors. Days to first service could be prolonged due to longer postpartum anoestrus interval (Batra *et al.*, 1986), when estrous activity ceases after a cow manifests its first postpartum estrous (Dawuda *et al.*, 1988) and due to low level of nutrition (Sasser *et al.*, 1988). Other factors such as the breeding management of a farm and genetic and non-genetic factors such as age, parity, season and calving year contribute to prolonged days to first service (Garcia *et al.*, 1990).

Service period depends on many genetic and environmental factors, which affect conception, embryo survival and heat detection efficiency. It is affected by the rates of conception to first and/or subsequent inseminations as well as the time intervals between successive inseminations. Generally repeated services per conception (Azage Tegegn *et al.*, 1981), long inter-service interval (Mukassa-Mugerwa *et al.*, 1991; Gemechu Wirtu, 1992; Gebregziabher Gebreyohannes *et al.*, 2003), long estrous cycles (Alberro, 1983) and embryonic mortality (Wood, 1976; Kummerfield *et al.*, 1978) influence the length of service period. First service conception rate was affected by postpartum energy and/or protein intake of the cow (Randel, 1990). Peters (1984) reported a positive relationships between nutritional status, body weight and body condition score and fertility in both dairy and beef cows. Lactation status at the time of mating affects fertility (Hetzel *et al.*, 1989), which is largely a manifestation of the extra nutritional demand of lactation. Therefore, this study is designed to asses the days to first service, service period and conception rate to first service and factors affecting in indigenous and crossbred cows and recommend appropriate improvement strategies for better postpartum reproductive efficiency.

Materials and Methods

The study was based on reproduction data obtained from Bako Agricultural Research Center of the Oromia Agricultural Research Institute. Detailed description of the study area livestock management, feeding, heat detection and breeding are presented in a previous work (Gebregziabher Gebreyohannes *et al*., 2003, 2004). Data from pure Boran and Horro and their F_1 crosses with Jersey, Friesian and Simmental exotic sire breeds were used to calculate DFS (period from calving to date of first service), service period (period from date of first service to date of effective service) and conception rate to first service (predicted probability of conception to first service). DFS was analyzed using the General Linear Model, while conception rate to first service was coded as zero (success) for cows that conceived or one (failure) for cows that didn't conceive to first service and analyzed using the Categorical Model Analysis (SAS, 1999). Maximum Likelihood analysis of variance and parameter estimates for each level of the class variables were obtained as an output of the CATMOD procedure of SAS. The predicted probability of conception and standard errors for each level of class variables was then calculated from the parameter estimates obtained from SAS using the LOGMLVAR computer program (Rege, 1997).

Cow breed (genotype), parity, calving year and season were considered as fixed effects and calving weight, age of the cow and body weight gain (postpartum body weight gain from calving to three months postpartum) as a covariate to analyze days to first service. Eight genotypes (Horro, Boran, Horro x Jersey, Horro x Friesian, Horro x Simmental, Boran x Friesian, Boran x Jersey and Boran x Simmental), six parities (1 to 6 with the sixth parity including parities six and above), four calving season categories based on the centers rainfall data (*Gana* (June to August); *Birra* (September to November); *Bona* (December to February); *Arfasa* (March to May)); 18 calving years (1980 through to 1998 except 1991) were considered for the analysis of DFS. For the analysis of conception rate to first service, the eight cow breeds (genotypes) were grouped into five sire breeds (Friesian, Jersey, Simmental, Horro and Boran) and two dam breeds (Horro and Boran) categories. Besides, to simplify the analysis, the mating weight was categories into five classes (<250, 251-300, 301-350, 351-400 and >400 kg) and calving age into five classes (<4, 4-6, 6-8, 8-10 and >10 years). Then sire and dam breed, mating weight and age were considered as fixed effects. Because of the very low number of observations the calving year 1991 was excluded from the analysis.

Results

The overall least square mean days to first service was 150.3 ± 3.41 days (Table 1). DFS was significantly (at least $P < 0.05$) affected by cow breed (genotype), calving year, cow parity, calving weight and postpartum body weight gain. The effect of age on DFS was not significant ($P > 0.05$). Boran (192.7 ± 17.55 days) and Boran x Simmental cross (200.1 ± 16.84 days) cows and first parity cows (202.0 ± 11.77 days) had significantly ($P < 0.001$) the longest DFS compared to their contemporaries. DFS ranged from 102.9 ± 30.59 days for cows that calved in 1998 to 254.3 ± 16.27 days for cows that calved in 1983. DFS was linearly related to calving weight ($b = -0.39 \pm 4.21$; $P < 0.001$) and postpartum body weight gain ($b = -0.03 \pm 2.81$; $P < 0.01$, Table 1). DFS declined at a rate of 0.39 and 0.03 days for a unit increase in calving weight and age respectively.

Conception rate to first service was analyzed as the probability of conception to first service. Accordingly, the overall predicted probability of conception to first service was 0.7 ± 0.03 and it was significantly affected by mating weight ($P < 0.01$) and age of the cow ($P < 0.001$; Table 2). The effect of sire and dam breed were not significant ($P > 0.05$). Besides, the maximum likelihood ratio was not significant indicating that the model provided good fit to the data. Conception rate ranged from 0.7 ± 0.05 for Simmental crosses to 0.6 ± 0.04 for pure Horro cows. The Boran (0.7 ± 0.03), as a dam breed, was not significantly different from Horro (0.7 ± 0.03). Heavier cows at mating (> 400 kg) had significantly ($P < 0.01$) the highest probability of conception compared to the lightest (< 250 kg) cows at mating (0.8 vs. 0.5). Cow age had significant ($P < 0.001$) and the highest probability of conception (0.8 ± 0.04) was observed for younger (<4 years) cows.

A service period of zero was observed in 69.6% of the cows indicating that the cows conceived with one service while 22.2% of the cows had very long service period (>48 days) suggesting that these cows required repeated services to conceive. About 1.5% of the service period was within a range of 1 to 17 and 25 to 35 days interval (Table 3).

Table 1. Least squares mean (± SE) days to first service (days) in indigenous and crossbred cows

Source	N	Mean ± SE
Overall mean	752	150.3 ± 3.41
Cow genotype		***
Boran	39	192.7 ± 17.55 [a]
Boran x Friesian crosses	68	178.7 ± 15.08 [ab]
Boran x Jersey crosses	57	146.3 ± 14.02 [bc]
Boran x Simmental crosses	49	200.1 ± 16.84 [a]
Horro x Friesian crosses	79	170.1 ± 11.93 [ab]
Horro	317	147.2 ± 10.56 [bc]
Horro x Jersey crosses	93	148.0 ± 15.58 [bc]
Horro x Simmental crosses	50	120.5 ± 7.20 [c]
Parity		**
1	150	202.0 ± 11.77 [a]
2	154	178.9 ± 9.96 [ab]
3	154	158.6 ± 9.73 [bc]
4	127	176.4 ± 10.78 [ab]
5	82	137.1 ± 14.08 [c]
6	85	124.7 ± 17.51 [c]
Calving year		***
1980	76	145.1 ± 12.28 [de]
1981	80	132.3 ± 11.54 [de]
1982	97	192.9 ± 10.04 [bc]
1983	35	254.3 ± 16.27 [a]
1984	33	221.8 ± 17.03 [ab]
1985	47	125.2 ± 14.36 [de]
1986	64	147.5 ± 12.48 [de]
1987	52	152.7 ± 13.96 [de]
1988	26	236.5 ± 19.65 [a]
1989	14	176.5 ± 26.67 [bcd]
1990	23	164.8 ± 21.66 [cd]
1992	25	216.9 ± 20.76 [abc]
1993	20	145.9 ± 22.98 [de]
1994	41	128.5 ± 17.76 [de]
1995	40	131.9 ± 17.78 [de]
1996	34	112.3 ± 19.06 [e]
1997	35	144.9 ± 17.80 [de]
1998	10	102.9 ± 30.59 [e]
Regression variables (covariates)		
Calving weight		-0.39 ± 4.21 ***
Age of the cow		4.91 ± 1.64 NS
Body weight gain		-0.03 ± 2.81 **

Means in a column within a group followed by different superscript vary significantly
(*** = P < 0.001, ** = P < 0.01 and NS (Not Significant) = P > 0.05)

Table 2. Predicted probability of conception to first service

Effect	N	Probability of conception to first service (± SE)
Intercept	864	0.7 ± 0.02
Sire breed		NS
Friesian crosses	146	0.7 ± 0.04
Jersey crosses	151	0.7 ± 0.04
Simmental crosses	97	0.7 ± 0.05
Boran	91	0.7 ± 0.05
Horro	379	0.6 ± 0.04
Dam breed		NS
Boran	263	0.7 ± 0.03
Horro	601	0.7 ± 0.03
Mating weight group		**
1. <250 (224 kg)	230	0.5 ± 0.03
2. 251-300 (279 kg)	236	0.7 ± 0.04
3. 301-350 (325 kg)	223	0.7 ± 0.04
4. 351-400 (373 kg)	106	0.7 ± 0.04
5. >400 (435 kg)	65	0.8 ± 0.07
Age group		***
1. ≤ 4 (3.5 year)	186	0.8 ± 0.04
2. 4.1-6 (5.1 year)	233	0.6 ± 0.03
3. 6.1-8 (7.0 year)	226	0.7 ± 0.03
4. 8.1-10 (8.8 year)	125	0.6 ± 0.04
5. >10 (12.1 year)	94	0.7 ± 0.05

Values in parenthesis are mean values of the group

Significance level *** = P < 0.001, ** = P < 0.01 and NS (Not Significant) = P > 0.05

Table 3. Distribution of service periods to different inter-service interval categories

Category (days)	No cows	Percent
0	624	69.6
1-17	8	0.9
18-24	29	3.2
25-35	5	0.6
36-48	31	3.5
≥48	199	22.2
Total	896	100

Discussion

First breeding after calving depends mainly on the breeding management of the farm. Any farm has a Voluntary Waiting Period (VWP) where the breeder retains a cow seen in heat unbred to allow sufficient time to recover from parturition stresses. Unless heat detection is poor, the average days to first breeding should be within 30 days after the VWP (Radostitis *et al.*, 1994). The VWP at Bako Agricultural Research Center ranges from 45 to 60 days, hence, the DFS**,** according to Radostities *et al.* (1994), had to be within 75 to 90 days. However, the DFS recorded in this study is very long, which could be resulted from poor heat detection, poor breeding and due to the influences of genetic (breed) and non-genetic (parity, calving year, calving age and weight, body weight gain) factors. Heritability of days to first breeding is generally low (Batra *et al.*, 1986) which suggests that improvement of the DFS is mainly possible through the improvement of non-genetic factors.

Days to first service is influenced by the postpartum anoestrus period. According to previous work by Gebregziabher Gebreyohannes *et al.* (2004) the postpartum anoestrus interval for the same herd was 79.4 days. This has contributed to the prolonged. Long DFS could also be due to cessation of estrus activity after a cow manifested its first postpartum estrus or cows observed in heat were not bred due to different reasons. Dawuda *et al.* (1988) observed that Bunaji cows stopped cycling and become anoestrus after three to four cycles which they partly attributed to seasonal fluctuations in nutrition. According to Gebregziabher Gebreyohannes and Mulugeta Kebede (1996) 64% of the observed heat in Horro and crossbred cows was not bred due to reasons associated with the bull, the cow or other external factors. This might contribute positively to the long DFS.

The breed and parity differences in DFS observed in this study are in agreement to the work of Garcia *et al.* (1990). Garcia *et al*. (1990) reported 176.8 ± 19 and 260.6 ± 26.7 days for European x Zebu crossbreds kept at the experimental and private farms and older cows (at least four calving) had about 100 days shorter DFS compared to first calvers. Differences among calving years could be associated to variations in breeding management and to variations in rainfall, humidity and temperature, which directly or indirectly affected the trait.

Calving body weight and postpartum body weight gain were inversely related to DFS. Heavier cows at calving and cows that gained weight during the first three months postpartum are in a positive energy balance which enabled them to return to normal estrus cycle and breeding within shorter period of time compared to lighter cows at calving and those cows that lost weight during this period.

The effect of sire and dam breed on the probability of conception to first service was not significant. This contradicts with the reports of Franke (1980) and Garcia *et al*. (1990). Franke (1980) reported significantly lower fertility for Brahmans and Brahman derived breeds than *Bos taurus* breeds. Similarly, Garcia *et al.* (1990) reported significant effect of parity and year on conception rate to first service.

The effect of mating weight on conception rate obtained in this study (Table 2) is consistent with the findings of Buck *et al.* (1976) and Sawyer *et al.* (1993). Buck *et al.* (1976) reported that cows weighing less than 300 kg at the beginning of mating season achieved a 50% calving and this increased to 85% as the body weight increased to 430 kg. Sawyer *et al.* (1993), however, reported high pregnancy rate of 93 to 94% for cows with the highest average live weight at conception in nulliparous heifers of both Angus and Angus Friesian heifers. Mating weight is a function of the feeding system before the mating season. For instance, Little *et al.* (1991) reported that N'Dama cows supplemented with ground nut cake reduced their body weight loss and this resulted in doubling the conception rate within 12 months of calving from 36 to 64% (Little *et al.*, 1991). Peters (1984) also reported a positive relationship between body weight and fertility. Mackinnon *et al.* (1989), however, reported a curvilinear response in fertility to increased live weight at mating with the response tend to be greatest in two-year-old heifers, in which maximum calving rates were achieved when the mating weight exceeded approximately 325 kg. Comparisons of the different weight groups showed that the change in conception rate increased drastically from the first (0.5 ± 0.03) to the second (0.7 ± 0.04) mating weight group, while the change from the second to third (0.7 ± 0.04) and fourth (0.7 ± 0.04) mating weight categories was not big. Therefore, the advantage in conception rate to be obtained through feeding the cows for higher mating weight need to be looked from the economic point of view. The opportunity cost of getting heavier body weight has to be weighed to the advantage in conception rate expected. Therefore, the mating weight 251 to 300 kg could be recommended as a target weight for higher probability of conception.

The effect of age on probability of conception to first service was significant (Table 2). Earlier reports (Reynolds *et al.,* 1979; Hillers *et al.,* 1984; Azzam *et al.,* 1989; Amsalu Sisay *et al.*, 1998) also indicated similar results. The reduced probability of conception to first service with increased age could partly be attributed to the exposure of the cows to different reproductive diseases. Similarly, Amsalu Sisay *et al.* (1998) reported a 9.2% higher pregnancy rate to first insemination/service in heifers than cows.

A service period of zero was observed in 69.6% of the cows indicating that these cows required one service to conceive. Since the highest numbers of the cows had a service period of zero, it was not possible to subject the remaining data to analysis of variance so that see the effect of the different factors. However, service period is related to the number of services required per conception, conception rate to first or subsequent services, inter-estrus and inter-service intervals and heat detection efficiency. Any thing that affects one or a combination of these traits can affect service period. Breeds vary in the number of services per conception (Azage Tegegn *et al.*, 1981; Eneyew Negussie *et al.*, 1998), estrus cycle length (Alberro, 1983; Mekonnen Haile-Mariam and Goshu Mekonnen, 1996; Yoseph Mekasha *et al.*, 2000), fertility to first service (Mackinnon *et al.*, 1989) and duration of estrus (Mattoni *et al.*, 1988). Breed difference also demonstrate a genetic component to fertility (Mackinnon *et al.*, 1989), for instance the problem of low fertility of Brahmans can be partly improved by crossing with *Bos taurus* breeds. An influence of parity on the length of the service period was also reported. However, the effect of parity on service period could be related to its effect on number of services per conception (Eneyew Negussie *et al.*, 1998), conception rate (Hillers *et al.*, 1984; Ron *et al.*, 1984; Garcia *et al.*, 1990) and estrus cycle (Mukassa-Mugerwa *et al.*, 1991) thereby influencing the service period. Heifers do not conceive as readily as other cows and they require more services per conception than cows in the later parities (Eneyew Negussie *et al.*, 1998). The cause of the age related difference in cows in the first parity may be due to delayed resumption of ovarian activity after calving as a result of the longer resting period needed to recover from parturition stress and to cope-up with the increased demand for growth and lactation (Eneyew Negussie *et al.*, 1998). Moreover, the length of the service period could also be affected due to embryonic mortality (Kummerfield *et al.*, 1978). Hillers *et al.* (1984) and Azzam *et al.* (1989) reported poor fertility and conception in older than younger cows.

Conclusion

DFS was found very long which could be the result of poor heat detection efficiency, poor breeding management and other genetic and non-genetic factors. Cow breed, parity, calving year, calving weight and postpartum body weight gain had an influence on DFS.

Service period also contributed to the prolonged days open. In this study, 69.6% of the cows conceived with one service and their corresponding service period was zero indicating that service period contributed little to the long days open of the herd.

Conception rate to first service could be improved through an improvement in calving weight and culling of aged cows and repeated breeders. Furthermore, the fertility of the breeding bull need to be studied since its contribution to wards conception is equally important as that of the cow. Among the mating weight groups, mating weight of 251 to 300 kg (average 279) resulted in high conception rate. Thus, attaining this target mating weight postpartum through proper feeding management could contribute to shorter high conception rate.

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The Performance of Naked Neck and Their F_1 Crosses with Lohmann White and New Hampshire Chicken Breeds under Long-Term Heat Stress Conditions

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Abstract

An experiment was conducted on 48 forty-eight female chicks from each of the five genotypes (*Angete-Melata*, Naked neck [Na]; New Hampshire [NH]; Lohmann White [LW]); and F_1 crosses (New Hampshire crosses [Na × NH]; Lohmann White crosses [Na × LW]) to assess the effect of long-term heat stress on performance traits. The female chicks were randomly divided into two groups and raised on floor pens in normal (18-20°C) and high (30-32°C) ambient temperatures up to the 20th week of age, after which they were transferred to a three-tiered system of individual cages in temperature-regulated houses and maintained in the same ambient temperatures up to the age of 68 weeks. The results revealed highly significant differences between Na and both F_1 crosses in performance traits under heat stress conditions. Accordingly, the F_1 crosses were superior to local Na hens for body weight, egg production, egg mass output, egg weight and feed efficiency. Age at sexual maturity for F_1 crosses was significantly shorter than Na but comparable to the average of pure lines. The body weight of heat stressed F_1 crosses was generally larger than Na and comparable to the average of pure lines. Percentage hen-day, hen-housed egg production and total egg number for F_1 crosses under elevated temperature did not significantly differ from the control group indicating their capability to tolerate long-term heat exposure. The present findings suggest that the F_1 crosses could be preferable to the local Na for improved egg production in hot regions.

Keywords**:** F_1 crosses, heat stress/high temperature, naked neck, performance traits, pure lines

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Introduction

Stress due to high environmental temperature is widely recognised as one of the primary problems in poultry production, especially in tropical and subtropical areas. High environmental temperature is the most important inhibiting factor to poultry production in hot regions (Horst, 1982), apparently because chickens cannot dissipate the heat produced following meals fast enough, which subsequently leads to reduced feed intake and lower weight gain and/or egg production (Washburn and Eberhart, 1988; Cahaner and Leenstra, 1992).

As a result of natural selection, "survival" rather than "product offtake" genes have been accumulated in local chicken strains resulting in poor growth and production. Most of indigenous chickens are, thus, non-descript, unimproved and are usually characterised by small body size, late maturity, low yield in egg number and egg weight, small clutch sizes, long laying pauses and an instinctive inclination to broodiness (Horst, 1989). Nevertheless, associated with low productivity are special desirable characteristics of local chickens such as their low input requirements, adaptability to the harsh conditions, and ability to produce special product qualities (pigmentation, taste, etc.) that are highly valued by the local producers and consumers (Horst and Mathur, 1992; Gueye, 1998).

Among the local chicken strains found in Ethiopia, the *Angete-Melata* (means Naked neck) strain is well known for better performance compared to other strains. Teketel (1986) and G/Yohannes (1997) reported that the *Angete-Melata* strain had significantly larger body weights, higher egg production associated with heavier egg weights and higher egg mass outputs, which were all significantly different from other local chicken strains. The reduction in feathering intensity through the naked neck gene may enhance the insensible heat loss through exposed body surface.

The genetic value of local chickens may be exploited through crossbreeding with exotic chickens to improve productive adaptability and product qualities. Because of the genetic distance between indigenous and exotic chickens, a higher degree of heterosis in some productive performance traits and adaptation to environmental stress would be expected (Horst and Mathur, 1992). This approach would further help to combine the adaptability of the indigenous chicken with the productivity of the exotic improved stock with additional advantage of the heterosis effects, which are expected to be higher under unfavourable environmental conditions (Barlow, 1981; Cunningham, 1982).

In a crossbreeding study carried out at Assela, Ethiopia, involving the exotic Yarkon chicken breed with unidentified local chickens (Brannang and Persson, 1990), F_1 crosses produced 129 eggs per year, which is far better than eggs produced by local hens. The annual egg production of F_1 crosses was 146 eggs per hen at Debre-Zeit Agricultural Research Centre, Ethiopia, (Alemu, 1995). Moreover, crossing with exotic egg type chickens had significant effects on egg numbers, egg weight, and total egg mass (Nwosu, 1992). The general purpose of the present study is, thus, to assess the heat tolerance capacity of *Angete-Melata* chickens and their F_1 crosses with Lohmann White and New Hampshire layer breeds as measured by their productive performance under long-term heat stress conditions.

Materials and Methods

Experimental animals

Two different experiments were conducted at Martin-Luther University Halle-Wittenberg, Germany between April 1997 and September 1999. In the first experiment (April 1997-May 1998), a total of 240 hens from five different pure breeds were used to test adaptability potential to long-term heat stress (30-32°C). The required five commercial chicken breeds were reared at Merbitz Livestock Research Centre of Martin-Luther University (MLU), where both experiments were conducted. The White Leghorn lines and New Hampshire were obtained from Merbitz Research Station, while both day old chicks of Lohmann White and Lohmann Brown were purchased from a commercial enterprise (Lohmann Company Ltd.) in Germany. Finally, on the basis of their performance and adaptability to heat exposure, both LW and NH breeds among the five were identified and eventually crossed with male cocks of *Angete-Melata* (Na) strain to produce the F_1 crossbreed population. To this effect, fertile eggs of *Angete Melata* strains were collected at Poultry Section of Awassa College of Agriculture and transported to Germany. The eggs were incubated and hatched at MLU of Germany.

The 2nd experiment was conducted between May 1998 and October 1999. Artificial insemination was employed for all populations. Female chicks of each genotype were then identified and randomly divided into control and experimental groups and raised on the floor pen up to the 20th week of age under normal (18-20°C) and high (30-32°C) ambient temperatures, respectively. Thereafter, 120 pullets from each group were moved to a three-tiered system of individual cages in temperature regulated layer houses with the respective ambient temperatures as indicated in Table 1.

All the birds had *ad libitum* access to feed and water during the entire experiment. Standard starter (11.4 MJ/kg and 18% CP) and grower rations (11.4 MJ/kg and 15% CP) were provided to all growing chicks and pullets, respectively. All hens maintained in individual laying cages, were fed on commercial laying feed with 11.4 MJ/kg energy and 17% crude protein contents. Hens were fed in-groups *ad libitum* (4 hens/feed pan). Water was supplied with individual nipple drinkers. The dimension of each individual cage was 1000 cm^2 (20 cm width x 50 cm length).

A Tinytalk™ II Data Logger device was used to measure the pen temperature and relative humidity during the course of the experiment. The device was loaded and unloaded at 72 days interval and was adjusted to record the pen temperature at two-hour intervals. The collected data were then converted to conventional data sets by Tinytalk™ PC software for Windows for further analysis.

Measurement of performance traits

Hens were weighed individually at the beginning (20^{th} weeks of age) and end (68^{th} weeks of age) of the experiment. Eggs were collected daily and egg production was calculated on a hen-day and hen-housed basis. Feed intake and egg weight were determined at 28-day intervals. Egg mass was calculated as a factor of egg weight and egg production. Feed efficiency ratio (feed consumed/egg mass) was calculated as grams of feed: grams of egg mass output. Heat stress index or change in performance to control group for performance traits was calculated by using the following formula:

$$Heat\ stress\ index = \frac{Performance\ in\ high\ temperature - Performance\ in\ normal\ temperature}{Performance\ in\ normal\ temperature} \times 100$$

Statistical analysis

Data were analysed using the General Linear Models Procedure of SAS® (SAS Institute, 1996). All performance parameters were analysed in a complete 2x5 factorial design (2 normal and high temperatures; 5 genotypes). Egg number, body weights and percentage data of egg production were analysed following logarithmic transformation to account for the skewed distribution. When significance differences in ANOVA were detected, comparisons of multiple means were made by using Tukey's HSD test. All statements of statistical differences were based on P<0.05 unless noted otherwise.

Results

Egg production traits

Percent fertility and hatchability of eggs for different genotypes is presented in Table 2. Rate of egg fertility was higher for LW and their F_1 cross, but lower for Na chicks. Conversely, hatchability of fertile eggs was higher for NH, but lower for Na × NH chicks. The same trend was also observed for the hatchability of total eggs set. In general, the NH breed showed better hatchability. Among F_1 crosses, the Na × LW was superior to Na × NH for egg fertility and hatchability.

Sexual maturity for exotic breeds (LW and NH) and F_1 crosses was not significantly affected by high temperature although it was slightly shorter by 3 days when compared to the control group. On the other hand, a significant difference in sexual maturity was noted between genotypes exposed to long-term high environmental temperature. Accordingly, age at first egg for F_1 crosses was significantly shorter compared to local Na strain but was comparable to that of exotic breeds.

Exposure to prolonged heat stress at the age of 20 weeks, which corresponds with sexual maturity, resulted in body weight loss of 9.4% in all genetic groups except in Na × LW crosses (Table 3). The body weight depression for individual genotypes was 14.1, 7.8, 13.7 and 12.6% for Na, LW, NH and Na × NH, respectively. Conversely, no significant effect of heat stress on body weight was found at the 68^{th} week of age for all genotypes, except for the NH line, which showed a significant body weight loss of 16.6%. The body weight of Na × LW (1189 g) at 20 weeks of age was comparable to LW (1248 g), but significantly larger than the Na strain (818 g) and Na × NH hens (1101g).

The effect of long-term high temperature on egg production, egg weight and egg mass output is presented in table 4. The effect of ambient temperature and genotype on egg weight and production was highly significant (P<0.001). The ambient temperature by genotype interaction was found to be significant as well. Egg production, as expressed in percentage hen-day and hen-housed, and total egg number for LW and NH exotic breeds were significantly affected by high temperature, while the effect remained insignificant for both F_1 crosses and local Na strains. As a result, percentage hen-housed egg production reduced by 10.8 and 9.7% for LW and NH breeds, respectively; and percentage hen-day egg production by 10.8 and 5.5%, for NH and LW breeds, respectively. There was no significant difference between NH, Na × LW and Na × NH genotypes in hen-day egg production under heat stress conditions.

On the other hand, significant differences between experimental and control groups were found in egg weight resulting in a 10% depression for all genotypes. The decline in egg weight due to heat stress followed the same trend as in egg production and was comparatively larger for NH (15.2%) and LW (11.7%) but smaller for Na × LW (6.0%) and Na (7.4%) compared to the control group. The depression in egg weight for Na × NH crosses was intermediate with 9.5%. The F_1 crosses at high temperature produced eggs with significantly heavier weights than the local Na strain.

The magnitude of heat stress effect on total egg mass output was larger ($p<0.001$) for both breeds (LW and NH) as well. The individual egg mass depression, as measured by heat stress index, for NH and LW was 25 and 21%, respectively (figure 1). However, the heat stress index for daily egg mass output for Na and Na × LW was insignificant. The difference in daily egg mass output between NH and Na × LW at high temperature was insignificant. The daily egg mass output for F_1 crosses was much better than local Na strain but comparable to both pure breeds as illustrated in figures 2 and 3.

Feed intake and efficiency

The effect of heat exposure on feed intake and efficiency for individual genotypes is presented in Table 5. The effect of ambient temperature and genotype on feed intake was highly significant ($P<0.001$). The temperature by genotype interaction effect for feed intake was highly significant as well. However, the effect of ambient temperature on feed efficiency and the temperature by genotype interaction was not significant. The feed intake in all genotypes was significantly depressed resulting in a general decline of 20.4% for pure breeds (NH and LW) and 14.5% for F_1 crosses. The heat stress index of feed intake for individual genotype was 22.7, 18.2, 17.8, 17.1 and 11.9% for NH, LW, Na, Na × NH and Na × LW, respectively (Figure 1).

The difference in feed intake between NH, Na × LW and Na × NH exposed to long-term heat stress was insignificant. The feed efficiency per kg egg mass for both F_1 crosses was comparable to that of the pure breeds, but significantly ($p<0.001$) better than the *Angete Melata* strain as shown in figure 4. The pattern of feed intake in the experimental group increased with age up to 50 weeks of age and declined slightly thereafter, while it increased consistently in the control group. On the other hand, feed efficiency increased constantly with age at both ambient temperatures.

Data for egg production, egg weight, daily egg mass output, feed efficiency, sexual maturity and body weight obtained at high temperature for F_1 crosses were compared to data with local Na hens (Table 6), In general, the performance of local Na strain significantly improved as a result of crossing with pure layer breeds. Accordingly, percentage hen-day egg production and egg weight were significantly higher for Na × LW and Na × NH crosses compared to Na strain (39.3%; 41.4g). The individual daily egg mass output showed similar pattern and improved by 113% and 91.4% for Na × LW and Na × NH, respectively, compared to Na hens. Age at sexual maturity was shorter by 7.2% and 4.2% for Na × LW and Na × NH, respectively. On the other hand, local Na hens consumed over 30% more feed than F_1 crosses and proved to be very poor feed converters.

As far as the performance efficiency for both F_1 crosses under heat stress conditions is concerned, the Na × LW cross was found to be significantly better in most performance parameters than Na × NH as shown in table 7. The Na × LW cross was superior to Na × NH for egg fertility, hatchability and daily egg mass output by 10, 18 and 11%, respectively. Moreover, egg weight and body weight at sexual maturity were significantly higher for Na × LW compared to Na × NH. Among the genotypes exposed to heat stress, the LW breed had a higher mortality rate of 11.1 and 16.7% before and after sexual maturity, respectively. During the laying period, no losses were observed for Na × LW crossbreed combination at high environmental temperature.

Discussion

The F_1 crosses between Ethiopian local chicken strains and White Leghorn raised at tropical environment reached their sexual maturity at 167 days (Mekonnen, 1998), which was comparatively longer by 13 and 8 days for Na × LW (154 d) and Na × NH (159 d), respectively. According to the same author, age at first egg of F_1 crosses was not significantly different from that of the White Leghorn.

On the other hand, the average depression in body weight due to prolonged heat exposure at adult stage was low (5.6%) compared to that at sexual maturity (9.4%), which is in agreement with the reports of Renden and McDaniel (1984) and Proudfoot and Hulan (1987). This might partly be explained that hens at the stage of sexual maturity not being fully adapted to the heat stress, while the tolerance has been improved with age resulting in a slight reduction of body weight at adult stage. The most interesting result in this experiment is that long-term heat stress did not depress the body weight of Na × LW crossbreed combination; instead, there was an increase of 1.7 and 2.9% at sexual maturity and adult stage, respectively, suggesting a gradual adaptation to prolonged heat exposure with age for this particular trait. This could be explained by the small body size of the Na × LW cross contributed by the genetic background of their LW parents, which accounts for better heat tolerance. This finding is supported by Squibb and Wogen (1960), who reported that light bodied breeds are affected less by heat stress. Moreover, the body weight of F_1 crosses in warm temperature was larger than Na, but comparable to the average of pure breed lines, which is in accordance with previous findings by Nwosu (1992).

In this data, a great diversity among the effects of the environments is evident by drastic depressions due to constant heat exposure in all investigated productivity traits confirming the findings of Pech-Waffenschmidt (1992) and Da Cruz-Lopes (1999). The average depression in egg production was 2.7 and 8.1% for F_1 crosses and pure breeds, respectively. This indicates that the F_1 crosses have showed better performance without being severely affected by long-term heat stress suggesting their suitability for egg production in hot climates. This is certainly due to the presence of the Na gene in the F_1 crosses, which is associated with reduced feathering of the Na allele that eased the heat-induced suppression of performance traits.

The significant reduction in egg weight due to prolonged heat stress is in agreement with Vo *et al.* (1980), Sauveur and Picard, (1987), Balnave and Muheereza (1997). All of these investigators compared 21°C with either 29, 31or 35°C and found a considerable depression in egg weight in various chicken lines. Eggs of Na × LW and Na × NH were 25.1 and 16.9% heavier than eggs laid by Na hens, which agrees with Nwosu (1992), who reported an increase of 14.9% in egg weight for F_1 crosses over local chickens. In an experiment conducted in Ethiopia, Mekonnen (1998) reported that the performance of local birds was significantly inferior to that of the White Leghorn and its crosses with local chicken. In the results of this study, the egg production of the local Na hens under heat stress conditions was comparatively lower than reported by Teketel (1986), but comparable to that reported for indigenous birds in Nigeria (Nwosu, 1979, as cited by Horst, 1989). Nevertheless, the egg production of F_1 crosses at high temperature in this study was higher than reported by Brannang and Persson (1990) and Mekonnen (1998) under a tropical environment in Ethiopia

The depression in egg production due to heat stress at the peak phase for F_1 crosses and pure breeds was 5.4 and 6.9%, respectively. The corresponding figure at the end of the experiment was 1.6 and 7.3% for F_1 crosses and pure breeds, respectively, which indicates that the F_1 crosses were very much less susceptible to constant heat stress with increasing age suggesting improved adaptability over time. This tendency was supported by the performance of the local Na, whose egg production rate was significantly depressed at peak (7.4%) but slightly (1.3%) at the end of the experiment.

Minimum voluntary feed intake and poorest performance were obtained with birds kept at long-term hot temperature (Kyarisima and Balnave, 1996). Moreover, reduced feed consumption along with depressed body weight at high temperatures was reported by De Andrade *et al*. (1977) and Balnave (1996). A progressive decline in body weight and feed intake was observed as the ambient temperature increased from 18 to 35°C (Yahav *et al.,* 1996a). In this study, the average feed intake for both pure NH and LW was significantly depressed by 21.7%, which is comparable to earlier findings by De Andrade *et al*. (1977), who reported a decline of 26.5% at 31°C in White Leghorns. Moreover, Kabo (1986) found a reduction of feed intake by 18.5% in young hens maintained at 32°C. In another experiment conducted on medium heavy hybrids, Chima (1975) found a reduction of 28% in feed intake at 34°C. The feed intake for F_1 crosses in this study depressed by 16.3%, which is comparatively lower than pure lines (21.7%).

Conclusion

The results of this study reveals that the F_1 crosses were by far better in all performance traits over the native *Angete-Melata* chickens and comparable to both exotic pure breeds under prolonged heat stress conditions. The Na × LW cross have particularly proved to be the best crossbreed combination for better performance at high temperature. The present findings suggest that the F_1-crosses could be preferred over local Na for improved egg production in hot regions. The crossbreeding approach should be, however, supported by selection of highly productive local Na birds for a better result. Moreover, the performance of F_1 crosses should further be evaluated under tropical environmental conditions. On the other hand, the LW breed at high temperature was found to be much better in most performance traits than NH and could, thus, be recommended for crossbreeding purposes to upgrade the low performance of native chickens under hot climates.

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Table 1. Genetic structure and size of the experimental and control chicken genotypes

Ambient temperatures	**F_1 crosses**		**Local Na and pure lines**		
	Na × LW	**Na × NH**	**Na**	**LW**	**NH**
Normal (Control group, 18-20 °C)	24	24	24	24	24
High (Experimental group, 30-32 °C)	24	24	24	24	24
Total	48	48	48	48	48

Table 2. Egg fertility and hatchability for local Na, pure breed chicks and their F_1 crosses (in %)

Traits	**Na**	**LW**	**NH**	**Na × LW**	**Na × NH**
Egg fertility	86.6	97.5	96.6	97.0	88.2
Hatchability of total eggs set	70.7	89.9	92.3	74.4	60.0
Hatchability of fertile eggs	81.7	92.2	95.6	79.9	68.0

Table 3. Effect of elevated environmental temperature on body weight and survival of local Na, exotic chicken breeds and their F_1 crosses (mean ± s.d.)

Body weight	**Temp.**	**Na**	**LW**	**NH**	**Na × LW**	**Na × NH**
At 20 weeks of age (g)	N	$952^{aE} \pm 124$	$1353^{aB} \pm 126$	$1574^{aA} \pm 166$	$1169^{aD} \pm 150$	$1259^{aC} \pm 136$
	H	$818^{bD} \pm 156$	$1248^{bB} \pm 143$	$1360^{bA} \pm 130$	$1189^{aB} \pm 95$	$1101^{bC} \pm 140$
At 68 weeks of age (g)	N	$1273^{aD} \pm 214$	$1594^{aBC} \pm 193$	$2031^{aA} \pm 200$	$1581^{aC} \pm 245$	$1719^{aB} \pm 257$
	H	$1230^{aB} \pm 206$	$1548^{aA} \pm 279$	$1694^{bA} \pm 304$	$1626^{aA} \pm 224$	$1643^{aA} \pm 281$
Mortality rate (%)	N	None	8.3	None	None	None
	H	4.2	16.7	4.2	None	4.2

$^{A-E}$ Means between genotypes within a row with different superscript differ significantly ($p<0.05$)

^{a,b} Means between temperatures within each genotype and body weight category with different superscripts differ significantly ($p<0.05$)

Temp.= Temperature N= Normal temperature H = High temperature

Table 4. Effect of high environmental temperature on total egg number, laying rate, egg weight and daily egg mass output of Na, pure breeds and their F_1 crosses (mean ± s.d.)

Performance traits	Temp.	Na	LW	NH	Na × LW	Na × NH
Hen-day Production (%)	N	39.2^{aD}±10.3	87.8^{aA}±15.4	73.5^{aB}±11.6	67.2^{aC}±11.2	67.6^{aC}±9.38
	H	39.3^{aC}±10.0	83.0^{bA}±14.4	65.6^{bB}±11.4	66.9^{aB}±10.5	64.3^{aB}±7.74
Hen-housed Production (%)	N	39.2^{aD}±10.2	85.3^{aA}±11.6	70.5^{aB}±11.6	66.8^{aC}±11.1	67.6^{aC}±9.41
	H	38.4^{aC}±10.7	76.1^{bA}±13.1	63.6^{bB}±14.9	66.9^{aB}±10.5	63.0^{aB}±9.82
Egg weight (g)	N	44.7^{aE}±4.98	62.6^{aA}±4.53	64.0^{aB}±5.87	54.9^{aC}±5.04	53.5^{aD}±4.92
	H	41.4^{bD}±4.17	55.7^{bA}±6.13	54.4^{bA}±5.67	51.8^{bB}±5.29	48.4^{bC}±5.45
Daily egg mass Output (g)	N	17.5^{aD}±5.18	54.9^{aA}±10.6	47.1^{aB}±7.98	36.8^{aC}±6.22	36.0^{aC}±4.90
	H	16.2^{aD}±4.42	46.3^{bA}±9.7	35.7^{bB}±9.19	34.5^{aB}±5.66	31.0^{bC}±4.86

$^{A\text{-}E}$ Means between genotypes within a row with different superscripts differ significantly (p<0.05)

^{a,b} Means between temperatures within each genotype and trait with different superscripts differ significantly (p<0.05)

Temp.= Temperature N= Normal temperature H= High temperature

Table 5. Voluntary feed intake and feed efficiency as affected by prolonged high temperature in local Na, exotic pure breeds and their F_1 crosses (mean ± s.d.)

Parameter	Temp.	Na	LW	NH	Na × LW	Na × NH
Feed intake (g/hen/d)	N	77.0^{aC}±4.94	121^{aA}±7.66	116^{aA}±6.09	101^{aB}±5.05	105^{aB}±5.12
	H	63.3^{bC}±3.60	98.8^{bA}±8.11	89.7^{bB}±5.09	88.8^{bB}±5.41	87.3^{bB}±6.28
Feed efficiency (kg/kg egg mass)	N	5.29^{aA}±1.22	2.28^{aC}±0.30	2.49^{aBC}±0.23	2.94^{aB}±0.56	2.89^{aB}±0.31
	H	5.00^{Aa}±2.13	2.23^{aD}±0.25	2.44^{aDC}±0.26	2.80^{aBC}±0.41	2.88^{aB}±0.31

$^{A\text{-}E}$ Means between genotypes within a row with different superscript differ significantly (p<0.05)

^{a,b} Means between temperatures within each genotype and parameters with different superscript differ significantly (p<0.05)

Temp.= Temperature N= Normal temperature H= High temperature

Table 6. Comparison of major performance traits between local Na and their F_1 crosses with exotic breeds under high environmental temperature (Change to Na, %)

Performance traits	Na	Na × LW	Na × NH
Egg production (% hen-day)	44.9^{b}	68.3 (+52.1)^{a}	65.5 (+45.9)^{a}
Egg weight (g)	41.4^{c}	51.8 (+25.1)^{a}	48.4 (+16.9)^{b}
Egg mass (g/hen-day)	19.3^{c}	36.1 (+87.0)^{a}	32.0 (+65.8)^{b}
Feed efficiency (kg/kg egg mass)	5.00^{b}	2.80 (-44.0)^{a}	2.88 (+-42.2)^{a}
Age at first egg (d)	166^{a}	154 (-07.2)^{c}	159 (-04.2)^{b}
Body weight at 20th weeks of age (g)	818^{c}	1189 (+45.4)^{a}	1102 (+34.7)^{b}
Body weight at 68th weeks of age (g)	1230^{b}	1626 (+32.2)^{a}	1643 (+33.6)^{a}

$^{a\text{-}c}$ Means within a row with different superscript differ significantly (p≤0.05)

Table 7. Performance comparison between Na x LW and Na x NH crossbreed combinations under high environmental temperature

Performance traits	**Na × LW**	**Na × NH**	**Difference to Na × NH (%)**
Egg fertility (%)	97.0[a]	88.2[b]	10.0
Hatchability (%)	80.0[a]	68.0[b]	17.6
Age at first egg (d)	154[a]	159[b]	-3.1
Body weight at sexual maturity (g)	1189[a]	1102[b]	7.9
Egg weight (g)	51.8[a]	48.4[b]	7.0
Egg mass (g/hen/d)	34.5[a]	31.0[b]	11.3

[a,b] Means within a row with different superscript differ significantly (p<0.05).

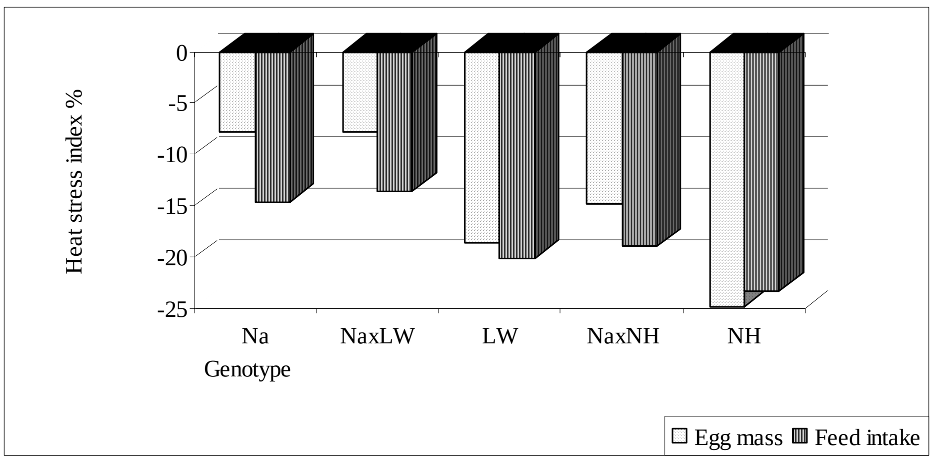

Figure 1. The magnitude of long-term heat stress effect on egg mass and feed intake of all genotypes as measured by heat stress index

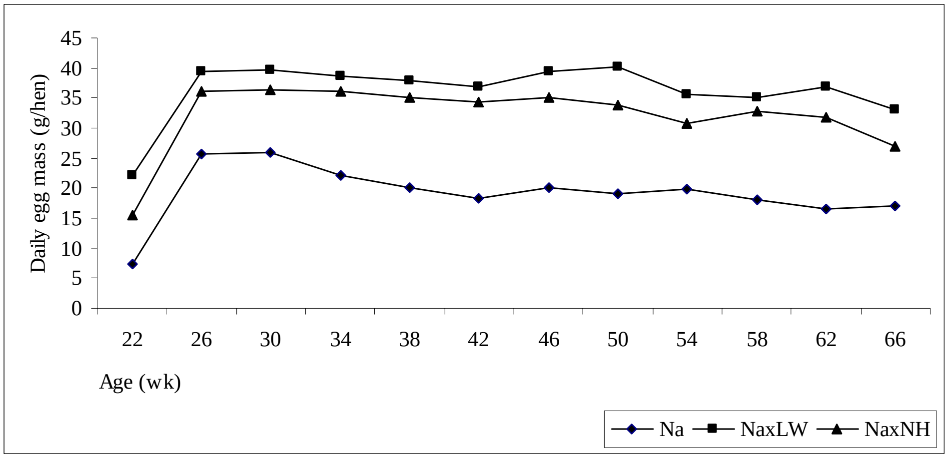

Figure 2. Trend of daily egg mass production for *Angete-Melata* and F_1 crosses in relation to age under heat stress conditions

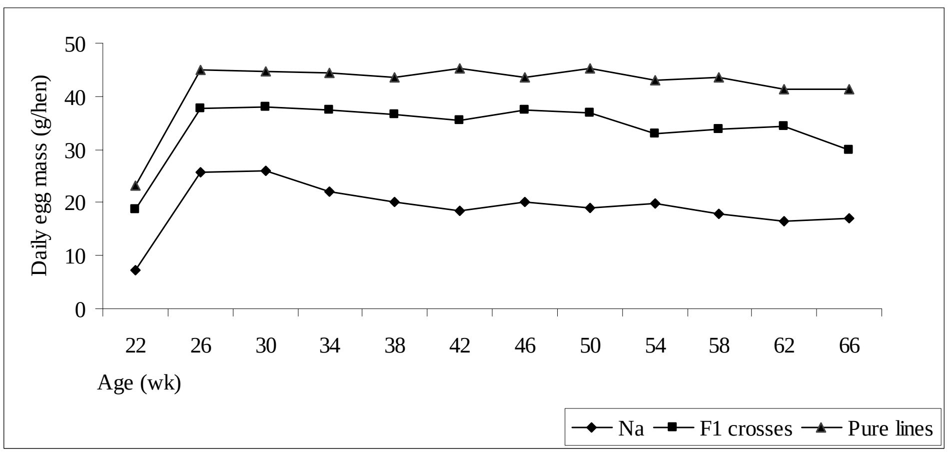

Figure 3. Tendency of daily egg mass production with age for local Na, F_1 crosses and pure breeds under high environmental temperature

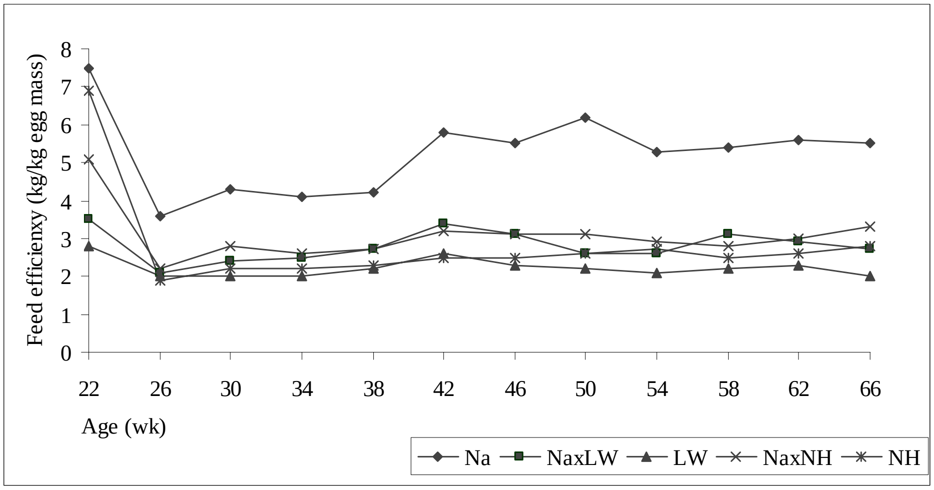

Figure 4. Comparison of feed efficiency between local *Angete Melata*, pure breeds and their F_1 crosses maintained at high environmental temperature

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Characterization and Classification of Potential Poultry Feeds in Ethiopia Using Cluster Analyses

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Abstract

The purpose of this work is to characterize and classify locally available poultry feeds, currently in use or potentially relevant but so far unutilized, based on literature data and to provide poultry farmers and local feed manufacturers with alternatives of feed stuffs that can potentially substitute each other.

The feeds were originally categorized according to the conventional classification scheme of the NRC. The feed stuffs under each general category were clustered into similar groups based on the nutrients more commonly considered in poultry feed formulations. Metabolizable energy, crude protein and fiber, and lysine, methionine and tryptophan were selected to characterize the crude nutrients and critical amino acid contents, respectively. Agglomerative Clustering of feeds (observations) was performed to classify the feeds into separate groups (clusters). Hierarchical Cluster Analysis of Observations was employed using a Squared Euclidean Distance matrix and a Complete Linkage method.

In the first category, eight cereal grains and five tubers clustered into seven groups: barley, finger millet, oats and carrot in cluster 1 and maize, sorghum and wheat in cluster 2 making the largest group. The cereal grain processing by-products clustered into four groups at 90% level of similarity, the first two clusters containing 75% of the observations. In the other category, close to 50% of the pulse grains formed a homogenous group at about 80% level of similarity. Oil seed cakes clustered into five distinct classes, about 40% of which grouped together containing feeds having average level of nutrients. The by-products of animal origin produced six clusters at 81% level of similarity with most of the feeds standing separately. Meat and fishmeal have the highest levels of energy and protein and a very good assortment of critical amino acids in this category.

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In conclusion, the cluster analyses produced different groups of alternative feed stuffs with reasonably high degree of homogeneity. The anti-nutritional factors limiting utilization of some of these feed stuffs in poultry rations were also presented along with the cautions needed.

Key words: Cluster analysis, grains, food processing by products, nutrient contents

Introduction

The contribution of intensive commercial poultry industry to the supply of poultry meat and egg in Ethiopia has been very small. The contribution of this sector doesn't exceed 2-3% of the total out put estimated at about 79,120 MT eggs and 76,560 MT of chicken meat produced annually (Alemu Yami, 1995), though there is a trend of expansion. Its staggering progress is attributed to a range of factors including arrays of policy issues, socioeconomic limitations and technical constraints. One of the most frequently cited and the foremost challenge facing the sector is inadequate supply and poor quality of poultry feeds and lack of systematically documented information in the value of the available feed resource base. The significance of feed availability and quality and information on alternative feed sources in poultry production can not be overemphasized since, especially under commercial systems, feed is the principal determinant of the economics of production.

Feeding alternatives should be explored adequately in countries like Ethiopia where poultry compete with an increasing human population for the limited food/feed resources available. Although the country has a diverse range of agro-ecologies enabling production of varieties of crops offering wide options of resources for poultry feeding, their utilization is still limited. So far most of the feed processing plants and poultry farmers in Ethiopia depend on very few and similar feed ingredients in formulating rations for different classes of chicken. Crops currently less popular locally are also included in the analyses taking into account the current, changing scenario in crop production in different parts of the country. In this respect, there is a growing prospect related to the emerging investments in the production of introduced species/varieties of crops that are relatively new in the existing production environment. Systematic presentation of available information on the quality of local feed stuffs would enable optimum and efficient use of these resources in the rapidly developing poultry industry.

Reasonably large quantity of information is available on the nutrient contents of major feed stuffs, currently in use or potentially relevant to poultry feeding in Ethiopia. A large portion of the data used to cluster the feed stuffs was drawn from local sources (Evaldson, 1970; Beyene Chichaibelu *et al.*, 1977; Alemu Yami, 1981; Seyoum Bediye and Zinash Sileshi, 1989; Alemu Yami and Guenther, 1992). Reference was also made to nutrient compositions of tropical feeds practically relevant to poultry feeding in Ethiopia (Oyenuga, 1959; Göhl, 1981; Close and Menke, 1986; SLU, 1986, Leeson and John, 2001) to complement the available information.

The purpose of this paper is to characterize and classify the major feed stuffs grown in most parts of Ethiopia that are relevant for poultry feeding in to different groups based on literature data of their nutrient contents. The outputs would enable poultry farmers and feed manufacturing/processing industries to look for suitable substitutes of individual feeds during formulation of different rations, and identify appropriate combinations for optimum quality and cost. Such information is also expected to give users the opportunity to take advantage of the seasonal abundance of certain feeds in times of scarcity of the others. Feeds with promising potential, such as tubers, that have currently very little or no role as poultry feed in Ethiopia, were considered in the analyses to encourage use of these resources in the future.

Methodology

The feed items were originally grouped according to the conventional classification scheme of the NRC (NRC, 1984) and analyzed based on the nutrients commonly considered in poultry feed formulations. Data on feed composition were collected from local sources complemented by information from nutrient composition tables of tropical feeds. Metabolizable energy (ME), crude protein (CP) and crude fiber (CF) were selected to reflect the crude nutrient contents of the feeds and lysine, methionine and tryptophan were considered to reflect the amino acids critical in poultry nutrition (McDonald *et al.*, 1995; Kellems and Church, 1998; Leeson and John, 2001).

Clustering methods were selected after repeated examination of cluster outputs of data subjected to different methods (Minitab Inc., 1996). Agglomerative clustering of feeds (observations) was performed by joining two clusters at each amalgamation step to classify the feeds into separate groups (clusters). Hierarchical Cluster Analysis of Observations was employed using a Squared Euclidean Distance matrix. A Complete Linkage method, where the distance between two clusters is defined as the maximum distance between a variable in one cluster and a variable in the other cluster, was applied (Minitab, 1996). Variables were standardized before processing the data. Similarity levels were reported under each cluster analysis. Dendrograms of observations were not presented in order to reduce the size of the paper.

Results

Cluster analyses of energy source feeds

Cereal grains and tubers. Table 1 presents the composition and cluster groups of eight cereal grains and five tubers. The feeds were grouped into 7 clusters at 85% level of similarity. Observations in each cluster displayed very little variability. Clusters 1 and 2 contained 62% of the feeds high in critical amino acid and ME contents. All the cereal grains and tubers considered have comparable levels of CP (8.0-12.7%) except cassava (3.9% CP, cluster 4) and sweet potato tubers (5.3% CP, cluster 6). Oats whole seed (cluster 3) and all the tubers (clusters 4,5,6, and 7) except carrot clustered into separate groups with considerable level of variability in all measurements compared to clusters 1 and 2, and each other. Oats whole seed is the lowest in ME (2380 kcal/kg) but contains the highest level of CF (13%) (Table 1)

Cereal grain processing by-products. Eight feeds of cereal grain processing by-products were considered for clustering in this category. Four clusters were identified at about 90% level of similarity. Except rice polishings (cluster 3) and brewer's dried yeast (cluster 4), all the by-products belonged to either cluster 1 or 2 (Table 2). Feeds in cluster 1 are high in CP and CF, but low in ME. Feeds in cluster 2 are characterized by moderate levels of ME, CP and CF (except rice bran, which is high in CF). Rice polishings is especially characterized by its rich assortment of the amino acids lysine, methionine and tryptophan. Brewer's dried yeast (cluster 4) is a unique item, least fibrous and exceptionally rich in ME, CP and lysine compared to all the rest in the category.

Cluster analyses of protein source feeds

Pulse grains and oil seeds. The most common types of pulse grains and oilseeds available in Ethiopia considered in this category. The feeds were clustered into 4 groups at 80% level of similarity. Cluster 1 includes 50% of the feeds containing high levels of CP and ME next to Soya bean. Soya bean, clustered separately (cluster 3), is the best in all measurements with a very good assortment of critical amino acids. Pea (cluster 2) is exceptionally high in lysine. Sunflower and pigeon pea (cluster 4) contain moderate levels of amino acids and low levels of CP relative to the other groups. Sunflower seed has the most fibrous in the category (Table 3).

Oilseed cakes. Five groups were identified at 84% level of similarity for 10 types of oilseed cakes common in Ethiopia. The nutrient composition and cluster classes were presented in Table 4. Feeds in this category have comparable levels of ME. Cottonseed and Soya bean cakes were grouped under cluster 1 with high levels of CP and critical amino acids. About 40% of the oil seed cakes were grouped in to cluster 2 containing moderate levels of CP, CF and amino acids. Peanut and safflower cakes were clustered separately, high CP content and very low levels of methionine and tryptophan, and the lowest levels of ME and CP and very high CF content characterizing each, respectively. Noug seed cake, cluster 3, is also high in CF but relatively lower in protein content compared to the rest in the category.

By-products of animal origin. Feeds in this category clustered into six classes at 81% level of similarity (Table 5). Crude fiber was excluded from the analysis since it was not a relevant measure of quality in feeds of animal origin.

Although cluster 1, consisting of blood meal and poultry offal meal, shares similar features in most measurements, very high level of CP and ME characterize each feed, respectively. Meat meal and fishmeal (cluster 4) contain the best levels and assortments of nutrients compared to all the rest in the category. Raw and steamed bone meal, both very low in ME and CP, and hydrolyzed feather meal, each formed separate groups with different features. Hydrolyzed feather meal (cluster 6) is comparable to blood meal (cluster 1) in ME and CP contents.

Table 1. Cluster groups of cereal grains and tubers based on metabolizable energy, crude protein and crude fiber (on DM basis), and lysine, methionine and tryptophan (as % protein, on DM basis)

Cluster	Feed	N	Energy (k cal/kg)	Crude Protein (%)	Crude Fiber (%)	Lysine (% protein)	Methionine (% protein)	Tryptophan (% protein)
1	Barley (*Hordeum vulgare)* seed, dehulled	5	3284	9.8	5.3	3.3	1.3	1.5
1	Finger millet (*Eleusine* spp.) whole seed	4	3002	11.0	6.3	3.0	1.3	1.2
1	Oats (*Avena sativa*, dehulled) seed	4	3107	11.8	7.0	3.8	1.5	1.4
1	Carrot (*Daucus carota*) tuber	3	2870	12.7	10.4	3.2	1.2	1.9
2	Maize (*Zea mays*) white seed	6	3679	10.8	2.0	3.0	1.1	0.6
2	Maize (*Zea mays)* yellow seed	6	3654	12.0	2.0	2.4	0.6	0.6
2	Sorghum (*Sorghum vulgare*) seed	6	3800	11.9	1.9	2.9	0.4	1.0
2	Wheat (*Triticum aestivum*) seed	6	3416	12.7	3.0	2.6	1.3	1.1
3	Oats (*Avena sativa*) whole seed	5	2380	11.3	13.0	2.7	1.1	0.9
4	Cassava (*Manihot esculenta)*	2	3510	3.9	4.9	6.2	0.6	0.5
5	Potato (*Solanum tuber.*) tuber, fresh	2	3730	11.0	2.9	5.6	0.0	2.0
6	Sweet potato (*Ipomoea batatas)* tuber	2	3100	5.3	0.2	4.1	1.1	1.8
7	Yam, trifoliate (*Dioscorea* spp) tuber.	2	2900	8.0	3.5	3.5	0.9	0.0

Table 2. Cluster groups of cereal grain processing by-products based on metabolizable energy, crude protein and crude fiber (on DM basis), and lysine, methionine and tryptophan (as % protein, on DM basis)

Cluster	Feed	N	Energy (k cal/kg)	Crude Protein (%)	Crude Fiber (%)	Lysine (% protein)	Methionine (% protein)	Tryptophan (% protein)
1	Barley, Brewer's dried grain	4	1890	23.4	17.6	3.3	1.2	1.3
1	Maize, gluten feed	6	2046	26.2	13.2	2.3	2.2	0.9
1	Wheat, bran	6	1656	16.2	11.4	3.8	1.5	1.5
2	Rice bran	3	2710	11	13	4.1	1.8	1.6
2	Wheat shorts, dry milled	6	2596	18.2	6.5	4.1	1.1	0.9
2	wheat, middlings	6	2425	17.8	9.3	4.1	1.6	1.3
3	Rice polishings	3	2735	10.8	1.1	6.3	4.4	3.5
4	Barley, Brewer's dried yeast	4	3210	44.3	0.2	7	1.3	1.4

Table 3. Cluster groups of pulse grains and oil seeds based on metabolizable energy, crude protein and crude fiber (on DM basis), and lysine, methionine and tryptophan (as % protein, on DM basis)

Cluster	Feed	N	Energy (k cal/kg)	Crude Protein (%)	Crude Fiber (%)	Lysine (% protein)	Methionine (% protein)	Tryptophan (% protein)
1	Cow pea (*Vigna sinensis)*	4	2930	25.9	5.6	6.5	0.9	1.3
1	Harricot bean (*Phaseolus vulg.)*	3	2916	25.6	5.3	6.9	0.3	1.9
1	Grass pea (*Lathyrus sativa, L.)*	3	3450	24.4	7.1	9.7	0.6	0.0
1	Lentil (*Lens culinaris)*	4	3660	26.2	3.1	8.0	0.7	1.2
2	Pea (*Pissum sativum)*	3	2860	26.4	6.7	13.4	2.2	0.8
3	Soybean (*Glycine max)*	5	3815	39.0	4.3	9.4	2.1	2.1
4	Sunflower (*Helianthus annus L.)*	5	2840	19.3	21.6	3.6	1.5	0.0
4	Pigeon pea (*Cajanas cajan)*	3	2942	21.8	8.8	7.0	1.5	0.3

Table 4. Cluster groups of oil seed cakes based on metabolizable energy, crude protein and crude fiber (on DM basis), and lysine, methionine and tryptophan (as % protein, on DM basis)

Cluster	Feed	N	Energy (k cal/kg)	Crude Protein (%)	Crude Fiber (%)	Lysine (% protein)	Methionine (% protein)	Tryptophan (% protein)
1	Cottonseed (*Gosypium spp.*), cake	5	2363	51.5	8.8	4.1	1.4	1.1
1	Soybean (*Glycine max)*, toasted, cake	3	2601	51.4	6.7	5.5	1.5	1.1
2	Linseed (*Linum usitatisimum*, cake	3	2096	37.3	10.8	3.5	2.4	1.5
2	Rapeseed (*Brassica napus)*, cake	3	2666	37.5	13	3.8	1.7	1.3
2	Sesame (*Sesamium indicum)*, cake	3	2632	45.7	8.6	2.9	3.1	1.4
2	Sunflower (*Helianthus annus)*, cake	5	2156	42.9	15.1	3.5	2.2	1.4
3	Mustard (*Brassica spp.)*, cake	3	2373	38.2	8.4	4.4	1.5	0.0
3	Noug (*Guizotia abyssinica)*, cake	5	2647	32.4	21.5	3.5	2.0	0.0
4	Peanut (*Arachis hypogae),*cake	4	2895	48.5	5.4	3.6	0.4	0.0
5	Safflower (*Carthamus tinctorius),*cake	4	1870	22.8	34.9	2.7	1.5	1.2

Table 5. Cluster groups of feeds of animal origin based on metabolizable energy, crude protein and crude fiber (on DM basis), and lysine, methionine and tryptophan (as % protein, on DM basis)

Cluster	**Feed**	**N**	**Energy (k cal/kg)**	**Crude Protein (%)**	**Lysine (% protein)**	**Methionine (% protein)**	**Tryptophan (% protein)**
1	Blood meal	6	2566	92.4	8.0	1.5	1.3
1	Poultry offal meal	4	4248	64.2	5.7	1.4	1.1
2	Bone meal, raw	3	1371	39.3	4.7	0.7	0.0
3	Bone meal, steamed	4	1219	29.6	13.5	2.8	0.8
4	Meat meal	6	4000	85.0	5.2	4.3	1.0
4	Fish meal	4	3175	70.0	7.7	3.1	1.1
5	Meat and bone meal	6	2388	55.3	5.0	1.4	1.1
5	Hatchery by-product meal	4	1840	37.0	4.1	1.9	1.3
6	Hydrolysed feather meal	3	2960	91.0	4.3	1.0	0.0

Discussions

Cluster analyses of energy source feeds

Cereal grains and tubers. Cereal grains and tubers are mainly used as sources of energy in poultry feeding. Theoretically the ME contents of most of these feeds are comparable to the levels specified for different classes of chicken; ranging from 2890, for 6-12 weeks old chicks and pullets, to 3345 kcal required per kg of dry matter (DM) (on 90% DM basis) for broiler starters and finishers (NRC, 1984; McDonald *et al.*, 1995). The cereal grains maize, sorghum and wheat (cluster 2) are the best sources of ME satisfying the requirements for energy of growers and pullets as well as laying and breeding hens; followed by the cereals (barley, millet and dehulled oats in cluster 1. Feeds in the latter class meet even the higher level required by starter chicks.

All the tubers, except carrot, are sufficient to meet the specifications for broilers. The tubers, when considered on fresh basis, are extremely deficient in energy due to their high water content, which often ranged from 70-80%. Their succulent nature renders them bulky and less convenient for poultry feeding. Thus, use of tubers should essentially involve adequate drying to a moisture content of not more than 10-15% (Göhl, 1981). Generally, subjecting tubers to simple processing, such as drying, would render them to be good sources of energy complementing grains. For instance, dried sweet potato meal could constitute up to 50% of the ration of poultry (Göhl, 1981).

The cereals are fairly comparable to each other but much better than tubers in CP content. But neither of the feeds in this category could supply the quantity of CP required by any class of chickens. Cassava and sweet potato tubers are exceptionally poor in CP and thus should be used with feeds very high in CP content. The level of CF is within the desirable range for both cereals and tubers, except oat whole seed. However, dehulling substantially reduced the fiber content of oats from 13 to 7.0% improving its ME content from 2380 to 3170 kcal/kg (Table 1).

Cereal grain processing by products. Cereal grains and their processing by products could often constitute up to 90% of poultry rations (McDonald *et al.*, 1995). In a country like Ethiopia, where there is a critical shortage of grains it is rather mandatory to increase/optimize the utilization of by products of grain processing. As expected, feeds in this class generally do not meet the nutrient requirements of chickens (Leeson and John, 2001) except brewer's dried yeast, which has the most desirable qualities in all measures considered.

The ME contents of brewers' dried grain, maize gluten feed and wheat bran are potentially equivalent to 40 to 50% of the amount in maize grain. This is expected to meet between 50 to 60 % of the energy demand of chickens (NRC, 1984) the utilization of which, however, would probably be limited by their high fiber content. The CP content of these feeds is equivalent to about 40% of the proportion in soybean meal or 53% of that in noug seed meal. Hence these by-products should be used with ingredients moderate to high in energy and protein. On the other hand, feeds in cluster 2, consisting of rice bran, wheat shorts and wheat middling are quite high in energy, containing 60 to 70% of the level potentially supplied by maize. This suggests that such feeds could be included in poultry diets along with ingredients less than average in energy, adjusting the level of CF. Brewer's dried yeast is exceptionally rich in ME and CP which make it a very good source of energy and protein to compliment poor quality feeds.

On the other hand, all feed stuffs in the different clusters of this category are generally poor in their content of critical amino acids. However, brewer's dried yeast and rice polishings could supply all the critical amino acids in sufficient quantity. Rice polishings are exceptionally rich in methionine and tryptophan containing about 200% of the level required by all classes of chicken (Banerjee, 1982; Leeson and John, 2001), expressed as percent of CP.

Cluster analysis of protein source feeds

Pulse grains and oil seeds. Observations within each of the four clusters in this category displayed very low variation. Feeds in cluster 1 constituting the common pulses (cow pea, haricot bean, grasspea and lentil) are low in CF and average in CP and ME compared to the rest in the category. Fifty percent of the feeds belong to this class potentially substituting each other at 80% level of similarity. It appears that they could be used to supplement feeds low to average in ME and moderate in CP and CF. However, the role of especially grass pea in replacing others is quite limited due to its content of a toxic factor, B-aminopropionitrile, causing paralyses (Close and Menke, 1986; McDonald *et al*., 1995) (Table 6). Pea is exceptionally high in lysine and methionine but comparable in other terms to feeds in cluster 1. Sunflower seed is remarkably high in CF (>18%) and marginal in CP (<20%) and, thus, could hardly be regarded as a protein supplement as such (Kellems and Church, 1998) although pigeon pea in the cluster appears to be slightly better. Soya bean obviously bears the most remarkable qualities as poultry feed in all aspects and thus, highly recommended for use in cereal based diets to balance especially their CP and critical amino acid contents. However, it should be processed prior to inclusion into rations because the seeds contain a number of toxic, stimulatory and inhibitory factors (McDonald *et al.*, 1995; Gohl, 1981) (Table 7).

The level of lysine is sufficient to excess in all of the feeds considered except in sunflower seeds. However, only soya bean and peas could meet the requirements of all the three amino acids specified for chicken. The amino acid composition of these feeds is characterized by high lysine content similar to that of fishmeal protein. While literature on the deleterious effects caused by high levels of this amino acid are scarce, according to Sinurat and Balnave (1995), higher proportions of lysine to metabolizable energy (ME) in the ration would decrease feed intake and growth of chickens under conditions of high housing temperature (25-35 ^{o}C).

Oilseed cakes. The 10 feeds in this category clustered in to five classes with a very high level of homogeneity. The second cluster in this category contained the largest set of observations, about 40%, with highly homogenous members (Table 4). Cottonseed and soya bean cakes in the first cluster are comparatively low in CF and contain very high level of CP, equivalent to about 70% of the amount in fishmeal. The ME value of these feeds is comparable to about 60% of the proportion in maize grain. Thus, feeds in this cluster have the most desirable qualities and could be considered as suitable alternative sources of CP and ME to supplement diets poor to average in CP and moderate to high in ME. Feeds in clusters 2 and 3 have average and comparable levels of ME and CP. However, inclusion of noug cake (cluster 2) in poultry diets would be limited by its high CF content (Smith, 1990). Safflower cake (cluster 5) appears to be the least suitable to poultry feeding due to its remarkably high CF and very low ME content.

Oil seed cakes are poor in critical amino acid profiles although soybean cake is slightly better in lysine. However, the overall assortment of critical amino acids in oil seed cakes is only comparable to that of cereal grains, grain processing by-products and tubers and far worse compared to pulse grains and oil seeds. As suggested elsewhere (Close and Menke, 1986; McDonald *et* *al*., 1995), considerable variations could exist in nutrient compositions of oil seed cakes of the same feed subjected to different oil extraction and processing techniques. Pre processing treatments such as decorticating and toasting, and oil extraction methods could result in large variability in the qualities of cotton seed, rapeseed and soybean cakes.

Feeds of animal origin. The 9 feed stuffs of animal origin produced using the complete linkage method displayed the 6 cluster groups with a very little variation within each cluster. Bone meal, raw or steamed, (clusters 2 and 3) and hatchery by-products meal (cluster 5) are obviously unsatisfactory as sources of both energy and protein. This is a reasonable classification since these feeds are considered rather as sources of minerals. Meat meal and fishmeal are the best sources of ME and CP. The quality of hydrolyzed poultry feather meal, on the other hand, is largely unpredictable since it is highly dependent upon the efficiency of hydrolysis. It could replace only 5-6% of an equivalent amount of soybean meal (Göhl, 1981).

As stated in most classical text books of animal nutrition (McDonald, *et al*., 1995; Kellems and Church, 1998), over view of the foregoing analyses shows that plant proteins of all sources except probably soybean seeds (to a certain extent) are unsatisfactory as sole sources of amino acids critical to poultry. Protein sources of animal origin are, therefore, necessary ingredients to correct the discrepancies unless the rations composed entirely of plant materials are fortified by addition of synthetic amino acids.

Most of the feeds in the category contain adequate level of lysine. However, feeds grouped in to cluster 4 (table 5) containing meat meal and fish meal have the best assortment of high levels of critical amino acids. These feeds could, thus, be used to balance rations based on plant protein sources severely limiting in critical amino acids. The levels of methionine and tryptophan in most of the other feeds are not large enough to overcome the deficiencies of these amino acids in high cereal diets of poultry (McDonald *et al*., 1995).

Conclusions and Recommendations

Most of the cereal grains and their processing by products, comprising the largest proportion of poultry rations, complemented with the different plant protein sources presented in the current paper appear to meet the crude nutrient requirements of different classes of chicken. However, such combinations usually fail to supply the required levels of critical amino acids.

Optimum utilization of these rations is achieved through inclusion of protein sources of animal origin such as fishmeal.

Table 6. Major factors limiting utilization of some poultry feeds and measures to overcome them-cereal grains and tubers

Feed	Limiting factor (s)	Precautions suggested	Reference
Millet	Some varieties have tannins which reduce palatability and protein digestibility	Limiting level of inclusion	Sreenivas, 1997
Sorghum	May contain tannins reducing palatability and protein digestibility	Limiting level of inclusion Treatment with ash	Sreenivas, 1997
Oats	High fiber, low energy	Using up to 30 (growing chicks) & 50% (laying hens)	Göhl, 1981
Barley	The owns would cause digestive upsets	Remove owns before feeding	Göhl, 1981
Wheat	High gluten contents may result in accumulation of a doughy mass in the crop (of the bird), upsetting digestion	Use of wheat stored for some time reduces the risk	McDonald *et al.*, 1995
Potatoes	The alkaloid solanidine and its derivatives causing gastroenterites	Avoiding green potatoes exposed to light, Steam/cook	McDonald *et al.*, 1995
Sweet potato	Trypsin inhibitors	Restricting the levels	"
Cassava	Cyanogenic glycosides (linamarin & lotaustralin) which are hydrolyzed into the toxin hydrogen cyanide (HCN)	Boiling, grating and squeezing, grinding, pelleting Sweet varieties have lower toxicity	Daghir, 1995 Close and Menke, 1986

The user of the present cluster classifications should mainly focus on identifying the deficiencies and excesses of nutrients of each feed in the cluster group and work out the combinations giving the best assortment of nutrients meeting his/her specific needs. On the other hand, even if the feeds belonged to the same cluster group with high degree of similarity this alone does not guarantee total replacement of one feed by the other due to the presence of potential anti nutritional factors limiting inclusion in the diet. The economic implications of alternative formulations should also be assessed critically by analyzing the economic benefit of each alternative.

Finally, standardizing the definition, quality, handling and processing procedures for animal feeds used in Ethiopia is the most critical issue deserving immediate action if future developments in the poultry industry in particular and the livestock sector in general are to be realized. Feed standards and quality control procedures should be formulated and enacted nationally and the regulations adopted strictly by feed manufacturers, suppliers and users as soon as is possible.

Table 7. Major factors limiting utilization of some poultry feeds and measures to overcome them: protein source feeds

Feedstuffs	**Limiting factor (s)**	**Precautions suggested**	**Reference**
Linseed oil cake	The toxic compound HCN which combines with cytochrome oxidase leading to immediate cessation of cellular respiration & even death; Has unidentified Anti Pyridoxine Factor; High levels of mucilage which is almost indigestible by poultry	Boiling, grating and squeezing, Grinding to a powder and then pressing, pelleting Restricting inclusion, 3-5%	Daghir, 1995; Göhl, 1981; Daghir, 1995
Soybean cake	Contains a number of toxic, stimulatory and inhibitory factors (problems mainly occur if whole seeds are used)	Toasting/ heating, less risk when meals produced by the expeller method are used	Göhl, 1981 Leeson and John, 2001
Cotton seed cake	Gossypol toxicity resulting in depressed appetite, loss of weight, haemolytic effects on the erythrocytes, cardiac irregularities and death	Restrict gossypol content in diet to not more than 100 mg kg^{-1}, Treat with ferrous sulphate /in a 1:1 molar ratio	McDonald *et al.*, 1995; Göhl, 1981; Daghir, 1995
Rape seed cake, Mustard cake	Glucosinolates resulting in goiter, kidney and liver poisoning	Limiting inclusions based on results from animal trials Not recommended for starters	Göhl,1981; Daghir, 1995
Peanut meal	Easily contaminated by Aspergillus flavus which produces aflatoxin, a potent liver toxin & very active carcinogen	Quick drying, proper storage to prevent mould growth	Daghir, 1995; Göhl, 1981
Sunflower seed cake	Fast oxidation and rancidity	Using up to 10% in diets of adult birds,	McDonald *et al.*, 1995
Sesame seed cake	*High content of phytic acid rendering the P in the meal unavailable,* The hulls contain oxalates	Decortication avoids oxalate toxicities, Limiting inclusion to about 5% for adult birds	Daghir, 1995; McDonald *et al.,* 1995
Grass pea, *Lathyrus s*p.	Contains a toxic ingredient, β-aminopropionitrile, causing paralysis	Restricting inclusion	McDonald *et al.*, 1995
Meat meal/ Meat and bone meal	Could easily be infected by pathogens, e.g. salmonella bacteria; Rancidity & loss of vitamin potency	Ensuring the final sterilization by heating to 100°C for 1hour, care in storing	Kellems and Church, 1998
Fish meal	Results tainting of products when used for grown/ adult animals	Remove from the diets in the finishing stage (broiler), Use lower levels for layers	Kellems and Church, 1998
Hydrolyzed feather meal	Risk of contamination of base material with Salmonella	Strict control of processing conditions	McDonald *et al.*, 1995

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SHORT COMMUNICATION:

Grassland Development Options

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Introduction

Grassland development options are primarily linked to the status, trends and opportunities of markets for livestock and livestock product. Ethiopia's great potential for livestock development is mainly constrained by availability of good quantity and quality of feed resources. It is therefore essential to recognize and accordingly exploit appropriate feed resource development options, among which grassland development is predominant and more feasible in Ethiopia.

Depending on local conditions, grassland development could take any one or a combination of the following strategies:

- increasing quantity of feed;
- increasing quality of feed;
- improving spatial utilization of feed;
- improving seasonal supply or temporal utilization of feed, and
- Minimization of inter-year variation in forage supply.

Grassland development options are mainly governed by the need for livestock production and are essentially coordinated with efforts for livestock development. Drought management, a primary issue of the semi-arid and arid zones, is a good example of this, which could incorporate, for instance, activities for maximizing grazing distribution, sale of stock as soon as drought is foreseen, formation of efficient breeding herds with fewer unproductive animals, use of special purpose pasture, expansion of the area available for grazing, strategic sale of livestock, and use of supplementary feeds.

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Development options

Development interventions include: grazing management, reseeding, fodder crop and shrub cultivation, use of crop residues, supplementary feeding, fertilizer application, weed, pest and disease control, water resources development, use of controlled fire, bush clearing, erosion control and restriction of inappropriate concurrent uses (Alemayehu, 1998.) Common grassland development components are discussed below, and prioritized according to climatic zones in Table 1.

Workable grazing management policies for extensive grazing are difficult to formulate and implement; they have to accommodate both the intra-year seasonal patterns of forage supply and frequently high inter-year variability. Socio-economic constraints often hinder otherwise viable technical options. Management systems are generally based upon various forms of rotational or sequential grazing with inter-grazing resting.

The prerequisite of all grazing management systems is to have sustainable stocking rates over the long term; the actual form of management is secondary to this. In overgrazed areas, optimization of livestock numbers relative to the forage resources must be given priority. Any other form of development is conditional upon livestock numbers being consistent with the forage supply.

Management programmes often recommend the strategic resting of grazing land to facilitate natural seeding of the grasses, thereby enhancing longevity of the stand. Some points to consider in relation to designing grazing management programmes in perennial grasslands are (Sindelar, 1988):

- Reproduction from seed may be relatively infrequent; vegetative reproduction may be more important for the perpetuation of the grasses.
- Grazing management practices directed at facilitating seed production are less important than commonly believed.
- Long-term grassland retirement may not favour grass reproduction from seed in many environments.
- Management practices should encourage vegetative reproduction, with secondary consideration for seeding.

- To improve reproductive efficiency, practices should reduce competition from undesirable plants, improve micro-environments and promote plant vigour.

Grassland improvement options are almost always based upon the advantages of having a high proportion of perennials in the system. Despite widespread disappointing results, the low potential in drier environments for the re-establishment of perennial species is often ignored. In contrast, annuals are vigorous establishers and strong competitors for water and nutrients and therefore warrant greater attention in such environments.

Seeding by over-sowing or direct drilling provides an alternative to complete seedbed preparation where the erosion hazard is high, and the preparation of a complete seedbed is impractical or where the purpose is to modify rather than replace the present stand. Inter-seeding is a compromise between slow natural reseeding and the theoretically quicker establishment expected from complete seedbed preparation.

Intensive pasture development is an option for moist environments or where irrigation is available. It usually involves the complete replacement of native grassland species with so-called “improved” high yielding grasses and legumes. The forages may be introduced after the complete destruction of resident vegetation by cultivation then drilling or over-sowing, or by direct drilling (sod seeding) into an existing sward controlled by grazing or herbicide application. Intensively managed pastures are useful for providing strategic grazing, priority feeding of livestock classes such as young or pregnant stock, or for conservation as hay and silage. They are usually managed on some form of rotational grazing designed to optimize overall productivity by controlling grazing period and intensity, and re-growth between grazings. This option is only viable where soil fertility is high, whether naturally or with added fertilizers, and local pasture and livestock management skills are sufficient to warrant improved livestock production (Alemayehu, 2002; 2004)

Fodder crop production is often considered a key to reducing excessive grazing pressures on grasslands. This usually involves the growing of grasses or legumes to be conserved as hay or silage, and used for special purpose or strategic feeding of livestock. High quality fodder may have a significant impact on the overall livestock production. The successful development of improved forage resources is increasingly related to the provision of fodder banks or the inclusion of forage legumes in the cropping systems.

Alternatives to fodder crops include the growing of fodder shrubs and trees in special purpose stands, or along fence or boundary lines. Fodder trees and shrubs generally require careful management. In theory, they have potential in semi-arid lands; however, this is not often proven in the context of traditional livestock husbandry. The extent of adoption of the technique has been disappointing, probably because of the labour and management requirements. However, fodder trees and shrubs have a niche, especially if they are multipurpose, contributing to erosion control and fuel wood supply, in addition to fodder.

The use of coarse crop residues for winter or dry season feeding of livestock is long established and widespread. Techniques such as urea treatment, chopping and mixing with high quality forages can improve their intake and dietary quality significantly. Locally produced industrial by-products and processed feeds are often used for special purpose supplementary feeding in some dairy and fattening development areas, including fishmeal, oilseed cake and compound feeds based upon cereals.

The yield response of grassland to chemical fertilizers containing nitrogen or phosphorus is well known. However, the technique is generally considered uneconomic and therefore livestock managers are not inclined to fertilize extensive grazing. In cropping areas, if fertilizer can be afforded, it is applied to crops. Special purpose pasture may be fertilized to overcome strategic forage shortages around doing development area. For example, in some environments, nitrogen may be used to enhance end-of-season production and extend the growing season.

Large predators exert an indirect effect on use of grazing land. Their presence changes the pattern of grassland use, causing some areas to be overused while other areas are underused. They may force a shift in the class of livestock used in the area, such as a shift to cattle on an area primarily suited to sheep grazing. Local made trapping fences and man-made ditches across large tracts of grassland can be used to prevent the spread of pests, predators and diseases between areas.

Availability of drinking water on grazing lands affects levels of utilization and livestock distribution. Risks associated with the provision of watering points include overgrazing of adjacent areas and the assurance of water supply and water quality. The provision of watering sites to facilitate the expansion of grazing into areas historically ungrazed may increase livestock production in the short term, but be unsustainable in the long term.

Fire is a very old tool for manipulating grazed vegetation. It has been used to control undesirable vegetation, to prepare sites for planting and seeding, to control plant diseases, to reduce the risk of uncontrolled fire, to remove senescent coarse vegetation and allow grazing access, and to improve forage yield and palatability.

It may be necessary to restrict inappropriate concurrent uses because of their negative environmental impact and associated reduction of forage resources. Such uses include the cultivation of marginal land, fuel wood harvesting, charcoal making, and collecting medicinal plants.

Table 1. The suitability of grassland development components according to climatic zones

Development Component	**Climatic Zone**				
	Per-Humid	**Humid**	**Sub-Humid**	**Semi-Arid**	**Arid**
Grazing management	Yes	Yes	Yes	Yes	Marginal
Grassland seeding (artificial)	Yes	Yes	Yes		
Intensive pasture development	Yes	Yes	Yes		
Fodder crops	Yes	Yes	Yes	Marginal	
Crop residues	Yes	Yes	Yes	Marginal	
Supplementary feeds	Yes	Yes	Yes	Marginal	
Strategic use of fertilizer on grassland	Yes	Yes	Yes		
Weed, pest and disease control	Yes	Yes	Yes		
Water supply development		Marginal	Yes	Yes	Marginal
Use of fire		Yes	Yes	Marginal	
Restriction of inappropriate uses	Yes	Yes	Yes	Yes	Yes

Source: Alemayehu (1998, 2002, 2004).

The Way Forward

To ensure relevance and sustainability, grassland and fodder crop development options have to be identified within the context of the following key factors:

- ***Purpose of the improvement:*** The purpose of grassland improvement is to improve forage production and secure sustainability of the grassland ecosystem.
- ***Participation of local people***: Local knowledge and traditional practices and customs should be taken as the basis for identifying options for sustainable development.
- ***Degree or extent of research support***: Local studies that demonstrate the validity of a particular development technique usually specify the environmental conditions, i.e. soils, climate, plant species, physiology and ecology. Likelihood of failure of a technique increases as conditions deviate from the research-supported circumstances.
- ***Use of proven methods except on a small- scale trial basis***: Undertake large-scale projects only where practical, effective and economically viable procedures have been unequivocally demonstrated.
- ***Understanding of how and why a practice works:*** Many factors influence the success of a programme, especially the proper application of establishment and management techniques. Consideration must be given as to whether a practice conforms to current vegetation, ecosystem dynamics, economics and managerial skills.
- ***Commitment of persons involved:*** This is required at all levels of the programme, from government officials to field workers and beneficiaries.
- ***A means to measure success:*** From an economic viewpoint, cost-benefit analysis is a popular method of measuring success of a technique. However, objective assessments of plant yield, cover and condition are also required. Conservation practices may not yield economic benefits in the short to medium terms.
- ***Compatibility with ownership:*** Grassland improvements must be compatible with the types and goals of ownership. Goals may be similar on private and communally grazed lands, or goals may differ widely.
- ***Availability of local labour, materials and equipment***.
- ***Extent of changes in management practices***: These may be required for application and maintenance of the development option at maximum benefit.

- ***Expected cost-benefit ratios***: Development options that are judged to offer the greatest returns on investments should be given priority, provided they are compatible with socio-economic factors and environmental sustainability. The level of risk of failure should be weighed against the potential returns.
- ***Use of sites with greatest potential***: Where possible, locate development programmes at sites with greatest potential incremental yields and avoid those where the development activity may seriously increase the risk of accelerated erosion. Areas with shallow or infertile soil, low site potential, low rainfall or steep topography often have too low forage production potential to justify expensive treatment.

Grassland development options are inextricably linked to livestock production and are often perceived from the livestock view point. Therefore development options have to expanded and promoted through addressing the above mentioned and discussed development interventions.

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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.

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

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

Frequency of publication
Once a year (May)

Guidelines to Authors

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

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

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

Format for Manuscripts

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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).

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