Ethiopian Journal of Animal Production

Volume: 6 Number: 2 2006 ISSN: 1607-3835

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

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

EJAP is published by the Ethiopian Society of Animal Production (ESAP)

This issue is sponsored by the Ethiopian Science and Technology Commission

EJAP
ISSN: 1607-3835
Volume 6, Number 2
2006

Cover page by Wossene Abay

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Eth. J. Anim. Prod. 6(2) - 2006: 1-16

Study on Age at First Calving, Calving Interval and Breeding Efficiency of *Bos taurus*, *Bos indicus* and their Crosses in the Highlands of Ethiopia

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Abstract

Data collected from 1968 to 1999 on age at first calving, calving interval and breeding efficiency from Asella, Debre Zeit and Holetta were used for this study. The breed group included in the study were Holestin Friesian, crossbred of Holstein Friesian and Jersey with local breeds (Arsi, Boran, and Barca). The effect of year, season, herd, parity and genetic group and partitioning of the later into additive and non-additive effects were analysed. Results indicate that the effect of breed, herd and season of birth significantly (P<0.05) affected age at first calving. For calving interval, all factors except season were significant (P<0.05). Mean age at first calving was significantly (P<0.05) shortest (32.22 months) for F_3 (½ J × ½ L) and longest (55.44 months) for (¼ HF × ¾ L) crosses. Mean calving interval were significantly (P<0.05) shorter (371.44 days) for (¾ J × ¼ L) and longest 516 days for 7/8 HF × 1/8 L. Breeding efficiency was significantly (P<0.05) highest (102%) for F_3 (½ J × ½ L) crosses and lowest (67%) for ¼ HF × ¾ L. Individual additive and heterosis effects on age at first calving were significant (P<0.05) and estimated at -7.9 and -11, 34 months, respectively. The individual additive, individual heterosis, maternal additive, maternal heterosis and maternal recombination were significant (P<0.01) on calving interval and estimated at 104.77, -72.38, -51.89, -62.66 and -168.25 days, respectively. Breeding decisions aiming to increase herd productivity should be determined not only by lactation milk yield but also by reproductive performance of animals under the production environment.

Keywords: reproductive performance, *Bos taurus*, *Bos indicus*, crosses, Ethiopia

Introduction

The indigenous cattle of Ethiopia are well adapted to the environment in the tropics. This is from the fact that they possess a high degree of heat tolerance and resistance to most of endemic diseases. However, their potential for milk production is poor. One way of improving tropical cattle regarding milk production is by crossbreeding with *Bos taurus* (or European type) dairy breeds. Such crossbreeding of European dairy breeds with indigenous cattle in tropical areas has been widely used as method to combine the high milk yield of exotic breeds with the adaptability of local breeds. Apart from the additive contribution of each breed to meet those requirements, there are also large non-additive heterosis effects in milk yield and reproductive traits which combine to give a large advantage in total productivity to the first generation (F_1) of these crosses (Cunningham and Syrstad, 1987). However, much of this heterosis seems to be lost in subsequent generation (Syrstad, 1989), thus wasting some of the genetic potential of such crosses. In a review of dairy cattle crossbreeding experiments in the tropics, Syrstad (1989) concluded that most of the decline in productivity from F_1 to F_2 generations was due to loss of heterozygosity, i.e. dominance effects were the most important contributor to heterosis, with perhaps a small negative effect of recombination on reproductive traits. In crossbreeding herds, improvement can be effected by two methods: (1) maximising heterosis and heterosis retention through optimal use of breed combinations and breeding systems, and (2) through utilisation of additive genetic values of the component breeds. In both methods the challenge is to separate the additive and non-additive contribution and partition of the later into within-locus (dominance) and between-locus (epistatic) contributions (Mackinnon et al., 1996). In this study data from crossbreeding experiments in herds located in the highlands of Ethiopia were used to: (1) evaluate the environmental and genetic effect on age at first calving, calving interval and breeding efficiency of crossbred dairy cows; (2) identify a breed combination which provides an optimal performance; and (3) determine breed additive and non-additive effects and their interaction with herd (environment).

Material and methods

Herd description and management

Data collected between 1968 and 1999 on age at first calving and calving interval and breeding efficiency from dairy herd at Asella, Debre Zeit and Holetta, Ethiopia were analysed. Asella station is located in a highland plateau about 275 km south east of Addis Ababa, Ethiopia. Its altitude is 2000 m.a.s.l. and received an average annual rainfall of 1300-1350 mm. Crossbreeding at Asella station was started in 1967/68 with the objective of producing F_1 heifers consisting of 1/2 *Bos indicus* and 1/2 *Bos taurus* genes. The F_1 would later be upgraded to produce animals with varying proportions of *Bos taurus* genes (CADU, 1970). Holetta Research centre is located in highland area about 50 km west of the capital, Addis Ababa town. Crossbreeding involving HF and Jersey with local Boran and Horro breeds to produce different crossbred animals ranging from 25% to 75% of both HF and Jersey has been underway for more than 40 years.

Debre Zeit Agricultural Research Centre is located at an elevation of 1900 m.a.s.l. An average annual rainfall was 851 mm with daily mean temperature varying from 9 to 27°C and an overall mean of 19.1°C. The Debre Zeit dairy herd were established during 1971. In 1972, 28 Barca heifers were bought from Eritrea and were mated to Barca bulls to generate station-born heifers. Subsequently, both parental cows and their first female offspring were assigned to (Holstein Friesian (HF) bulls to generate up graded animals of different Holstein Friesian inheritance. Breeds included in the study were as follows.

Beeed Code	Acronym
HF	Holstein Friesian
L	Local zebu breeds (Boran, Arsi and Barca),
1/4HF×3/4L	(25% Holstein Friesian ×75% Local)
F_1 (½ HF× ½ L))	(50% Holstein Friesian ×50% Local),
F_1 (½ J× ½ L)	(50% Jersey ×50% Local)
F_2 (½ HF× ½ L)	{(1/2 Holstein Friesian ×1/2 Local),×(1/2 HF×1/2 Local)}
F_2 (½ J× ½ L)	{(1/2 Jersey ×1/2 Local),×(1/2 Jersey ×1/2 Local)}
F_3 (½ HF× ½ L)	{{(1/2 Holstein Friesian ×1/2 Local),×{(1/2 Holstein Friesian ×1/2 Local)× (1/2 Holstein Friesian ×1/2 Local)}}
F_3 (½ HF× ½ L)	{(1/2 Jersey ×1/2 Local),×{(1/2 Jersey ×1/2 Local)× (1/2 Jersey ×1/2 Local)}}
5/8HF×3/8L	(62.5% Holstein Friesian ×37.5%Local)
5/8J×3/8L	(62.5% Jersey ×37.5% Local)
3/4HF×1/4L	(75% Holstein Friesian ×25% Local)
3/4J×1/4L	(75% Jersey ×25% Local)
$(3/4H{\times}F1/4L)^2$	{(75% Holstein Friesian ×25% Local)× (75% Holstein Friesian ×25% Local}
$(3/4J{\times}1/4L)^2$	{(75% Jersey ×25% Local) (75% Jersey ×25% Local)},
7/8HF×1/8L	(87.5% Holstein Friesian ×12.5%Local)
1/4HF×1/4J×1/2Local	(1/4% Holstein Friesian ×1/4% Jersey ×1/2 Local),
5/8HF×2/8J×1/8L	(5/8 Holstein Friesian ×2/8 Jersey ×1/8 Local)
5/8J×2/8HF×1/8L	(5/8 Jersey ×2/8 Holstein Friesian ×1/8 Local)

Data analysis

Least squares analysis of variance was carried out using General Linear Model (GLM) procedures of SAS (2000). Three models were used for data analysis, the first model (model 1) was used to compare among breed groups with respect to age at first calving, calving interval and breeding efficiency. The second model (model 2), multiple regression analysis was used to estimate contribution of individual and material additive genetic effects, heterosis, recombination loss and interaction of additive and heterosis with environment (herd). For comparison among breed groups (model 1) the effects included in the model were herd of cow, breed group, lactation number, season and year (season and year of birth for age at first calving and season and year of calving for calving interval and breeding efficiency). The years of calving/birth ranged from 1969 to 1999 and were grouped into 4 periods each period consisting of 8 years; Period 1 included from 1969 to 1975, period 2 from 1975 to 1982, period 3 from 1983 to 1989 and period 4 from 1990 to 1999.

For season of birth and calving, months of the year were classified into 3 seasons based on rainfall distribution; dry season from October to February, short wet season from March to May and long wet season June to September. Five Parities of dam were considered consisting of the first through fifth.

Statistical model for data analysis

Model 1 for comparison among breed groups:

$y_{ijkl} = \mu + H_n + L_i + S_j + P_k + B_l + e_{ijkl}$, where:

y_{ijkl} = Age at first calving, calving interval and breeding efficiency of an individual animal with lactation I, in season j, year groups k of breed group L and in herd n.

μ = underlying constant common to all animals

H_n = the effect due to n^{th} herd of cow (n=1…3)

L_i = the effect due to the i^{th} lactation number (i = 1...5) for calving interval and breeding efficiency

S_j = the effect due to j^{th} season (J=1...3) season of birth for age at first calving and season of calving for calving interval and breeding efficiency

P_k = the effect due to the k^{th} year group of birth/calving (k = 1...4) year group of birth for age at first calving and year group of calving for calving interval and breeding efficiency

B_l = the effect due to the l^{th} breed group (l = 1...19)

e_{ijkl} = random error effect.

Breeding efficiency is used for comparisons among breed groups with respect to their suitability / adaptability. It is a measure based on the regularity of calving and the age at which cows first calve. If an animal calves late for the first time its maintenance costs as a fraction of total costs tend to increase and its life time production tends to decrease (Kiwuwa et al., 1983). The following method was used for evaluation of breeding efficiency (BE):

BE = {(N-1)390 + 960} / (age at each calving)

Where, N-1 = the number of calving intervals with N calving; 390 = is the upper limit of desirable calving intervals (days); 960 = is the upper limit of age at first calving (days). The estimated coefficients were expressed as percentage.

Model 2 for estimation of crossbreeding parameters:

$y_{ijkl} = \mu + L_i + S_j + P_k + H_n + g^I X_1 + h^I X_2 + g^M X_3 + h^M X_4 + R^I X_5 + R^M X_6 + (g^I \times H_i) + (h_I \times H_n) + e_{ijkl}$

Where:

μ = intercept (general level of local breed)

H_n = the effect due to n^{th} herd of cow (n=1…3)

L_i = the effect due to the i^{th} lactation number (i = 1...5)

S_j = the effect due to j^{th} season of birth and calving (1...3).

P_k = the effect due to the k^{th} year group (k = 1...4)

g^I = individual genetic effect.

h^I = individual heterosis effect.

g^M = maternal additive genetic effect.

h^M = maternal heterosis effect.

R^I = individual recombination effect.

R^M = maternal recombination effect.

X_1 = proportion of genes from Holstein Friesian.

X_2 = proportion of maximum individual heterosis.

X_3 = proportion of genes from Holstein Friesian in dam.

X_4 = proportion of maximum maternal heterosis.

X_5 = proportion of maximum individual recombination effect.

X_6 = proportion of maximum maternal recombination effect.

$H_n \times G_i$= interaction of breed additive with herd

$H_n \times H_i$ = interaction of heterosis with herd

e_{ijkl} = random error

The proportions of *Bos taurus* genes, individual and maternal heterosis, individual and maternal recombination effect (x_1 to x_6) were considered as continuous variables in model 2.

Results and discussions

Year and season effects

Least square means of year group, season, herd and parity effects on age at first calving (AFC), calving interval (CI) and breeding efficiency (BE) are presented in Table 1. Year of birth had no marked effect on age at first calving. Mean calving interval increased from period one (1969 to 1975) to period three (1983 to 1989) and slightly decreased then after. This shorter calving interval during period 1 and longer one during period 3 attributed to change in management such as feed, health and reproductive management. Similar significant effect of year on calving interval was reported in crossbreeding experiment conducted at Abarnosa ranch, Ethiopia, (Ababu Dekeba 2002). Kiwuwa et al. (1983) also reported significant effect of year of calving on calving interval in crossbreeding HF and Jersey with local breeds at Asella dairy farm.

Mean breeding efficiency was significantly (P<0.05) decreased from period 1 (1969 to 1975) to period 3 (1983 to 1989). The highest breeding efficiency during period 1 was related to the better performance in age at first calving and calving interval of cows during this period. Similar significant effect of year on BE was also reported on crossbreeding HF with local Arsi breed at Asella dairy herd (Million Tadesse 1997). Kiwuwa et al. (1983) also reported significant year effect on breeding efficiency in crossbreeding HF and Jersey with local breeds.

Season effect was significant (P<0.05) for age at first calving but not for calving interval and breeding efficiency. Heifers born during long wet season calved at younger age (41.4 months) and calving interval was slightly shorter for cows calved during this period. In contrast, Melaku Negash (1994) did not find any effect of birth season on age at first calving in HF dairy herd at Holetta. Likewise, Hirooka and Bhutyan (1995) did not find any effect of season of birth on age at first calving in HF and local crosses. The better age at first calving during long wet season could be related to availability of green feed during the mating period and its positive effect to cyclicity in the breeding cows. The non-significant season of calving on calving interval in the present study indicated that the similarity in management across seasons. This finding is in agreement with report by Hirooka and Bhutyan (1995). Singh and Rout (1980), Mekonnen and Goshu (1987), Sharma *et al*. (1988) and Enyew (1992) didn't find difference between seasons of calving on calving interval on the study of different indigenous breeds. On the other hand, significant effect of season was observed by Mekonnen and Goshu (1987) and Alemu et al. (1988) on Boran cattle at Abarnosa ranch and Asheber Sewalem (1992) and Addisu Bitew (1999) on Fogera cattle. These different results on calving interval attributed to different in feeding and breeding management provided to the animal.

Table 1. Least square means on age at first calving (AFC), calving interval (CI) and breeding efficiency (be) for year, season, herd and parity effects

Year group	AFC (months)			No	CI (Days)		BE (%)	
	No	Mean	S.e		Mean	S.e	Mean	S.e
1969-1975	25	40.61a	2.1	49	403.6d	23.27	110a	7
1976-1982	118	43.80a	1.1	213	451.5c	14.61	88b	1
1983-1989	117	42.50a	1.2	238	476.6a	12.11	79c	1
1990-1999	182	42.67a	1.6	837	460bac	11.74	78c	1
Season								
Short wet season	141	42.3bac	1.1	324	449.7ns	11.45	87a	1
Dry season	106	43.5a	1.1	328	453.1ns	11.71	88a	1
Long wet season	195	41.3c	1.0	685	441.3ns	10.47	87a	1
Herd effect								
Asella	102	41.4b	1.4	165	448.1b	15.90	88b	2
Debre Zeit	105	37.6c	1.6	414	429.5b	13.23	96a	2
Holetta	215	48.5a	1.3	758	466.5a	15.38	81c	2
Parity								
1				409	471a	10.22	88c	1
2				339	469ba	10.85	86c	1
3				210	429d	12.75	87c	2
4				146	443cde	14.59	90b	2
5				233	428ed	14.99	92a	2

Means within a column followed by different superscripts are significantly different

Herd effect

Heifers at Debre Zeit herd were produced the first calf significantly (P<0.05) at younger age (37.38 months) followed by heifers at Asella herd (41.35 months), while heifers at Holetta herd calved significantly at older age (48.46 months). Mean calving interval was significantly (P<0.05) longer (467 days) at Holetta herd, while the difference between Asella and Debre Zeit herds was not significant. This difference in age at first calving and calving interval across herd attributed to the difference in management (feed, health and reproductive) provided to the animal. Mean breeding efficiency was significantly highest 96% at Debre Zeit herd followed by Asella (88%) and significantly (P<0.05) lowest (81%) at Holetta herd. The better breeding efficiency of cows from Debre Zeit herd is related to shorter age at first calving and calving interval.

Parity effect

Although there is no consistent trend calving interval slightly decreased from parity one to parity three and increased from parity three to parity four and decreased then after. Bhatnagar et al. (1986), Addisu Bitew (1999) and Wilson and Traore (1988) reported significant effect of parity on calving interval. The shorter calving intervals at later parities are a function of selective culling against repeat breeder cows and were as expected for a well managed herd. Similar result of shorter calving interval for parity 5 and above was reported for HF and Gir crosses (Hirooka and Bhutyan 1995). Shorter calving interval for parity six and above was also reported on crossbreeding HF with local breed at Debre Zeit (Million Tadesse 1997). Kiwuwa et al. (1983) also reported a declined calving interval from parity on to parity 4 on crossbreeding of HF and Jersey with local breeds at Arsi. Melaku Negash (1994) reported shorter calving interval for parity 6 and above on reproductive performance of HF dairy cattle herd at Holetta. The difference in breeding efficiency for parity 1, 2 and 3 were not significant and significantly (P<0.05) increased from parity 3 to 5. The better breeding efficiency for latter parities is attributed to shorter calving interval obtained for the same parities.

Breed group effect

Least square means of breed group effect on age at first calving, calving interval and breeding efficiency are presented Table 2. Mean age at first calving was significantly (P<0.05) longest 55.44± 2.7 months for 25% HF (1/4HF×3/4L) crosses and significantly shortest 32.22±3.3 months for F_3 (½J× ½ L) crosses). Mean calving interval was significantly (P<0.05) longest 516.66±21.68 days for 87.5% (7/8HF×1/8L) crosses and significantly (P<0.05) shortest 371.44 ±34.62 days for 75% Jersey (3/4J×1/4L) crosses. Mean breeding efficiency was significantly (P<0.05) highest (102%) for F_3 (½J×½L) Jersey crosses and lowest (67%) for 25% HF (1/4HF×3/4L) crosses.

Table 2. Least square means of breed group effect on age at first calving (AFC), calving interval (CI) and breeding efficiency (BE)

Breed	AFC (Months)			CI (Days)			BE (%)	
	No	Mean	S.e	No	Mean	S.e	Mean	S.e
L	5	43.77dcb	4.2	204	419.52h	11.63	84cd	2.2
HF crosses								
1/4HF×3/4L	13	55.44a	2.7	8	429.04fe	49.37	67e	3.4
F_1 (1/2HF×1/2L)	48	35.91fe	1.3	226	438.90fe	10.49	93b	3.3
F_2 (1/2HF×1/2L)	28	41.91dcb	1.8	100	494.66ba	15.45	88c	1.7
F_3 (1/2HF×1/2L)	14	45.60b	2.6	23	457.01dc	29.08	84cd	2.6
5/8HF×3/8L	45	44.36b	1.5	77	466.52dc	17.70	87c	1.8
3/4HF×1/4L	83	40.77dcb	1.2	211	479.23cb	12.92	87c	1.4
$(3/4HF×1/4L)^2$ inter se	11	45.32b	2.7	21	438.72fe	29.97	89c	2.7
7/8HF×1/8L				62	516.66a	21.68	85c	1.9
HF	8	42.59dcb	3.2	77	479.74cb	17.26	80d	2.6
Jersey crosses								
F_1 (1/2J×1/2L)	15	38.61e	2.5	92	417.02	16.35	94b	1.8
F_2 (1/2J×1/2L)	23	44.43b	2.1	83	486.09ba	17.03	89c	1.9
F_3(1/2J×1/2L)	8	32.22g	3.3	5	429.03fe	60.50	102a	4.6
5/8J×2/8L	12	39.74dcb	2.8	22	377.09j	30.07	95b	2.9
3/4J×1/4L	6	46.91b	3.8	16	371.44j	34.62	96b	3.0
$(3/4J×1/4L)^2$ *inter se*	4	34.25fe	4.6	7	440.52ed	51.19	96b	4.4
1/4HF× 1/4J×1/2L	45	43.42cb	1.8	73	447.78dc	18.56	87c	1.9
5/8HF×2/8J×1/8L	9	40.07dc	3.1	12	450.27dc	39.75	94ba	3.3
5/8J×1/4HF×1/8L	11	44.95b	2.9	18	472.91cb	32.88	86c	3.2

Means within a column followed by different superscripts are significantly different

Holstein Friesian crosses: Among Holstein Friesian crosses age at first calving significantly (P<0.05) increased by 4.86 months from F_1 (HF×L) to 75% (3/4HF×1/4L) crosses. The F_1 (½ HF× ½ L) crosses gave the first calf by 4.86 months earlier than 75% (3/4HF×1/4L) crosses. The breed group F_2 (½ HF× ½ L) crosses had significantly longer age at first calving by 6 months than F_1 (HF×L) and the breed group F_3 (½ HF× ½ L) had significantly longer age at first calving by 3.7 months than F_2 (½ HF× ½ L). Shorter age at first calving for 3/4 Exotic 1/4 Arsi crosses was reported in crossbreeding experiment at Asella station Kiwuwa et al. (1983). Rao and Tanega (1980) also reported shorter age at first calving for 1/2HF, 5/8HF and 3/4HF crosses on crossbreeding HF with Sahiwal crosses in India.

Mean calving interval significantly (P<0.05) increased by 40 days from F_1 (HF×L) to 75% (¾ HF×¼ L) and increased by 37 days from 75% (¾ HF × ¼ HF) to 87.5% (7/8 HF × 1/8 L). The F_2 (½ HF× ½ L) and F_3 (½ HF× ½ L) had significantly longer calving interval by 55.7 and 37.6 days than their parent F_1 (½ HF× ½ L) and F_2 (½ HF× ½ L) respectively. The F_1 (½ HF× ½ L) had better breeding efficiency than other breed groups. The breed group produced by inter se mating at 75% crosses (3/4HF×1/4L) had longer age at first calving, shorter calving interval and had better breeding efficiency than the 75% (3/4HF×1/4L) crosses. The relatively longer calving interval for grade HF crosses indicate problem with adaptation in tropical environmental condition. Similar longer calving interval of 525 days was reported for (7/8HF ×1/8 L) crosses in crossbreeding HF with local breed at Asella dairy farm (Kiwuwa et al., 1983). Gebeyhu Goshu (1999) also reported longer calving interval for grade dairy HF cows and Boran crosses at cheffa dairy farm, Ethiopia. The relatively longer age at first calving for F_3 (1/2 HF× ½ L) and calving interval for F_2 (½ HF×½ L) crosses can be ascribed to unfavourable parental breakdown of epistatic combinations which have been built up in the parental populations (Syrstad, 1989).

Jersey crosses: The breed group F_2 (½ J× ½ L) Jersey crosses had significantly (p <0.05) longer age at first calving (by 5.82 months) and longer calving interval (69.07 days) but had lower breeding efficiency (5%) than the F_1 (½ J× ½ L) crosses. The F_3 (½ J× ½ L) crosses produced the first calf significantly earlier (by 12.21 months) and had significantly shorter calving interval (57.06 days) than F_2 (½ J× ½ L). The F_3 (½ J× ½ L) had also better breeding efficiency by 8% than F_1 (½ J× ½ L) and by 13% than F_2 (½ J× ½ L). Similar longer calving interval was reported for F_2 crosses than F_1 in crossbred of local with exotic at Haringhata, India (Bala and nagarcenkar, 1981). Parmar et al., (1980) also reported longer calving interval for F_2 than F_1 in crossbreeding between Hariana and Jersey at Haringhata, India. The longer calving interval of inter se mated of at 75% $(3/4J×1/4L)^2$ breed group compared to their parent might be related to recombination losses (epistatic effect).

Three breed crosses: The three way crosses (5/8J×2/8HF×1/8L) had significantly (P<0.05) longer age at first calving than (5/8HF×2/8J×1/8L). The difference in age at first calving between (1/4HF×1/4J×1/2L) and (5/8J×2/8HF×1/8 L) was not significant. The difference in calving interval among three way crosses was not significant. Breeding efficiency was significantly (P<0.05) higher for (5/8HF×2/8J×1/8L) while the difference in Breeding efficiency between (5/8J×2/8HF×1/8L) and (1/4HF×1/4J ×1/2L) was not significant.

The difference in age at first calving between F_1 (½ HF× ½ L) and F_1 (½ J× ½ L) crosses was not significant, while the breed group produced by inter se mating at 50% F_3 (½ J× ½ L) and 75% (3/4J×1/4L) of Jersey inheritance had significantly (P<0.05) shorter age at first calving than the breed group produced by inter se mating of HF at similar level. In similar way the 62.5% Jersey (5/8J×3/8L) inheritance had significantly (P<0.05) shorter age at first calving than the 62.5% HF (5/8HF×1/8L) inheritance but the 75% (3/4J×1/4L) Jersey inheritance had significantly longer age at first calving than the 75% HF crosses (3/4HF×1/4L). Calving interval was shorter for Jersey crosses compared to HF crosses and in most cases breeding efficiency was also higher for Jersey crosses than HF crosses indicating the superiority of Jersey crosses over HF crosses in terms of adaptation in harsh tropical environment. Similar shorter calving interval was reported for Jersey crosses compared to HF crosses in crossbreeding of Jersey and HF with local at Asella dairy herd, Ethiopia (Kiwuwa et al., 1983).

Crossbreeding parameters

Estimates of additive and heterosis effects for individual and maternal traits are presented in Table 3. The individual breed additive and individual heterosis effect were significant (P<0.05) on age at first calving while individual additive, individual heterosis, maternal heterosis and maternal recombination effects were significant (P<0.05) for calving interval. The individual breed additive effect was estimated at -7.9 months for age at first calving and 104.77 days for calving interval. Individual heterosis effect was estimated at -11.34 months for age at first calving and -72.38 days for calving interval. The significant and large individual additive genetic effects 104.77 days obtained in this study on calving interval is lower than the 213 days reported on crossbreeding HF with Arsi breed at Asella station Ethiopia (Million Tadesse, 1997). The significant and negative estimate of 72.38 days heterosis effect on calving interval in this study is similar with negative heterosis effect of 77 days of calving interval on crossbreeding HF with Arsi breed at Asella station (Million Tadesse, 1997). Syrstad (1984) reported negative heterosis effects (-30.3 days) for calving interval on crossbreeds of *Bos taurus* × *Bos indicus* in the tropics. Mandalena (1981) reported heterosis effect of positive 37 days at dry season and 129 days (22%) in rainy season on calving intervals between Holstein × Gir crosses. The lower heterosis effect obtained in this study compared to most of literature reports might be related to difference in environments in which the animals were kept. The significant individual heterosis on age at first calving and calving interval in this study between local and exotic genes is in accordance with the theory of heterosis which predicts that the wider the genetic distance or the greater the phenotypic differences between parental breeds, the greater the heterosis expressed.

Maternal heterosis effect was estimated to be positive 2.65 months for age at first calving and negative 62.66 days for calving interval. The negative value obtained for maternal heterosis on calving interval may imply that recombination loss is involved. Hirooka & Bhutyan (1995) obtained similar negative and significant estimate of maternal heterosis on crossbreeding of local × Friesian cross at Bangladesh, while Ahlborn-Breier & Hohenbhoken (1991) did not find any significant maternal heterosis between Bos Taurus and Bos indicus crosses. The individual and maternal recombination effect was not significant on age at first calving, while maternal recombination effect was significant (*P*<0.01) for calving interval and estimated to be negative 168.25 days.

Table 3. Estimated Genetic parameters and standard error for age at first calving and calving interval

Genetic parameter	AFC (months)		CI (days)	
	Estimate	S.e	Estimate	S.e
Additive breed effect	-7.9**	3.4	104.77**	82
Individual heterosis effect	-11.34**	2.4	-72.38**	42
Maternal additive effect	NA		-51.89**	81
Maternal heterosis effect	2.65NS	2.6	-62.66**	31
Individual recombination effect	-2.17NS	6.7	260.63NS	101
Maternal recombination effect	-2.68NS	4	-168.25**	47

*** *P*<0.0001; ** *P*<0.05; NS = not significant

Interaction effect

Results on interaction of both additive and heterosis effect with herd are presented in Table 4. The difference between pure Bos Taurus and Bos indicus breed (breed additive effect) were estimated to 115.83± 84 days at Asella herd, 111.54± 91 days at Debre Zeit herd and 86.93±97 days at Holetta herd. Interaction of heterosis with herd was significant (*P*<0.05) and estimated to be negative 132 days at Asella herd, -43 days at Debre Zeit herd and -41 days at Holetta herd. The Average performance of a group of animals is determined by the genetic capacity and by the environmental conditions in which the animals are kept. The genetic and environmental components interact when genetic differences between animals are larger in one environment than in another. Both, additive and heterosis effects can vary with environmental level. Rich and Bell (1980) demonstrate experimentally in Drosophila that the percentage of heterosis can be more than twice as much in a nutritionally poor environment than under good nutrition. This large and significant difference in breed additive and heterosis effect across herd in this study is attributed to the environmental differences (differences in feeding, breeding and climate) in which the animals are kept.

Table 4. Interaction effects of additive and heterosis by herd on calving interval

Interaction	Asella	Debre Zeit	Holetta
Additive by herd	115.83±84a	111.54±91ba	86.93c±97c
Heterosis by herd	-132±55a	-43±49b	-41b±50cb

Means within a column followed by different superscripts are significantly different

Conclusions

The shorter age at first calving, calving interval and better breeding efficiency of F1 than F_2 of both HF and Jersey crosses with local breed indicate the superiority of F_1 over other crosses. The pure HF breed and grade animals had longer age at first calving, calving interval and lower breeding efficiency indicating problems with adaptability in tropical environment. In most cases the Jersey crosses had shorter age at first calving and calving interval and had better breeding efficiency than the Holstein Friesian crosses indicating the suitability of Jersey crosses in tropical environment than HF crosses. The Individual heterosis effect was more important compared to individual breed additive effect and this vary with environmental and management level as indicated by significant difference in breed additive and heterosis effect across herd. Based on breeding efficiency which combine both age at first calving and calving interval and significant and large heterosis effect the optimum breed combination is about equal proportion of exotic and local inheritance, however to maintain heterosis advantage obtained in F_1 generation back crossing F_1 female with pure exotic bull to produce 75% or alternatively mating F_1 female with 75% exotic inheritance bull to produce 62.5% exotic inheritance is the best strategy. In general, breeding decisions aiming to increase herd productivity will be determined not only by lactation milk yield but also by reproductive performance of animals and the environment at which the animal kept.

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Eth. J. Anim. Prod. 6(2) - 2006: 17-28

Development of Prediction Equations to Estimate Potential Fertility of Tropical Dairy Bulls: Obsevation in India

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Abstract

This study was conducted with the aim of developing prediction equations to estimate potential fertility of breeding bulls at an early age at Artificial Breeding Complex of the National Dairy Research Institute, Karnal, India in 2002. Data were collected on body size and testicular measurements from 12 Sahiwal and 28 Karanfries dairy bulls. Multiple regression equations were constructed to predict scrotal circumference (SC), paired testis volume (PTV), total testis weight (TTWT) and body weight (WT) from age, linear body size (chest girth and height) and testicular measurements. Results indicate that testis characteristics can be predicted from body size measurements of animals. Significant advantages of testicular measurements like SC, testis length (TL) and testis width (TW) were discovered to reasonably predict PTV and TTWT, which have direct relationship with the capacity to produce spermatozoa. SC was best predicted from heart girth (G), body weight from G and age of the animal, PTV from SC, TL and TTWT and TTWT from TL and TW. Multiple regression equations were constructed and best models were presented for each parameter. These models indicate the potential fertility of a bull, based on measurements of testis size, and this facilitate culling decisions at an early age before investing money, labor, time and space in rearing bulls.

Keywords: Bull selection, body size, testicular measurements, prediction equation

Introduction

The productive capacity and physical appearance of animal populations can be changed by selective breeding. Man improves his livestock by limiting the reproduction of inferior animals and by choosing superior animals for mating

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to produce the progeny which constitute the next generation (Banerjee, 2002). Selection for higher milk yield in indigenous cattle breeds through culling of inferior cows and selection of young bulls on dam's yield and body conformation is the origin of animal breeding (Falvey and Chantalakhana, 1999). Sire selection, on average, has a greater impact on the genetic improvement of a herd than most producers realize. Because the sire is more likely to produce a higher number of calves in his lifetime compared to a cow, and has the potential to contribute a larger portion of the genes to the herd.

The association between body measurements and testicular characteristics has long been used to predict the potential fertility performances of a bull. So it could be advantageous if such traits like testes weight and volume which have direct relationship with the capacity of that particular animal to produce spermatozoa are reasonably predicted from simple, easy and accurate live measurements of the animal. This paper presents the best selected prediction equations for estimating potential fertility tropical dairy bulls using the relation of body weight and testicular measurements of a bull.

Materials and Methods

Study area

The study was carried out at Artificial Breeding Complex, National Dairy Research Institute, Karnal, India in 2002. The farm is situated at an altitude of 250 m above sea level on 29.42° N latitude and 77.42°E longitudes. The climate of the farm is sub-tropical with atmospheric temperature varing from near freezing point (0 °C) in winter months to about 45°C in summer months. The average annual rainfall is approximately 760 mm to 960 mm which is received mostly during months of July to August. Relative humidity varies from as low as 41 % to as high as 85%.

Animals and Management

The Sahiwal, one of the best dairy breeds of Zebu cattle of Indian subcontinent, has its origin in Montgomery district of Pakistan and is distributed in farmers' herds in certain pockets of bordering districts of Punjab and Rajasthan in India. It is available at organized farms in North, North Western and Central India. The importance of this breed is evident from the fact that Sahiwal animals have been imported by countries, like Kenya, Tanzania, Australia, West Indies and Bangladesh. The breed has been imported by these countries either for crossbreeding with their local breeds or for incorporating some Zebu genes in crossbred animals for developing synthetic strains, like, Jamaica Hope, Australian milking zebu and Australian Friesian Sahiwal besides Mpwapwa and Pabna crosses. Karan Fries is a cross of Sahiwal and Holstein-Friesian (HS) available at NDRI.

Loose housing system was being followed, and bulls were kept in open paddocks with roof over mangers. This system provides adequate exercise for animals, which are exposed to all types of climate. *Adlib* feeding of good quality green fodder throughout the year is provided along with silage during the lean period. In order to ensure good health of bulls, prophylactic and sanitary measures are taken for all the bulls.

Body Size Measurement

During the experimental period, the body size (height and girth) measurements were monitored fortnightly. Body weight was taken on platform type, computerized weight management system, balance in the morning (from 07:00 – 09:00 hours) before feeding. Girth and height at withers were measured with flexible cloth tape in centimeters.

Testicular Size Measurements

The following testicular measurements of all the bulls were taken fortnightly. i) Scrotal circumference, SC, ii) Testis length (Right and Left), TL, iii) Testicular width, TW, iv) Testis thickness (Right and Left), TT, v) Scrotal Skin thickness, SST and vi) Paired Testicular Volume, PTV.

The bulls were restrained well with the help of bull attendants in a crate and the readings were taken at standing position. The testicular length, width and thickness were measured within scrotum by bringing the testicles on one side at bottom. The scrotal skin thickness was subtracted from the testis length, testis width and testis thickness to get actual testis length, testis width and testis thickness, respectively.

Scrotal Circumference (SC): The scrotal content was palpated to ensure normal position. Then the testes were pulled into the bottom of the scrotum gently and evenly so that the testicles were side by side and scrotal skin was devoid of any wrinkles. Then the area of greatest circumference was measured with flexible plastic plated cloth tape in centimeter (Coulter et al., 1987).

Testicular Length (TL): The *in situ* proximal-distal length of left and right testicles was measured (Podany, 1964), by Electronic Digital Caliper in centimeter. Both testicular measurements were averaged. Care was taken to exclude the epididymides in measuring the length.

Testicular Width (TW): The medial-lateral width of left and right testicles was measured *in situ* with Electronic Digital Caliper in centimeter (Fields et al., 1979), on both testes at the point of maximum dimension. Both testicular widths were averaged.

Testicular Thickness (TTH): The anterior posterior thickness of both left and right testicles within scrotum was measured by Electronic Digital Caliper in centimeter. The thickness of both testicles was averaged.

Scrotal Skin Thickness (STH): The testicles were pushed upward and the bottom of the scrotal skin was pushed down. Then scrotal skin thickness was measured by Electronic Digital Caliper in centimeters.

Paired Testicular Volume (PTV): Two formulae were frequently used to compute paired testicular volume: (i) PTV (V1) = 0.0396(average L)$(SC)^2$, formula of Prolate spheroid using scrotal circumference, SC; (Lunstra *et al.*, 1978) and (ii) PTV (V2) = 4/3 (∏)(L/2)$(W/2)^2$, formula of Prolate spheroid using length and width of testis (Bailey *et al.* 1998). In their comparison of Caliper and Ultrasonographic measurements of bovine testicles and a mathematical formula to estimate testicular volume and weight *in vivo*, Bailey et al. (1998) found that the prolate spheroid formula is more reliable in determining testicle volume (r^2=0.89; P<0.05). They also pointed out that testicular volume and weight are highly correlated (r^2=0.98; P<0.05). Therefore, a modification of prolate spheroid formula was used in this study to predict weight, (r^2=0.91; P<0.05).

Total Testicular Weight (TTWT): The high correlation of testicular measurements (SC, TL and TW) with total testis weight has been utilized to predict the TTWT in live animals. Only one formula (Bailey et al., 1998) is available which computes TTWT from TL and TW: TTWT = 0.5533(L)$(w)^2$, where L = length of the testicle and w = width of the testicle. This formula was applied in this study to compute total testis weight (TTWT).

Statistical Analysis

Forward Stepwise Multiple Regression Analysis, as described by Draper and Smith (1981), was used. Multiple regression equations were constructed to predict SC, PTV, and TTWT and body weight from age, body size and testicular measurements. Regression analysis was used to predict traits, which were otherwise impossible or difficult to measure in live animals, especially in large livestock. The analysis was continued in a stepwise manner until all useful variables were entered. At each step, the variable added was the one, among those not yet included, which would make for the greatest reduction in error sum of squares. In other words, the variable added at each step was the one, among those not yet included, which in combination with already included, would maximize R^2, or, equivalently, it was the variable, among those not yet included, having the largest partial correlation with the dependent variable being predicted. Based on R^2 values, the best-fitted prediction equations were selected.

The following linear regression model was fitted: $Y = X\beta + e$; R2 = ss-r/ ss

Y = observed vector of the dependent variables (SC, PTV, TTWT, WT)

X = incidence matrix of one or a combination of independent variables

β = Vector of unknown parameters (ß0, ß1, ß2… ßn)

e = error term

ss-r = Sum of squares due to regression

ss = Total sum squares

R^2 = Coefficient of determination

Results and Discussion

Prediction of scrotal circumference (SC) from age and linear body size measurements

Results of forward stepwise multiple regression analysis for Sahiwal and Karan Fries bulls using age (months), body weight (kg) and measurements of body size (height, cm; girth, cm) as independent variables to predict SC (dependent variable) are presented in Table 1. Stepwise prediction equations were developed based on the significance of partial correlation coefficients between SC and age and body size measurements. Either linear, when each fitted as a single covariate or multiple effects of age, weight, chest girth and height all affected ($P<0.001$) scrotal circumference. Of the four, chest girth had the greatest effect. In both breeds, the first step of the stepwise regression procedure picked up chest girth, with the highest partial correlation of 0.94 and 0.88 with SC in Sahiwal and KF, respectively. This equation explained 72.0% and 77.3% of the total variation in SC in Sahiwal and KF, respectively.

Table 1. Coefficients of forward stepwise regression analysis using age (months) and weight (kg), girth (cm) and height (cm) to predict scrotal circumference (cm)

Breed	Step	Traits	b±S.E.	R^2 Value (%)
Sahiwal	I	Girth	0.204 ± 0.010	72.0
	II	Age	0.054 ± 0.030	73.0
		Girth	0.165 ± 0.021	
KF	I	Girth	0.197 ± 0.007	77.3
	II	Weight	-0.012 ± 0.005	78.0
		Girth	0.277 ± 0.034	
	III	Weight	-0.012 ± 0.005	78.4
		Height	0.106 ± 0.053	
		Girth	0.277 ± 0.034	

Little improvement in the accuracy of prediction was achieved when the second highly correlated variable, age (0.173) and weight (-0.167) (data not presented) in Sahiwal and KF, respectively, were included in the model. The inclusion of the corresponding traits resulted in increase in the R^2 value only by 1%. Body weight and age continued to influence SC (P<0.05) (data not presented) with girth in the model though its effect was diminished. In general SC appears to be most affected by body size, although age remains an important factor.

Stepwise regression was terminated at step 2 in Sahiwal, as the partial correlation of SC to height becomes non-significant. But the regression analysis was further continued for KF bulls by including the remaining variable, height, as the partial correlation after the second step of the regression analysis was found significant between SC and height, without significant improvement in accuracy of the prediction equation. Because of this fact the first equation was taken as the best prediction equation of SC from body measurements in Sahiwal and KF bulls (Table 1).

Prediction of paired testis volume, PTV (cm^3) from age, body size and Testicular measurements in Sahiwal and KF bulls

Several prediction equations were constructed using age, weight, height, girth and testicular size measurements (length, width and SC) to predict paired testicular volume in Sahiwal (Table 2) and Karan Fries (Table 3) bulls. Based on the significance of partial correlation coefficient, SC (P<0.001) (data not presented) was the first trait picked up in the stepwise regression analysis with partial correlation coefficient of 0.967, explaining the 95.0% and 93.5% of the variation in paired testicular volume for Sahiwal and KF bulls, respectively. This study showed that there existed a linear relationship between SC measurements and testicular volume in Sahiwal and KF bulls.

Table 2. Coefficients of forward step wise regression analysis using age (months), weight (kg) and testicular size(cm) to predict paired testicular volume, PTV (cm) in Sahiwal bulls

Prediction of PTV_1

Step	Traits	b±S.E.	R^2 Value (%)
I	SC	33.771 ± 0.627	95.0
II	Age	28.003 ± 3.976	
	SC	27.623 ± 0.975	96.4
III	SC	25.217 ± 1.036	
	Length	24.544 ± 3.533	
	Age	1.1596 ± 0.239	96.9

Prediction of PTV_2

Step	Traits	b±SE	R^2 Value (%)
I	Width	122.357 ± 3.583	88.8
II	Length	32.143 ± 2.180	95.3
	Width	90.645 ± 3.150	
III	Length	24.903 ± 2.370	96.1
	Width	87.387 ± 2.931	
	Age	0.917 ± 0.163	
IV	SC	2.177 ± 0.839	96.3
	Length	21.412 ± 2.687	
	Width	84.328 ± 3.109	
V	SC	2.878 ± 0.844	96.5
	Length	22.517 ± 2.633	
	Width	84.478 ± 3.019	
	Weight	-0.155 ± 0.710	
	Age	1.55353 ± 0.318	

Prediction of Total Testis Weight, TTWT (g) from age, body weight and Testis size Measurements

In the stepwise regression analysis to predict total testis weight from age, body weight and testicular measurements, it was observed that step 1 alone could account for 88.5% and 90.8 % of the variation in testes weight, in Sahiwal and KF bulls, respectively. But step 2 seems to be the best fit model as inclusion of length to width increased the coefficients of determination from 0.885 to 0.963 in Sahiwal bulls and from 0.908 to 0.948 in KF bulls. Overall, SC was found to be best predicted from heart girth (G), body weight from G and age of the animal, PTV from SC, TL and TTWT and TTWT from TL and TW (Tables 4 and 5).

Table 3. Coefficients of forward step wise regression analysis using age (months), weight (kg) and testicular size (cm) to predict paired testicular volume, PTV (cm) in KF bulls

Prediction of PTV_1

Step	Traits	b±S.E.	R^2 Value (%)
I	SC	35.425 ± 0.661	93.5
II	SC	26.463 ± 1.327	95.0
	Length	33.645 ± 4.475	
III	SC	24.102 ± 1.281	95.6
	Length	28.995 ± 4.019	
	Age	1.338 ± 0.220	
IV	SC	26.082 ± 1.337	96.1
	Length	36.402 ± 4.464	
	Width	-29.799 ± 7.613	
	Age	1.308 ± 0.212	
V	SC	27.635 ± 1.353	96.3
	Length	40.857 ± 4.465	
	Width	-29.987 ± 7.357	
	Age	1.767 ± 0.237	
	Height	-2.200 ± 0.570	

Prediction of PTV_2

Step	Traits	b±S.E.	R^2 Value (%)
I	Width	152.580 ± 3.187	92.0
II	Length	27.659 ± 2.635	94.9
	Width	105.022 ± 5.205	
III	Age	0.751 ± 0.141	95.5
	Length	22.010 ± 2.689	
	Width	102.810 ± 4.890	
IV	Age	1.520 ± 0.193	96.1
	Girth	-1.168 ± 0.215	
	Length	28.200 ± 2.760	
	Width	107.301 ± 4.652	
V	Age	1.185 ± 0.233	96.2
	Weight	0.158 ± 0.063	
	Girth	-1.971 ± 0.384	
	Length	27.742 ± 2.730	
	Width	108.713 ± 4.625	

Table 4. Coefficients of forward stepwise regression analysis using age, weight and testis size to predict TTWT (g) in Sahiwal bulls

Step	Traits	b ± S.E.	R^2 Value (%)
I	Width	129.246 ± 3.785	88.5
II	Length	33.953 ± 2.309	95.3
	Width	95.749 ± 2.931	
III	Length	26.306 ± 2.504	96.1
	Width	92.306 ± 3.096	
	Age	0.969 ± 0.173	
IV	SC	2.299 ± 0.886	96.3
	Length	22.617 ± 2.839	
	Width	89.076 ± 3.284	
	Age	0.751 ± 0.189	
V	SC	3.040 ± 0.892	96.5
	Length	23.785 ± 2.78	
	Width	89.234 ± 3.189	
	Weight	-0.164 ± 0.052	
	Age	1.641 ± 0.336	

Table 5. Coefficients of forward stepwise regression analysis using age, weight and testis size to predict TTWT (g) in KF bulls

Step	Traits	b ±SE	R^2 Value (%)
I	Width	29.216 ± 2.302	90.8
II	Length	29.216 ± 2.302	94.8
	Width	110.934±3.541	
III	Length	21.557 ± 1.034	96.0
	Width	98.222± 2.096	
	Age	2.336 ± 1.273	
IV	SC	1.939 ± 0.886	96.7
	Length	20.764 ± 4.339	
	Width	90.760 ± 3.454	
	Age	1.751 ± 0.189	
V	SC	2.556 ± 2.891	96.8
	Length	23.785 ± 2.781	
	Width	89.423 ± 5.289	
	Weight	-1.255 ± 1.052	
	Age	1.641 ± 0.336	

Even though age as the third most useful independent variable in prediction of TTWT was included in step III of the stepwise regression analysis, it could not influence the accuracy of prediction much. The stepwise analysis continued up to step 5 by including SC and body weight in steps 4 and 5, respectively. But the increases in coefficients of variation were not significant in both breeds. Hence, model II was taken as the best prediction equation to predict TTWT from TL and TW. The importance of SC was obscured in prediction of TTWT because of the fact that the current total testis weight was estimated from TL and TW only. Even then, when we consider SC in a single effect model using pair correlation of SC and TTWT, it accounted about 77% of the variation in TTWT.

Prediction of body weight (WT) from age and body size measurements

As can be seen from Table 6 body weight was sufficiently predicted from model I. It was observed that there was highly significant partial correlation coefficient of 0.956 and 0.960 between body weight and chest girth in Sahiwal and KF bulls, respectively. As the result, chest girth was taken first in stepwise regression analysis accounting for 91.6% and 95.2% of the variation in body weight in Sahiwal and KF bulls.

Table 6. Coefficients of forward stepwise regression analysis using age and body size measurements to predict body weight (Kg)

Breed	Step	Traits	b ± S.E.	R^2 Value (%)
Sahiwal	I	Girth	5.786 ± 0.142	91.6
	II	Age	3.316 ± 0.226	96.5
		Girth	3.379 ± 0.188	
	III	Age	3.307 ± 0.220	96.7
		Height	1.828 ± 0.558	
		Girth	2.724 ± 0.271	
KF	I	Girth	6.513 ± 0.103	95.2
	II	Age	2.141 ± 0.214	96.8
		Girth	4.970 ± 0.176	
	III	Age	2.239 ± 0.213	96.9
		Height	1.703 ± 0.599	
		Girth	4.135 ± 0.341	

The partial correlation coefficient between body weight and age was higher causing further forward regression analysis with the increment of 4.9% and 1% in R^2 values in Sahiwal and KF bulls, respectively. When age was included in step II, significant partial correlation ($P<0.01$) was observed between body weight and height and then in step III all the three parameters were included. But the increase in R^2 value was very insignificant indicating Model II as the best prediction equation for body weight in Sahiwal. As the increase in coefficient of determination was not statistically significant after the first step of the analysis, model one alone was found sufficient for KF breed to predict weight based on the chest girth measurement. This finding is advantageous in that the measurement of girth is easy and applicable without any infrastructure barrier. The availability of the weighing scale for livestock in general and that of larger animals in particular is a persisting problem for performance evaluation at field level. The ease and accuracy of measurement of chest girth with flexible cloth tape can meet the challenge of this problem.

Table 7. Best selected equations in estimating potential fertility of breeding bulls using age, weight, linear body size and testicular measurements

Breed	Traits	Selected Equations	R^2 Value (%)
Sahiwal	SC	Y= -3.96990 + 0.20414 (G)	72.4%
KF	SC	Y= -3.62808 + 0.69739 (G)	77.3%
Sahiwal	WT	Y = -320.14 + 30.14 (Age) + 0.30378 (G)	96.5%
KF	WT	Y = -728.13409 + 6.51311 (G)	95.2%
Sahiwal	V1	Y = -613.12553 + 33.77196 (SC)	95.0%
KF	V1	Y = -642.80489 + 35.42521 (SC)	93.5%
Sahiwal	V2	Y = -500.51626 + 32.14 (TL) + 90.64 (TW)	95.3%
KF	V2	Y = -514.03991+27.66 (TL) + 105.022 (TW)	94.8%
Sahiwal	TTWT	Y = -528.69545 + 33.95 (TL) +95.75 (TW)	95.2%
KF	TTWT	Y = -542.98034+29.23 (TL) +110.934 (TW)	94.8%

Conclusion

This study has shown the possibility of predicting body weight from easily measured body measurements like chest girth and height. Chest girth was also found to have high correlation with scrotal circumference, which otherwise is difficult to measure at least in some bulls. It also showed the advantages of testicular measurements like scrotal circumference, testis length and testis width, in reasonably predicting paired testicular volume and testis weight, which have direct relationship with the capacity of that particular animal to produce spermatozoa. Bull selection has a greater impact on the genetic improvement of a herd than usually realized by livestock producers. As a bull determines the fate of many individual females and calves by contributing a larger portion of the genes to the herd, selection of bulls is a first prerequisite in improvement of farm animals. In this study the potential fertility of a bull was predicted from a combination of direct and indirect measurements of testis size. Body measurements provided an indirect estimate testis size. Accordingly several equations were developed and best models were presented. These models help to predict potential fertility of bulls so as to facilitate culling decisions at an early age. These decisions help reduce costs of bull management, in terms of labour, space and time. The study has high relevance under Ethiopian condition as the methodology is simple to apply even at on-farm condition. Based on this, a similar research is in progress at Bako Agricultural Research Center to test the method on Horro bulls and their crosses. Since these correlations of testis size measurements with body measurements are not close to unity, it is always necessary to substantiate the implied correlations with the actual fertility status of bulls.

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Eth. J. Anim. Prod. 6(2) - 2006: 29-36

Study on Sexual and Fattening Performance of Partially Castrated Horro Rams

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Abstract

Thirty, nine-month old, fully castrated, partially castrated (unilateral) and entire Horro rams (10 of each) were used to evaluate the fertility status of partially castrated rams as compared to entire rams and to compare feed intake, weight gain and fattening performance of partially castrated rams with entire and fully castrated rams. Four rams from each sex group were sacrificed for carcass measurements at the end of the experiment. Besides, four other rams from each of partially castrated and entire were assigned to mating for fertility test. Feed intake was not significantly ($p>0.05$) different between the three sex groups. Initial live weight and treatment significantly ($p<0.05$) affected final live weight, total gain and average daily gain. Slaughter weight significantly ($p<0.05$) influenced carcass weight, forequarter and hindquarter, blood, skin and tail. Treatment had no significant ($p>0.05$) effect on most carcass traits measured except on viscera full and viscera empty ($p<0.05$). No significant ($p>0.05$) difference was observed in fertility between partially castrated and entire ram lambs. However, partially castrated rams had similar fat deposition as intact rms. Yet partially castrated rams were similar to fully castrated rams in weight gain performance. They performed equally well as those of entire rams in terms of fertility. However, the evidence generated does not show a particularly useful advantage of partial castration, and further investigation is suggested also using another type of partial castration.

Keywords: Horro rams, partially castration, sexual and fattening performance.

Introduction

Partial castration (castrating only one testis) has been practiced since long ago for it's various advantages. The growth rate, feed conversion efficiency,

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and carcass traits of partially castrated rams and bulls fall between entire and fully castrated animals (Rakesh, 1981). Partial castration is also recommended for its economic advantage as the animals take less time to recover and be fattened earlier under fattening conditions thus minimizes cost and time for maintenance. More over based on observation study conducted at Bako partially castrated rams were also found to be sexually fertile and comparable to entire rams.

Full castration has a depressive action on weight gain and it favors more fat deposition (Demisse *et al*, 1989; Thys, *et al*., 1989). Thus, in countries where fat has a moderate demand, partial castration is advocated. From the information available, partial castration has many biological and economical advantages. It favors growth and better-feed conversion efficiency than full castration and more fat deposition than entire ones and adequate male fertility level as entire rams. This study was, therefore, carried out to compare the fertility, live weight gain and fattening performance of partially castrated Horro rams with entire and fully castrated rams of the same breed.

Materials and methods

The study Center, Bako, is situated in east Wollegga zone, about 250 km west of Addis Ababa on the main road to Nekemte at an altitude of approximately 1650 m above sea level (09° 06´ N and 37° 09´ E). Bako has a hot and humid climate and receives a mean annual rainfall of about 1219 mm, more than 80 % of which is recorded in the months of May to September. Mean monthly maximum and minimum temperatures are about 28°C and 14°C, respectively, with 21°C of average temperature. Potential evapotranspiration averages 62 mm per month.

Thirty Horro rams, all nine month old, obtained from the sheep research unit of Bako Agricultural Research Center were used for the current study. They were assigned into three treatments following a stratified random procedure on the basis of their body weight and type of birth. Treatment one (T1) was fully castrated, treatment two (T2) was partially castrated (castrated only one testis) and treatment three (T3) was entire (uncastrated) rams. Castration was conducted using Burdizo both in treatments one and two.

The animals were kept in-door and supplemented 400g/head/day of concentrate mixture composed of 49% maize, 49% noug cake, 1% bone meal and 1% salt on individual feeding base with *ad-libitum* hay for a period of about three month. Feed intake and refusals were recorded daily. They were weighed at the beginning of the experiment and fortnightly there after until the end of the trial. Water was provided twice a day.

Four rams from each sex group were slaughtered for carcass measurements at the end of the trial. They were fasted over night and weighed before slaughtering. Carcass and non-carcass components were weighed immediately after slaughter. Besides, four other rams from each of partially castrated and entire rams were mated to twenty-four Horro ewes (24 ewes/ram) for fertility test. The ewes were allocated to the different rams at random, based on their parity and live-weight. Number of services per conception and number of lambs born per ewe joined were considered for comparison of fertility between partially castrated and entire rams. Herdsmen recorded observed and recorded services during the day.

The General Linear Models of the Statistical Analysis System (SAS, 1996) was used in the analysis of the data to determine the effects of treatments (sex groups) on experimental measurements. Initial body weight was included as a covariate in the analysis of body weight; treatment was the only independent effect in the analysis of carcass traits. Analysis was also done for ram's fertility in terms of number of service per conception and number of lambs born per ewe joined.

Results and Discussion

Feed intake

The least squares means (±SE) of feed intake were 383±4.00, 391±4.48 and 383±4.01 g/head/day for fully castrated, partially castrated and entire rams, respectively. There was no significance ($p>0.05$) difference in feed intake between the different treatments evaluated. Though not significant, partially castrated rams tended to have higher feed intake than fully castrated and entire ram lambs.

Body weight

Analysis of variance and least squares means (±SE) of the different traits investigated were shown in Tables 1 and 2, respectively. Initial body weight and treatment significantly ($p<0.05$) affected final body weight, total gain and average daily gain. Liveweight growth performance of Horro lambs in the current study was not significantly different between treatments in the first two-months of the experimental period. But it was significantly different between treatments (sex groups) after two-months. This could be attributed to the stage of growth considered in the current study. According to Fourie and Heydenrych (1982), Nagy *et al.* (1999) and Solomon and Gemeda (2000), the influence of sex on live weight increased with increase in age. In a study by Thys *et al.* (1989) no significant difference was observed between totally and partially castrated rams in live weight, heart girth and height at withers of Poulfouli rams of the far north of Cameroon at the end of a 244-days study period.

Table 1. Analysis of variance and level of significance of body weight as affected by treatment and initial body weight.

Sources	Df	Mean squares of:						
		Wt2	Wt3	Wt4	Wt5	Wt6	Wt7	Wt8
Trt	2	1.01	1.46	1.23	4.45	6.29	22.73**	15.91*
IWt	1	1263.39***	269.77***	196.08***	254.67***	240.29**	207.87***	149.76***
R^2 (%)		97.64	92.09	71.59	86.49	73.90	83.24	74.88
CV (%)		2.64	4.78	8.35	5.09	8.37	6.03	6.42
EMS		7.12	25.85	86.38	46.65	100.73	58.25	69.59

Trt= treatment; IWt= initial body weight EMS=error mean squares; *=p<0.05; **= p<0.01; ***=p<0.001

Table 2. Least squares means (±SE) of body weight of Horro rams as affected by treatments.

Source	Overall mean	T1	T2	T3
Wt2 (Kg)	20.6	20.4 ± 0.17	20.8 ± 0.19	20.8 ± 0.17
Wt3 (Kg)	21.7	21.4 ± 0.33	21.8 ± 0.37	21.9 ± 0.33
Wt4 (Kg)	22.7	22.3 ± 0.45	22.7 ± 0.69	23.0 ± 0.59
Wt5 (Kg)	23.6	23.3 ± 0.45	24.3 ± 0.50	23.5 ± 0.44
Wt6 (Kg)	24.5	24.2 ± 0.67	25.2 ± 0.74	24.1 ± 0.65
Wt7 (Kg)	25.8	24.7 ± 0.50^{a}	27.1 ± 0.56^{b}	25.9 ± 0.49^{ab}
Wt8 (Kg)	26.5	25.6 ± 0.55^{a}	27.5 ± 0.62^{b}	26.7 ± 0.54^{ab}
Total gain (Kg)	7.7	6.7 ± 0.55^{a}	8.7 ± 0.62^{b}	7.8 ± 0.54^{ab}
Average daily gain (Kg)	0.07	0.06 ± 0.01^{a}	0.08 ± 0.01^{b}	0.07 ± 0.01^{ab}

T1= Fully castrated rams, T2= partially castrated rams and T3= Entire rams.

Different superscripts in a row denote significant differences between effects at *P* =0.05.

In the current study, partially castrated rams had higher average daily gain and final body weight than fully castrated rams. Though not significant, the relatively higher average daily gain and final body weight of partially castrated rams as compared to fully castrated rams might be attributed to the feed intake. Partially castrated rams had higher feed intake than fully castrated and entire rams, though not significant (p>0.05). Owen (1976) also reported that higher concentrate intake resulted in an increased growth rate.

No reports on performance of partially castrated rams could be found in the literature either for Horro sheep or the other indigenous sheep breeds of the country for possible comparison. However, according to Sibanda *et al.* (1989)

there is an interaction between nutrition and sexual condition (entire, partially castrated and fully castrated). Better growth in castrates than in entire goats was reported by Raghavan (1988) while Arnold and Meyer (1988) reported better growth in rams than in withers. The discrepancy in the literature might be attributed to feed type used and the stage of growth considered. Louca *et al* (1977) reported that late castration (7 months) depressed growth as compared to early castration (7 days of age) and entire.

Carcass traits

Analysis of variance and least squares means (±SE) of carcass traits measured from Horro rams of different treatments were shown in Tables 3 and 4, respectively. Final liveweight has significantly influenced carcass, forequarter and hindquarter, blood, skin and tail weight ($p<0.05$). There was no significance ($p>0.05$) difference in carcass traits measured among treatments, except on visceral full and visceral empty ($p<0.05$). In the current study, the absence of significant differences between treatments in carcass traits measured could be attributed to body weight and the stage of growth considered. Non-significant differences in hot carcass weight between withers and ram lambs was reported by Notter *et al* (1991) in spite of sizeable differences in slaughter weight. Gemeda *et al.* (2002) reported that castration had no significant effect on carcass traits measured at early age. They indicated that differences might still appear if animals were slaughtered at latter ages. The growth curve of Horro sheep shows that maturity is achieved at about 3-year of age (Solomon and Gemeda, 2000).

Table 3. Analysis of variance of some carcass traits of Horro rams as affected by treatment and slaughter weight

Source	Df	Mean squares of:										
		CWt	DP	FQ	HQ	VE	VF	BLD	KF	OF	TW	Skin
Trt	2	0.58	8.80	0.44	0.08	1.31*	1.64*	0.08	2751.52	12295.61	0.12	0.08
SWt	1	18.64***	1.78	5.67***	3.73***	0.43	0.45	0.09*	1233.01	150.97	0.61*	0.57**
R2 (%)		93.35	34.60	86.88	0.88	67.68	57.05	60.77	42.25	11.93	70.26	73.38
CV (%)		3.78	3.84	6.27	4.67	15.82	8.19	11.46	32.72	60.88	29.52	7.34
EMS		1.53	23.85	1.08	0.57	0.71	1.38	0.09	5969.99	95617.78	0.34	0.22

Trt= treatment, SWt= Slaughter weight, CWt= carcass weight, DP= Dressing percentage, FQ= forequarter, HQ= hindquarter, VE= visceral empty, VF= visceral full, BLD= blood, KF= kidney fat, OF= omental fat, TW= tail weight. EMS= Error mean square.

Though not significant, dressing percentage was greater in partially castrated rams than entire and fully castrated rams. Contrary to this result, lower dressing out percentage for intact males than in castrates were reported (Demissie *et al.* 1989) for the breed used in the current study. There were indications of some sex differences in pattern of deposition of fat, though not significant. Fully castrated rams had higher omental and kidney fat than partially castrated and entire ram lambs.

Fertility

Analysis of variance and least squares means of ram's fertility measured by number of service per conception (NOS) and number of lambs born per ewe joined (NLB) were shown in Tables 5 and 6, respectively. Fertility was not significantly (p>0.05) different between partially castrated and entire ram lambs. Entire rams had similar number of services per conception though they had a slightly higher number of lambs born per ewe joined than those of partially castrated rams, but the difference was not significant (Table 6).

Table 4. Least squares means (±SE) of carcass traits measured from Horro rams as affected by treatments.

Traits	Overall mean	T1	T2	T3
SWt (kg)	25.7	25.0 ± 1.47	26.4 ± 1.47	25.8 ± 1.47
CWt (kg)	11.6	11.4 ± 0.22	11.9 ± 0.22	11.5 ± 0.22
DP (%)	45.0	44.3 ± 0.87	46.2 ± 0.87	44.5 ± 0.86
HQ (kg)	5.7	5.7 ± 0.14	5.8 ± 0.14	5.6 ± 0.14
FQ (kg)	5.9	5.6 ± 0.19	6.1± 0.19	5.8 ± 0.10
Hindleg (g)	221.7	234.2 ± 48.01	210.9 ± 47.94[a]	219.9 ± 47.40
Foreleg (g)	265.4	274.3 ± 20.09	260.6 ± 20.06	261.4 ± 19.84
VF (kg)	5.1	5.6 ± 0.21[a]	4.9 ± 0.21[b]	4.8 ± 0.21[b]
VE (kg)	1.9	2.4 ± 0.15[a]	1.6 ± 0.15[b]	1.7 ± 0.15[b]
BLD (kg)	0.9	1.0 ± 0.05[a]	0.8 ± 0.05[b]	0.9 ± 0.05[ab]
TW (kg)	0.7	0.6 ± 0.10	0.7 ± 0.10	0.8 ± 0.10
Head (kg)	1.6	1.6 ± 0.08	1.6 ± 0.08	1.6 ± 0.08
KF (g)	83.5	99.7 ± 13.83	87.7 ± 13.8	63.2 ± 13.66
OF (g)	179.6	219.0 ± 55.37	179.7 ± 55.29	140.1 ± 54.67
Skin (kg)	2.3	2.3 ± 0.08	2.1 ± 0.08	2.3 ± 0.08

Different superscripts in a row denote significant differences within effects *P* =0.05. Abbreviations as indicated in Table 3.

Table 5. Analysis of variance of NOS and NLB as affected by service sire treatment.

Sources	Df	Mean squares of:	
		NOS	NLB
Treatment	1	0.02469[NS]	0.09877[NS]
R^2 (%)	1	1.82	3.67
CV (%)		35.32	69.40
EMS		13.56	26.81

NOS= Number of service per conception and NLB= Number of lambs born per ewe joined.

EMS= Error mean squares. NLB-Number of lambs born per ewe joined.

Table 6. Least squares means of NOS and NLB as affected by service sire treatment.

	NOS	NLB
Overall mean	1.2	0.8
Service sire		
Entire	1.2 ± 0.08	0.9 ± 0.11
Partially castrated	1.2± 0.06	0.8 ± 0.08

Abbreviations as indicated in Table 5

Conclusion

The results of the study confirmed that partially castrated rams are equivalent to entire (non-castrated) rams in growth performance but superior to fully castrated animals. They were equally important as those of entire rams in terms of fertility. In terms of fat deposition difference was not significant among the three treatments. The study has not shown the advantage of partial castration in terms of fat deposition over the intact animals. Therefore partial castration is not a recommendable practice. However, the current study has used a unilateral type of partial castration as opposed to a short-scrotum (pushing the testis into the groin) type of partial castration. Future work may need to consider the effect of the latter type of partial castration.

Acknowledgement

The authors wish to thank Mr. Berhanu Soboqa and Mr. Berhan Feleke for their assistance in flock management and data collection during the study period.

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Eth. J. Anim. Prod. 6(2) - 2006: 37-52

Lifetime Production and Reproduction Performances of *Bos taurus* x *Bos indicus* Crossbred Cows in the Central Highlands of Ethiopia

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Abstract

Lifetime reproduction and production records of 170 Boran crossbred cows belonging to six genetic groups that were born between 1974 and 1995 at the Holetta Agricultural Research Center (HARC) were used in this study. The genetic groups were F_1 Friesian x Boran (F_1FBo), F_1 Jersey x Boran (F_1JBo), F_2 Friesian x Boran (F_2FBo), F_2 Jersey x Boran (F_2JBo), 75% Friesian inheritances (FxBoF), and 75% Jersey inheritances (JxJBo). Reproductive traits studied were age at first calving (AFC, n=170), calving interval (CI, n=844) and days open (DO, n=844). Productive traits studied were lactation milk yield (LMY, n=1011) and lactation length (LL, n=1010). Fixed effects included in the model were birth year, birth season, calving year, calving season and parity. The overall least square means (s.e) was 43.20 (0.84) months for AFC, 200.13 (25.55) days for DO and 481.30 (25.73) days for CI. AFC was significantly affected ($P<0.01$) by genetic groups and birth year. However CI and DO were not affected by any of the fixed effects considered. The overall least square means (s.e) was 1919.60 (103.21) liters for LMY and 360.76 (16.11) days for LL. Both traits were significantly affected ($P<0.05$) by genetic groups, birth year, calving year and parity. In general, F_1 crosses produce significantly more average LMY of 2150.03(1.92) liters and had longer LL of 365.01(12.56) days as compared to F_2 crosses with average LMY and LL of 1553.96(106.35) liters and 346.30(16.52) days, respectively. Likewise average AFC, DO and CI were 41.39 (1.92) months, 189.16(19.13) days and 469.25(20.27) days, respectively for F_1 crosses. However, AFC, DO and CI were found to be 49.02(0.9) months, 213.26(26.56) and 494.36(26.75) days, respectively for F_2 crosses. Therefore, results showed that when productive and reproductive performances were simultaneously considered, F_1 crosses were superior to the second-generation crosses in all the traits considered.

Keywords: lifetime, lactation length, lactation milk yield, age at first calving and calving interval

Introduction

Two different types of factors are responsible for the differences between individual animals within a breed. First, there are environmental factors such as climate, nutrition, health and overall management. Second, there are genetic factors, which are due to the genes received from the two parental gametes.

The genetic and environmental factors interact, so that the total variations between animals are equal to the sum of the effects of the entire environment and genetics, and the interaction between them (Syrstad, 1990).

Poor productive and reproductive performances of cattle breeds, which are indigenous to tropical climates, have mainly originated from influences of these two factors. On one hand, they have poor inherent genetic potential to produce sufficient milk and on the other hand, the natural environments in which they survive are stressful and as a result, even if milk production potential exists, they cannot perform to their maximum capacities.

Several reports (Kiwuwa *et al*., 1983; Beyene Kebede, 1992; Sendros Demeke, 2002) showed that cattle breeds indigenous to Ethiopia are characterized by extended age at first calving, which ranges from 3½ to 4 years, longer calving interval and inter-calving period. Lactation milk yield also hardly exceeds 600 liters in a shorter lactation length of less than 200 days.

On the other hand, improved dairy breeds imported to tropical environments showed unsatisfactory result compared to their performances in their home environment. Study conducted by Vaccaro (1973, 1974a, 1975a, 1990), Mason (1974), Nagarcenkar (1982), Taneja and Bhat (1986) confirmed that the performances of temperate breeds imported to tropical climates showed disappointing results such as low growth rate, high mortality rate of calves and low fertility of the cows.

As a result, crossbreeding of improved breeds of *Bos taurus* with the indigenous cattle of the tropics (*Bos indicus*) was popularized as an option to improve milk production potential of tropical breeds. Review works have been done in several tropical countries by a number of expatriates (Buvanendran and Mahadevan, 1975; Vaccaro, 1973; McDowell, 1985b) and all unanimously concluded that crossbred cows have marked superiority over indigenous cattle breeds in dairy traits.

In Ethiopia, crossbreeding of indigenous cattle breeds with the commonly used exotic dairy breeds was started in 1974 by the then Institute of Agricultural Research (IAR) at four research stations, that represent different agro-ecological zones of the country with various outcomes (Mohammed *et al*., 1987 Sendros *et al*., 1987a, 1987b, Beyene Kebede, 1992).

However, some of the results presented on production and reproduction traits were based on few lactation records and might not reflect the actual lifetime production and reproduction performances of crossbred cows. This paper is therefore, designed to evaluate lifetime production and reproduction efficiencies of various crossbred dairy cows at Holetta Agricultural Research Center, Ethiopia.

Materials and Methods

Study area

This study was carried out at Holetta Agricultural Research Center (HARC). Holetta is one of typical highland areas of Ethiopia, which is conducive for dairying. It is located at 45km west of the capital Addis Ababa. It is located at an altitude of 2400 meters above sea level. Geographically, it is situated at 9^0 3'N latitude and 38^0 38' E longitudes.

Breeding plan and animal management

The data were obtained from a long-term crossbreeding program undertaken from 1974 to 1995. Semen from two exotic sire breeds; Friesian (F) and Jersey (J) were imported and crossed with local Boran (Bo) dams to produce F_1 crossbred calves. F_1 bulls in turn were selected based on dam milk yield, growth performances and physical appearances for the production of F_2 generations (Table 1). In addition, semen from exotic bulls was used to produce advanced generations like 75% exotic inheritances.

All animals were treated under similar feeding and management practices. They graze for approximately 7:00 hrs per day from 8:00 hour to 15:00 hour on native pasture except during the main rainy season when the herd is restricted limited grazing area. Upon return to the barn, they were supplemented with conserved hay and green grass from natural pasture or cultivated forage (elephant grass) depending on availability. Milking cows were supplemented with nearly 2 kg/head/day local concentrate feeds mainly constituting 30% wheat bran, 31% wheat middling, 35% noug seed cake (*Guizota absysinica*), 3% bone and blood meal and 1% salt during milking.

As the cows were kept for experimental purposes of various natures, there were no stringent culling procedures. Calves were immediately separated from their dams after birth and fed colostrum for five days. Bucket feeding of whole milk continued until weaning at 98 days of age. Two weeks from birth, calves were supplemented with additional hay and concentrate. Calves consumed a total of 260 liters of milk until weaning and further maintained in a calf-rearing pen until six months. After six months of age, female calves joined the breeding herd and were bred when they attained body weight of above 230kg.

Table 1. Mating design and genotype produced in the breeding programs †

Sire genotype	Dam genotype	Progeny produced
F	Bo	F_1 FBo
J	Bo	F_1JBo
F_1FBo	F_1FBo	F_2FBo
F_1JBo	F_1JBo	F_2 Bo
F	F_1FBo	3/4F:1/4Bo
J	F_1JBo	3/4J:1/4Bo

†Bo = Boran; F = Friesian; J = Jersey; F_1FBo = F_1 Friesian x Boran; F_1JBo = F_1 Jersey x Boran; F_2 Bo = Friesian x Boran F_2; F_2JBo = Jersey x Boran F_2; 3/4F:1/4Bo = 75% Friesian inheritances; 3/4J:1/4Bo = Jersey inheritances.

Treatment of the herd against any incidence of diseases was a routine practice. Seasonal outbreaks of major diseases of economic importance were identified and control measures were taken according to the disease control calendar set by the animal health research division of the HARC.

Traits studied

Two major types of dairy traits were considered in this study. These were productive traits, which include lactation milk yield (LMY) and lactation length (LL) and reproductive traits, which include age at first calving (AFC), calving interval (CI) and days open (DO) (Table 2).

Table 2. Production and reproduction records by genetic groups †

Genetic groups	Number of cows	Production records		Reproduction records		
		LMY	LL	AFC	CI	DO
F_1FBo	44	278	278	44	234	234
F_1JBo	44	299	299	44	256	256
F_2FBo	27	144	144	27	117	117
F_2JBo	31	148	148	31	117	117
¾ F:¼ Bo	11	54	54	11	45	45
¾J:1/4Bo	13	88	88	13	75	75
Total	170	1011	1010	170	844	844

†LMY= lactation milk yield, LL= lactation length, AFC= age at first calving, CI= calving interval, DO= days open

Statistical model and data analysis

The data were analyzed using linear additive model where the independent effects include genetic groups, birth year, calving season, parity and calving year. The dependent variables were subjected to the analysis of variance using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS, 1999).

Birth year from 1974 to 1997 inclusive was analyzed. However, because of few observations in 1995, 1996 and 1997, they were grouped together and analyzed as single year record denoted as 1995^+. Similarly, early calving year of 1977, 1978 and 1979 were grouped together and analyzed as single year record denoted as 1979^+. Lactation lengths of less than 50 and greater than 720 days and lactation milk yield of less than 70 liters were not included in the final data analysis.

The general linear models used were;

i) $Y_{ijklm} = \mu + B_i + Y_j + S_k + P_l + C_m + e_{ijklm}$

Where

Y_{ijklm} = lactation milk yield, lactation length, days open and calving interval of ijklmth cow

μ = Overall mean;

B_I = the effect of ith genetic groups (I = 1 to 6)

Y_j = the effect of jth birth year (j=1974 to 1995^+)

S_k = the effect of kth calving season (dry, short rainy and heavy rainy seasons)

P_l = the effect of lth parity (l=1 to 8^+)

C_m = the effect of mth calving year (m=1979^+ to 2000)

e_{ijklm} = random error associated with ijklmth observation assumed to normally and independently distributed with mean = 0 and variance δ_e^2.

ii) Age at first calving was analyzed by fitting the data to fixed effects of linear model that consists of genotype of the cow, birth year and birth season.

$Y_{ijk} = \mu + B_i + Y_j + S_k + e_{ijk}$

Where

Y_{ijk} = age at first calving of i^{jkth} heifer

μ = Overall mean

B_I = the effect of i[th] genetic groups (i= 1 to 6)

Y_j = the effect of j[th] birth year (j=1974 to 1995[+])

S_k = the effect of k[th] birth season (dry, short rainy and heavy rainy seasons)

e_{ijk} = random error associated with ijk[th] observation and assumed to be normally and independently distributed with mean =0 and variance δ_e^2.

Results

Productive performances

The overall LMY and LL for the genetic groups was 1919.6 (103.21) liters and 360.76 (6.11) days, respectively. Genetic group and parity were detected to be significant (P< 0.05) sources of variation in both traits. Lactation milk yield (LMY) and LL were also highly influenced (P<0.001) by birth year and calving year (Table 3). However, the effect of calving season was not significant (P>0.05). Crosses with 75% Friesian inheritance were found to be more productive per lactation though did not produce significantly more LMY than the F_1 crosses. However, they produce more LMY as compared to F_2 crosses and crosses with 75% J inheritance (Table 4).

Table 3. Least squares means analysis of variance of different genetic groups of Boran crossbred cows by fixed effects †

Traits	Genetic groups	Birth year	Calving year	Calving season	Parity	Birth season
LL (days)	*	***	***	NS	*	-
LMY (days)	***	***	***	NS	**	-
AFC (months)	**	**	-	-	-	NS
CI (days)	NS	NS	*	NS	NS	-
DO (days)	NS	NS	*	NS	NS	-

†LL = lactation length; LMY = lactation milk yield; AFC = age at first calving; CI = calving interval; DO = days open; NS (p>0.05); * = p<0.05; ** = p<0.01; *** = p<0.001 and - = fixed effect in a column was not used to analyze trait in a row

Parity had no significant influence on both LL and LMY up to the sixth parity, but its effect was considerable beginning from the seventh parity. LMY tended to increase from the first through to the forth parity where peak LMY was attained in the fourth parity. However, it showed a declining trend after reaching a peak at the fourth parity (Table 4).

Birth year and calving year were detected to be significant sources of variation for both LL and LMY (P<0.001). However, no clear yearly trend can be detected. Rather it showed inter-annual fluctuation in both traits. However, it was noted that earlier and later years of birth and calving had better response than the intermediate years.

Table 4. Least squares means (s.e.) of LMY and LL of Boran crossbred cows by genetic groups, calving season and parity based on lifetime records

Effects		LMY (s.e.) (liters)	LL (s.e.) (days)
Genetic groups			
	F_1FBo	2149.67 (85.86)[a]	359.11 (13.46)[b]
	F_1JBo	2150.39 (75.42)[a]	371.00 (11.67)[b]
	F_2FBo	1765.25 (111.4)[b]	360.41 (17.3)[ab]
	F_2FBo	1342.66 (101.3)[c]	332.19 (15.73)[c]
	3/4F:1/4Bo	2342.90 (136.9)[a]	392.66 (21.61)[a]
	3/4J:1/4Bo	1766.77 (108.3)[b]	349.17 (16.94)[b]
Calving season			
	Dry season	1900.92 (80.01)	358.35 (13.26)
	Short rainy	1910.72 (88.15)	365.28 (14.02)
	Rainy season	1947.18 (91.81)	358.64 (13.11)
Parity			
	1	1833.26 (72.61)[a]	367.79 (11.37)[a]
	2	1993.37 (64.14)[a]	375.40 (10.07)[a]
	3	1974.91 (71.90)[a]	355.42 (11.29)[a]
	4	2035.54 (89.62)[a]	384.77 (14.02)[a]
	5	2022.69 (113.63)[a]	369.30 (17.70)[a]
	6	1965.48 (136.11)[a]	373.14 (21.25)[a]
	7	1946.98 (168.73)[a]	349.61 (26.27)[a]
	8^+	1584.62 (194.43)[b]	310.62 (30.35)[b]
Overall mean		1919.60 (103.21)	360.76 (16.11)
CV		0.3953	0.3311

Means with the same superscript within columns are not significantly different from each other (P>0.05)

Reproductive performances

The overall least squares means (s.e.) for AFC (months) CI (days) and DO (days) for the entire genetic group was 43.20 (0.84), 481.30 (25.73) and 200.13 (25.55), respectively. Genetic group had significant influence on AFC (P<0.01) where as CI and DO were not influenced by any of the fixed effects considered (P>0.05). F_1JBo and crosses with 75% Friesian inheritance had shorter AFC than the second generation crosses (Table 5).

Though the fixed effects considered had no significant influence (P>0.05) on CI and DO, least squares means analysis of variance showed a progressive improvement in CI and DO with the advancement in parities. At earlier parities, all the cows had longer CI and DO than the later parities.

Though the overall effect of birth year and calving year were significant sources of variation for all reproductive traits (P<0.05), no clear trend was found except for AFC. Graph 1 showed that almost constant AFC was observed during the early periods of crossbreeding program and the longest AFC was observed during the years of 1981 through 1984.

Table 5 Least squares means (s.e) of reproductive performances of Boran crossbred cows by genetic groups, calving season and parity based on lifetime records

Effects	Reproductive performances		
Genetic groups	AFC (months)	DO (days)	CI (days)
F_1FBo	44.02 (0.72)[b]	195.24 (21.55)	474.25 (21.70)
F_1JBo	38.76 (0.60)[c]	183.08 (16.71)	464.21 (18.84)
F_2FBo	49.80 (0.96)[a]	206.10 (27.73)	486.46 (27.92)
F_2FBo	48.24 (0.84)[a]	220.41 (25.40)	502.56 (25.57)
3/4F:1/4Bo	38.52 (1.44)[c]	227.42 (33.52)	509.55 (33.75)
3/4J:1/4Bo	39.72 (1.08)[c]	168.55 (26.42)	450.30 (26.60)
Calving season			
Dry season	-	183.56 (20.06)	465.08 (20.20)
Short rainy	-	207.66 (22.24)	488.87 (22.40)
Rainy season	-	209.18 (22.62)	489.97 (22.78)
Parity			
1	-	242.87(16.70)[a]	520.80(16.81)[a]
2	-	218.83(14.64)[a]	496.14(14.75)[a]
3	-	202.45 (17.25)[a]	483.94 (17.37)[a]
4	-	210.82 (22.21)[a]	491.62 (22.37)[a]
5	-	200.25 (28.53)[a]	482.37 (28.73)[a]
6	-	184.45 (35.86)[a]	468.76 (36.11)[a]
7	-	185.38 (43.50)[a]	462.82 (43.80)[a]
8^+	-	156.01 (50.08)[b]	439.00(50.42)[b]
Overall	43.20 (0.84)	200.13 (25.55)	481.30 (25.73)
CV	0.2169	0.7511	0.33

Means with the same superscript within columns are not significantly different from each other (P>0.05)

Discussion

The overall mean of LMY observed in the present study for Boran crosses is within the ranges of LMY reported by different authors. Schaar *et al*. (1981), Alberro (1983), Kiwuwa *et al*. (1983) and Chernet *et al*. (1999) reported LMY of 1885, 2031, 1977 and 1478 liters, respectively for different crossbred cows in Ethiopia. As expected, variability in these reports and the present findings could perhaps stemmed from dam breed differences that comprised the crosses, agro-ecological variations or management differences implemented by individual farms. In addition, LMY in the reports is entirely based on few records, which may not clearly reflect actual lifetime performances.

Higher productivity per lactation obtained in crosses with 75% Friesian inheritances could be due to relatively longer lactation length observed in this cross and/or it may have arisen from high proportion of Friesian genes as Friesians are known for high milk production. For instances, Million Tadesse, (2001); Million *et al*. (2004) reported that LMY increased as the proportion of Holstein Friesian blood increased from 0 to 15/16. In this study, though the level of LMY in 75% Friesian inheritances is relatively better than the rest of genetic groups, it was realized to be unsatisfactory. This indicates that raising the level of exotic inheritance (upgrading) alone would not improve LMY unless the level of management is simultaneously improved.

The relatively better productive performance noticed in F_1 crosses of both Friesian and Jersey is consistent with several other reports. McDowell (1988b) revised crossbreeding results from 25 countries of the tropics involving 57 genetic groups, 15 native breeds and 7 European breeds and reported that F_1 crosses had considerable benefits. They calved earlier, yielded more milk (147%), were milked for more days, and had slightly shorter calving interval. Other researchers (e.g. Kiwuwa *et al.*, 1983; Vacarro, 1973; Beyene Kebede, 1992) also reported the superiority of F_1 over the rest of genetic groups.

The consistently better rank of F_1 crosses could be attributed to maximum heterotic effect obtained by crossing the two diverse populations. Apparently, lower LMY exhibited by F_2 crosses in the present study might be in part due to reduction in hybrid vigor as explained by McDowell (1988b) and Falconer and Mackay (1996). On the other hand, lower selection intensity of F_1 bulls or cows for the production of F_2 crosses because of small population size may have resulted in low LMY. Besides, the decline in performance from F_1 to F_2 or backcross generation in tropical environments could be due to recombination losses than other factors (McDowell 1985; Cunningham and Srystad 1987; Srystad, 1989).

In addition to genetic factors, reproductive traits are mainly affected by environmental factors (climate, nutrition, health and other factors which are not of genetic origin). Relatively poor performances in measure of reproductive efficiencies such as AFC, DO and CI observed in this study (Table 5) could be attributed to the fact that level of management practices that could support optimum performances in these traits was unmet at the center.

The overall least square means for AFC, CI and DO in this study were longer than the voluntary waiting periods of each trait. This expected to affect the lifetime productivity and, therefore, profitability of diary cows. A study conducted by Mukasa-Mugerwa (1989) also revealed that the lifetime productivity of a cow is influenced by age at puberty, age at first calving, inter-calving period and calving interval.

Several reports (Kiwuwa *et al*., 1983; Enyew Nigussie, 1999; Tawah *et al*., 1999; Sendros Demeke, 2002) showed that the effect of birth year on AFC and calving year on CI and DO were significant for grazing animals under tropical conditions. The trend of influence was, however, irregular and not similar for all traits. In this study too, the inter-annual variation on reproductive traits may indicate a failure to maintain uniform management practices over the years.

Shorter AFC observed in the present study for Jersey crosses is in agreement with most other reports (Beyene Kebede, 1992; Sendros Demeke, 2002). However, shorter AFC noticed in crosses with 75% F inheritances was inconsistent with most of the results reported under tropical conditions. This could be attributed to the smaller sample size in this study and/or due to the faster growth rate in the early traits of Friesian breeds as the level of inheritance increased. Though there were no significant differences in CI and DO, high variability has been observed in these traits.

The relative superiority of F_1 crosses in all traits compared to their F_2 crosses are reported in several studies. Buvanendran *et al.* (1981); McDowell, (1985b); Tawah *et al.* (1999) and Sendros Demeke (2002) noted that F_1 crosses ranked first in all the traits considered. In particular, decline in performance from F_1 to F_2 and later generations are common phenomenon because of reduction in heterozygosity in F_2 (McDowell, 1985b; Syrstad, 1989).

Both CI and DO showed a decreasing tendency with advancing lactation number even though they were not influenced by any of the factors considered in the study. Several reports (Silva *et al.,* 1992; Tawah *et al*., 1999; Saha *et al*., 2000) noted that CI and DO tended to decrease with increases in the number lactation completed. Though there is no hard fact to justify this trend, results suggest that reproductive efficiency of dairy cows show tendency of improvement with increasing lactation number.

Conclusion

In general, results of this study showed that F_1 crosses in particular, that of Jersey were superior in all production and reproduction traits considered. Second generation crosses were inferior in all the traits studied.

Productivity per lactation was high for crosses with 75% Friesian inheritance. However, they completed fewer numbers of lactations in their lifetime, which has a negative impact on the total lifetime milk yield. Therefore, improvement in the level of overall management has to be considered before designing to increase the level of Friesian inheritance.

In Ethiopia, where there is no clear crossbreeding program, careful decision should be made in selecting appropriate exotic breed and the level of their inheritances. In addition, the crossbreeding program should take into account of dairy production systems and available resources since these factors influence the types of crossbred cow to be maintained.

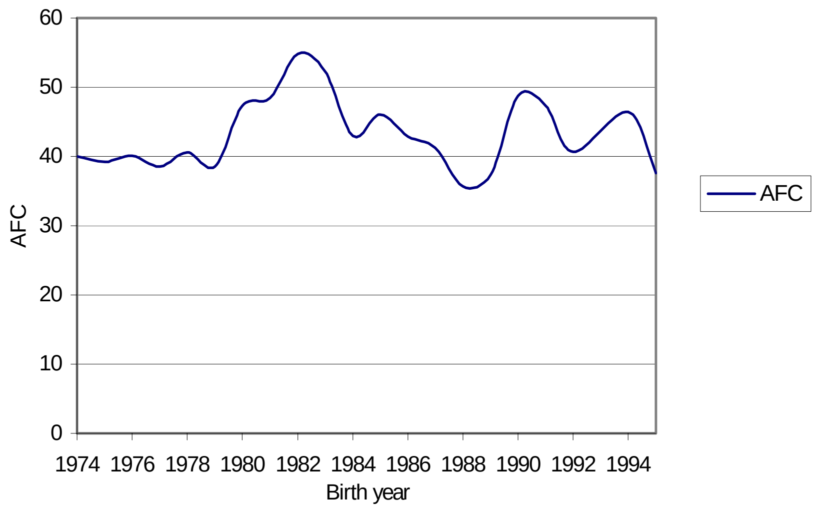

Figure 1. Yearly variation of age at first calving

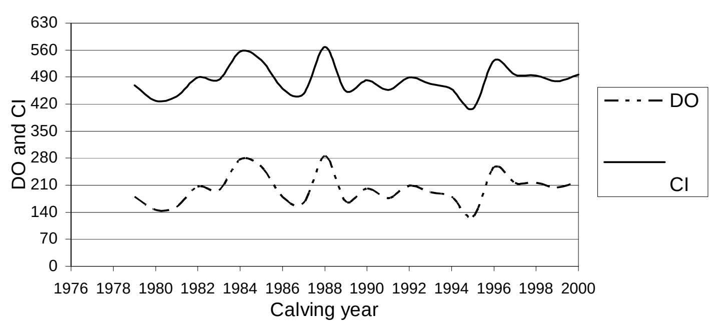

Figure 2.Yearly variation of calving interval (CI) and days open (DO)

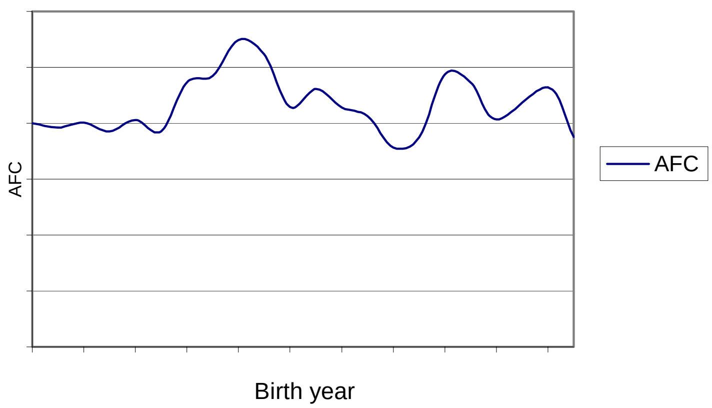

Figure 3. Yearly variation of age at first calving

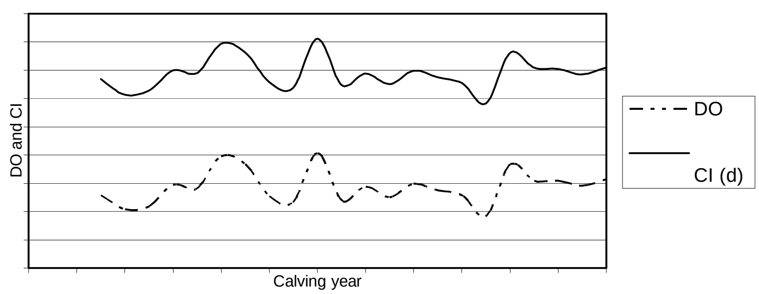

Figure 4.Yearly variation of calving interval (CI) and days open (DO)

Acknowledgements

The authors are grateful to the Ethiopian Institute of Agricultural Research /Agricultural Research and Training Project (EIAR/ARTP) for funding this study as a scholarship grant to the first author. The devotion of Dr. Sendros Demeke in creating the breeding database is highly appreciated. We also thank the staff of Holetta Dairy Research Program for their devotion in this long way research process.

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Eth. J. Anim. Prod. 6(2) - 2006: 53-66

Breeding Scheme Based on Analysis of Community Breeding Objectives for Cattle in North-western Ethiopia

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Abstract

Knowledge of traditional animal breeding practices and techniques is important to develop sustainable genetic improvement schemes under smallholder settings. Unfortunately, inadequate attention has been given to the investigation of these practices. This knowledge gap leads to the setting up of unrealistic breeding goals in the design of livestock genetic improvement programs, the consequences of which can endanger the conservation of indigenous animal genetic resources. This study was conducted to study the existing cattle breeding practices of the study area, and to outline priority areas of intervention for genetic improvement of the indigenous cattle breed types based on farmer trait preferences. A rapid field visit had been conducted to outline sampling framework based on types of cattle breed types, which was used as the basis for the selection of six sample sites. The actual survey included focus group discussions and administration of a semi-structured questionnaire on 20 to 30 representative sample households. Results showed that the indigenous cattle in the study area have multipurpose functions and were preferred mainly for their adaptive traits, including resistance to disease, drought tolerance and low feed requirements. Almost all respondents (98%) employed pure breeding of their local cattle types. In females, the selection criteria are coat color, body size, size of udder and teats and length of the naval flap. However, importance of each of the different traits varies with sites. Farmers have strong desire to improve their indigenous genotypes, and suggested different goal traits for genetic improvement. Based on this, community/village-breeding scheme is proposed, taking into account milk production, adaptation and longevity as goal traits, as the first step for genetic improvement of the indigenous cattle breeds.

Keywords: breeding objectives, breeding scheme, indigenous cattle, Gondar, Ethiopia

Introduction

The traditional animal production in Africa is mainly characterized by subsistence production and it is the largest farming sector in terms of numbers of farmers. It includes pastoral as well as crop-livestock systems in semi arid and wet and cool highlands and landless (requiring little land) production system (Jahnke, 1982; Rege *et al*., 2001). Despite the importance of the subsistence sector, no breeding objective suitable to the system is currently available (Rege et al., 2001; Amer *et al*., 1998). However, natural selection has resulted in animals that are tolerant to prevalent diseases and parasites.

Traditional animal breeding efforts and techniques are important, but more information is needed regarding the breeding population that exists in the system. This background information should precede any major interventions (Cunningham, 1992). Characterization and utilization of local indigenous breeds as stated by Hall (1992) should be considered whenever development of animal production system is discussed. Indigenous genotypes may well be adequate and able to respond sufficiently to reasonable economic improvements in the low-input smallholder production system (Workneh *et al*., 2003). Over many generations indigenous breeds have evolved to perform various functions under local conditions. Unfortunately, inadequate attention has been given to evaluating these resources or to setting up realistic and optimum breeding goals for their improvement. As a result some of the animal genetic resources of Africa are endangered and, unless urgent concerted efforts are taken to characterize and conserve, these resources may be lost even before they are described and documented (Rege and Lipner, 1992).

A coherent and comprehensive breeding program suited to the existing production systems (decentralized breeding program) is required to guide stakeholders in the sustainable management of animal genetic resources. Failure to create effective genetic improvement program for subsistence type of farming may accentuate any decline in the number of indigenous breeds with the added disadvantage of being replaced by other production systems which might not be sustainable in the long run. Knowledge on traditional breeding practices and cattle goal traits are crucial if sustained genetic improvement is to be in place. The objectives of this study were to explore cattle trait preferences in the study area, outline priority areas of intervention for genetic improvement of the identified indigenous cattle breed types based on farmer trait preferences, and investigate the existing breeding practices.

Materials and methods

The study area

The study area, North Gondar and some part of South Gondar, is located in northwestern part of Ethiopia. It is generally divided into three main agro-climatic zones, namely: highland, mid highland and lowland regions. According to the 2002 report by the departments of agriculture of the respective zones, the study area hosts 2.654 million cattle. The altitude ranges from 4620 meters in the Semein Mountains in the North to 550 meters in the western parts of the study area and rainfall varies from 880mm to 1772mm with a monomodal distribution. The farming system is largely characterized by crop-livestock production system both the highlands and lowlands, and in both cases the crop farming is heavily dependent on livestock. Transhumance, from the highlands to western lowlands, is practiced as one of the most important strategies to secure grazing resources for the highland livestock during lean seasons of the year. The average herd size varies greatly, and it ranges from 2.11 to 7.15 animals in the high and mid altitudes to around 65 in the lowlands (DOA, 1999).

The most common breeding system in the study area is pure breeding. Crossbreeding between indigenous and exotic Holstein-Friesian and Jersey, however, is practiced in some parts of the mid and mid-highland region of the area with the purpose of improving milk production. The livestock feed is predominantly derived from unimproved pasture, fallow land grazing, hay, crop residues, non-conventional foodstuffs and to some extent also agro-industrial by-products. The extent of relative use of these feed resources depends on proximity to town. Foot-and-mouth disease (FMD), Blackleg, Anthrax, Lumpy skin disease, Contagious Bovine Pleuropneumonia (CBPP), Trypanosomosis, Mastitis and Dermatophilosis are commonly found. Infertility and Tuberculosis (TB) are also reported (DOA, 1999).

Sampling framework and data collection procedure

Initially a rapid field visit had been conducted to identify the types of cattle breed types and thereby to outline sampling framework. Based on the outcome of this survey six sample sites were selected:

a. Semien: Semein Mountain area, consisting of Beyeda and Janamore districts
b. Wegera: highlands of Debark, Dabat, and Wegera districts of North Gondar
c. Dembia: mid-altitude areas of North Gondar districts (Dembia, Chilga, Gondar zuria)
d. Fogera: eastern flanks of Lake Tana, Fogera and Dara districts of South Gondar
e. Western lowlands: Western lowlands of North Gondar, Quara, Metema and Tachiarmachiho
f. Monastery: Mahibere Sillasie Monastery, an Orthodox Church monastery, located in the western lowlands of North Gondar

Actual survey work included focus group discussions and administration of semi-structured questionnaire. Semi-structured questionnaires were prepared, pre-tested and administered on 20 to 30 (except at Site 6, the Monastery) representative sample households. Data were analyzed using simple descriptive statistics.

Results and discussions

Purposes of keeping cattle

Cattle in the study area have multipurpose functions. These include traction power (traction), milk production, income generation, manure, reproduction and meat production (Table 1). Similar results were reported earlier by Mukasa-Mugerwa (1989) in Ethiopia and Rege *et al*. (2001) in Kenya. Multiple functions are particularly relevant in high-risk production environments. According to Scarpa *et al*. (2002) in developing countries, especially in low input smallholder production systems, the most valuable livestock attributes are often those that successfully guarantee multi-functionality, flexibility and resilience in order to deal with variable environmental conditions.

The relative importance of these functions varies between the sites. For instance, traction was most frequently reported in Semein Mountains, and less frequently in Wegera and Dembia. In Fogera, milk was reported more frequently than was traction (Table 1). Despite the general assumption that only male cattle are used for traction, it was found out in this study that cows are also used for traction. This appears to be due to shortage of male animals. Especially in Semien and Wegera areas using horses for traction on light soils is common tradition. According to the sample farmers the contribution of the latter as power animal is so significant. On average, horse traction is estimated to cover around 35-40 % of the traction requirement of the area. It seems that the ox is giving way to the horses to be used as a traction animal thus leaving more land for cows to graze. This may pave a road for the creation of specialized breeds and/or gives better opportunity for dairy breed improvement. Similar event was observed in Europe at the end of 18th century (Mason and Buvanendran, 1982).

Table 1. Reported frequency of purposes for keeping cattle (percentage)

Purposes	Semein	Wegera	Dembia	Fogera	Western lowlands	Monastery
Income	28.1	27.1	21.2	27.9	30.1	40.0
Meat	16.6	23.6	18.2	16.6	23.1	0.0
Milk	40.1	54.7	57.9	60.0	62.0	7.0
Manure	26.6	25.8	28.9	27.8	27.6	3.0
Reproduction	26.4	35.3	26.9	22.7	25.7	23.0
Draft	93.5	78.4	75.9	50.0	54.5	27.0

Cattle trait preferences

The communities have preferences for certain traits of their cattle, and these traits are again multiple, suggesting that multipurpose rather than specialized breeds are more suitable for the kind of low input – low output production system of the study area (Table 2). The local breed types were preferred mainly for their adaptive traits, including resistance to disease, drought tolerance and low feed requirements. Similar findings were documented, for example, by Rege *et al.* (2001) for the Kenyan Zebu breeds. Further, Davis (1993) in northern Australia and Moyo (1996) in Zimbabwe reported the relative significance of adaptive traits of tropical/indigenous breeds compared to temperate breeds.

Adaptation traits as defined by FAO (1999) are complex traits related to reproduction and survival of the individual in a particular production environment. Adaptation traits contribute to the individual's fitness and to the evolution of animal genetic resources. A similar study by Kamuanga *et al.* (2002) in West Africa also showed that farmers commonly give higher ranks for such traits as fitness for traction, disease resistance, fertility and fecundity. Thus, to be consistent with those preferences, breed improvement programs should ensure that improved genotypes are also selected for these traits (Kamuanga *et al.*, 2002). Some farmers rated traction capacity of local cattle in the very cool and highland areas high. In addition to these, milk production (mostly quality, taste), reproduction (related to asset and social values), and body conformation were identified as important cattle traits. The order of preference of these traits varied considerably between sites (Table 2).

Table 2. Reported frequency of cattle trait preferences (percentage)*

Reason for preference	Semein	Wegera	Dembia	Fogera	Western Lowland	.Monastery
Milk production	0.0	48.8	50.0	48.0	50.0	10.0
Meat type	-	-	-	-	-	-
Adaptation	90.3	96.0	58.8	73.3	80.9	20.0
Conformation & size	50.0	38.5	70.6	32.2	54.5	20.0
Traction capacity	50.0	50.0	75.0	33.3	-	10.0
Reproduction	34.6	30.4	37.8	31.5	44.4	40.0
No alternative breeds	36.4	35.3	27.8	0.0	-	-

* Proportions derived from less than 5 respondents are omitted

Mating system and selection of breeding animals

Almost all respondents (98%) employ pure breeding of their local cattle types. Even though artificial insemination (AI) and exotic bull services for cross breeding of local cattle with exotic dairy breeds have been promoted for the last nine years, only a very small proportion of farmers (around Wegera, 14%) are utilizing the services. Mating is totally uncontrolled in Semien Mountains and partially controlled in Wegera. But in in Dembia and Fogera plains as well as the western lowlands, cattle keepers practice selection of male and female breeding cattle based on preferred traits (Zewdu, 2004). The majority of farmers in all study sites obtain their breeding animals from their own farm and from their relatives and neighbors. In some instances, farmers buy female breeding animals from the nearby open markets using certain selection criteria. These are coat colour, body size, size of udder and teats and length of the naval flap (Table 3). Besides, fertility, dewlap width and temperament are considered as secondary criteria. Other traits mentioned as useful in selecting females are long neck, small size of head, and short calving interval for females and long preputial sheath, large hump and medium tail length for males.

Importance of each of the different traits varies with sites. For instance, solid colour is not preferred in mid and low altitude areas for which scientific explanation cannot be given. In Semien Mountains and Wegera area, however, plain coat colour pattern, red coat colour, and spotted patchy combinations of red and white colour are preferred. According to the respondents from lowland areas, flies are more attracted to plain coat colour pattern of their cattle, and hence they do not prefer plain coat colour. Furthermore, coat colour preferences influence market prices of cattle and this becomes more important in light of the relative significance of cash income generating functions of cattle (Table 1). These preferences for coat colour pattern actually match the observed patterns in sample herds, whereby mixed colour were more common than solid plain colour in the low and mid altitude areas. Another important trait, probably the most important in all sites, is body size (Table 3), which comprises body length, height and pelvic width. In this case also relatively small size is preferred in the very cool highland areas and larger animals are preferred in the rest of the sites. This is purely associated with the available feed reserves.

The importance of colour and fertility is high in Semien Mountains, Wegera and the western lowlands, whereas low in Dembia and Fogera (Table 3). The relative importance of sizes of udder, teats and naval flap tends to increase as we go down from highland to lowland areas. This might be related to the emphasis given to milk since the traits are assumed to be milk traits.

Table 3. Reported frequency of traits used to select breeding female (percentage)

Selection traits	Semein	Wegera	Dembia	Fogera	Western lowlands
Colour	34.6	53.0	25.9	23.9	35.9
Dewlap	0.0	25.0	25.0	23.3	0.0
Body size	58.7	93.0	95.6	70.6	68.0
Fertility	60.0	44.0	29.2	26.7	50.0
Temperament	33.3	35.5	0.0	0.0	28.6
Udder, teat and naval length	28.6	32.9	40.0	42.3	56.0
Others	22.8	21.4	25.0	20.8	22.2

Breeding objective

Development of any genetic improvement strategy requires description of production environment, setting appropriate breeding objective, selecting traits to be improved based on their influence on returns and costs to the producer and consideration of stockholders. In addition, available infrastructures and organizational set up established in the target area have to be considered. Thus, designing a breeding program needs decision on a series of such interacting components. Similar approaches were followed by Sölkner *et al*. (1998), Amer *et al*. (1998) and Rege *et al*. (2001).

Production system, stakeholders and infrastructures of the study area

The production system of the study area is basically subsistence-oriented production system, and not market-oriented. As reported by the farmers, feed shortage and animal diseases are the most important limiting factors. Lack of marketing facilities was also mentioned. There is no performance or pedigree recording. Farmers live with low level of education. The typical herd sizes are small; there are no farmers' associations specifically equipped for livestock development. The involvement of other stakeholders (non-governmental organizations and government bodies) in genetic improvement of local indigenous cattle genotype was very minimal or none. Infrastructures such as artificial insemination services are established for some of the mid and high altitude districts though frequent shortage of liquid nitrogen and lack of trained manpower are constraints of the service delivery system.

Goal traits for genetic improvement in the study area

The goal traits, which are used in designing of the upcoming breeding program, should logically be based on preferred traits identified by farmers (Table 4). Only few traits that represent breeding goal, easy to measure, heritable are considered. Traits, if not easily measured, must have a high genetic correlation with measured indicator trait, and desirable economic value, either as a marketable commodity or as a means of reducing production costs. Previous works done by Sölkner *et al.* (1998) and Rege *et al.* (2001) used similar approaches.

Some of the farmers' preferred traits (Table 4) have low heritability values and others, like post weaning growth and mature body weight, have contradictory role to the existing management system, as such traits need better management and require additional feed, which may compound the already existing problem. One of the adaptive mechanisms of local indigenous cattle in stressful tropical environment is to keep their body size small (Payne, 1990; Hegde, 2002). So care should be taken to ensure that the traits selected are those of real economic importance to the farmers. Thus both traits (post weaning growth and mature weight) are excluded. Improvement on the growth performance through selection should aim at having faster growth but not oversized animals. High growth rate will produce cows that require heavier body weight to achieve puberty. This can prolong the age at first calving, thereby further increasing the already extended age at first calving. Reports by Hegde (2002) and Rege *at al.* (2001) also gave similar justification for not considering high growth rate.

Female fertility is also suggested by farmers for improvement. Reproductive rate in most tropical breeds of cattle is low. Yet, this trait is very important not only in the economics of production but also in genetic improvement because of its influence on selection intensity. Though the heritability of the various measures of reproduction is low, rigid culling to eliminate animals with low fertility may improve fertility in Zebu cattle. However, as most of the improvement resulting from such selection may be non-genetic, fertility may decline in subsequent generations unless the practice of culling on reproductive performance is sustained. Another trait selected by farmers for genetic improvement was tolerance to diseases, especially trypanosomosis. Development of disease resistant breeds is not an easy task and needs time and mobilization of huge resources. Thus, the most important and practical way is to concentrate on selection for production traits in the presence of environmental stress, thus allowing animals to be selected while responding also to the stressors. A similar approach was suggested by Rege *et al*. (2001).

In addition to these, almost all farmers have included milk production traits in their goal traits. Since milk was mentioned as one of the most important functions of the local cattle and one of the primary reasons for keeping indigenous cattle, its inclusion as one of the goal traits is justifiable. An increase in milk yield will bring additional income from the sale of butter and in some cases, e.g. in Fogera plains, from the sale of raw milk. More milk production also means better-fed calves that will have better pre- and post-weaning survival rates. These calves will also grow better and hence reach puberty earlier thus reducing age at first calving. Farmers also preferred to see short calving intervals of their cows, which can also be improved to a certain extent by improving feeding and health management. However, at this stage, it is advisable to work on very few selected priority traits to allow quick realization of the benefits from genetic improvement.

Finally, longevity in terms of length of productive life in a herd was identified as a preferred target trait. This is definitely important since animals that stay longer under production help to lower the cost of raising replacement heifers. Animals with longer productive life should be identified so that their close relatives could be selected. Earlier works done by Mason and Buvanendram (1982) and Sölkner *et al*. (1998) reported that for marginal areas, long term reproductive performance of female animals will clearly be of higher value.

Table 4. Frequency (%) of reported traits for genetic improvement of indigenous cattle

Traits	Semein	Wegera	Dembia	Fogera	Western lowlands	Monastery
Longevity and adaptation	34.5	13.4	27.3	15.0	15.5	100.0
Fertility of breeding females:						
Age at first calving	86.2	41.4	54.5	8.3	9.2	0.0
Calving interval	100.0	27.6	63.6		22.2	0.0
Growth and mature weight	86.2	44.8	77.3	33.3	68.9	0.0
Milk production (yield)	100.0	96.5	100.0	50.0	94.4	0.0
Traction	27.6	58.6	18.2	0.0	28.7	0.0
Other traits	0.0	12.7	0.0	0.0	6.7	0.0

Proposed breeding program

Analysing all these major components shows that genetic improvement is not an easy task. However, there is still a possibility to devise appropriate genetic improvement programs for the existing production systems. The most important advantage was the availability of indigenous cattle breeds adapted to a wide range of harsh environments. Farmers in the study area showed great interest to improve these genotypes and suggested traits for improvement (Table 4). It is important that such breeding programs are monitored for success and failure.

Sustainable use and improvement of such traits is the most effective way of conservation of indigenous genetic resources. These populations could be potential sources of the so-called transgressive or cryptic alleles (Notter, 1999), that are superior genes for some productive traits found 'hidden' in unselected breeds. Nucleus breeding programs employing large herd sizes maintained in stations are suggested (Smith, 1988; Ponzoni, 1992). Such a concept, however, is criticized for its heavy operational costs, high organizational demand, for lacking pertinence, sustainability and possible genotype by environment interactions (Sölkner *et al.,* 1998; Zumbach and Peters, 2002; Olivier *et al*., 2002).

Thus, for the study sites community/village-breeding program is proposed, taking into account milk production, adaptation and longevity as goal traits for genetic improvement of the indigenous cattle breeds. This should be designed to be carried out by rural communities under most likely unchangeable environments, e.g. feed resources will not be improved, large seasonal variations among the years will continue, disease prevalence will persist, level of organization is low, data recording is difficult and flow of information between hierarchies is not functioning. Previous work by Sölkner *et al*. (1998) also suggested similar approach. In this system the herds of the communities, which shared large common environmental effects will be clustered, in what is known as Herd-as-Village concept. In this approach the whole herd of the village will be considered as one herd and used as a foundation stock for selection. From these herds young untested bulls are selected based on evaluation results of their ancestors' performance. This is similar to what is known as young sire program suggested by Syrstad and Ruane (1998), and Philipsson (2000). Some of protocols for the proposed schemes are listed below:

a. This system is believed to work with full participation of the communities. So discussion of the issue with the communities and organizing community members is the vital and first step. Farmers establish community-breeding groups, which will be responsible for execution of the program.
b. Farmers are advised to indicate their trait preference from which the goal traits will be determined.
c. Basic training on recording and importance of breed improvement programs as a whole should be delivered regularly. This can be taken up by the existing extension services. Moreover, the livestock development extension service will be responsible for the day-to-day activities and monitoring of the whole program.
d. Seed money in the form of revolving fund, administered by the community, is necessary. Along with this, government bodies, and relevant nongovernmental organizations can take part in its implementation to the extent that their services are found relevant for effective implementation of the scheme.
e. Based on the communities' goal traits, selection of young untested sires in reference to their ancestors' performance will be executed; then the owner of the bull will enter into a written undertaking. When the bull reaches to age at maturity, it can be used in one of the two schemes, such as:
    a. Community bull scheme where the community will own the bull and provide service to breeding females of all community members at a reasonable charge.
    b. Bull service scheme where an individual maintains the selected bull and will provide the service at a fixed service charge

The use of multiplication center as a source for breeding bulls in other similar schemes is indicated. However, the use of such a center may lead us to Open Nucleus Breeding System (ONBS), which is heavily criticized for its relevance and the possible environment by genotype interaction effect. This village breeding scheme is based on the transfer of selected bulls within communities under the direct supervision of the organized groups. Continual monitoring of the suggested breeding program should be an integral part of this breeding program too.

This scheme is believed also to offer a powerful approach to overcome the structural problem of small herd size. It requires simple organizational set up and minimum technical backstopping. This scheme is probably the only method suited to the existing situation and could enable genetic improvement of local indigenous cattle breeds of the study area. It is hoped that the use of untested bulls for natural mating in the participating herds leads to a substantial reduction in the time lag required for dissemination of the genetically superior animals.

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Handling and Microbial Load of Cow's Milk and *Irgo* - Fermented Milk Collected from Different Shops and Producers in Central Highlands of Ethiopia

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Abstract

Microbial analysis preceded by a survey was conducted to study the handling and the microbial properties of milk and *Irgo* - Ethiopian fermented milk. One-hundred-twenty-four producers (109 small-scale producers, 12 large-scale producers and 3 research centers) were interviewed for the survey. A total of 32 (milk=16 and *Irgo*=16), samples collected from different dairy product shops and 3 producer groups (small-scale, large-scale and research center) in the central highlands of Ethiopia were tested for their microbial properties (counts of aerobic mesophilic, coliforms and lactic acid bacteria) using standard classical methods. Milk samples collected from five different dairy product shops had mean aerobic mesophilic, coliform and lactic acid bacterial counts of 6.97, 5.4 and 6.81 log cfu mL^{-1}, respectively. *Irgo* samples had mean aerobic mesophilic, coliform and lactic acid bacterial counts of 7.1, 4.47 and 6.89 log cfu mL^{-1}, respectively. Mean aerobic mesophilic, coliform and lactic acid bacterial counts of milk sampled from all sources were 8.38, 6.57 and 7.68 cfu mL^{-1}, respectively. The values recorded for *Irgo* were 8.11, 4.82 and 6.7 cfu mL^{-1}, respectively. The highest aerobic mesophilic bacterial counts of 8.63 and 8.40 log cfu mL^{-1} were observed in milk and *Irgo* samples respectively collected from large scale farms. The highest coliform counts recorded for milk and *Irgo* sampled from large scale farms were 6.82 and 5.40 log cfu mL^{-1}, respectively. These high microbial counts indicate the importance of microbial contamination. The isolation and identification of emerging pathogens such as Enterohemorrhagic *Escherichia coli* O157:H7 deserve a due consideration.

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Further investigation in order to identify risk factors is crucial to design preventive interventions.

Key-words: Milk handling, Ethiopia, microbial quality, cow milk, *Irgo*

Introduction

The safety of dairy products with respect to food-borne diseases is of great concern around the world. This is especially true in developing countries where production of milk and various dairy products takes place under rather unsanitary conditions and poor production practices (Mogessie Ashenafi, 1990).

A commonly used procedure to measure the sanitary quality of milk is to estimate its bacterial content. The number of bacteria in aseptically drawn milk varies from animal to animal and even from different quarters of the same animal. On average, aseptically drawn milk from healthy udders contains between 500 and 1000 bacteria mL^{-1}. High initial counts (more than 10^5 bacteria mL^{-1}) are evidence of poor production hygiene (O'Connor, 1994). In proportion to the numbers present, existence of coliform bacteria in milk and milk products is suggestive of fecal contamination and unsanitary practices during production, processing, or storage (Richardson, 1985).

In Ethiopia, dairy processing is generally based on *Irgo* (Ethiopian fermented milk) where the fermentation is natural, with no defined starter cultures used to initiate it. Raw milk is left either at ambient temperatures or kept in a warm place to ferment. The souring is brought through the proliferation of the initial milk flora, with microbial succession determined by chemical changes in the fermenting milk (Mogessie Ashenafi, 2002). Understanding the microbial properties of this fermented product is therefore vital to encourage development of industrial dairy processing. Lactic acid bacteria that mainly produce lactic acid from carbohydrates such as lactose are involved in the fermentation. They are widespread and include the genera *Lactococcus* and *Lactobacillus*. *Lactococcus lactic subsp. lactis* and *Lactococcus lactic subsp. cremoris* grow rapidly in milk, especially above 20°C. So milk turns sour if kept uncooled and losses heat stability (Walstra *et al.*, 1999).

Most of the milk produced in Ethiopia is marketed to the consumers without being pasteurized or subjected to any quality standard and 98% of the annual milk is produced by subsistence farmers who live in rural areas where dairy infrastructure is almost non-existent (Tsehay Reda, 1998). This implies that dairy processing in the country is basically limited to smallholder level and hygienic qualities of products are generally poor. Information on the hygienic handling of dairy products is generally lacking and that on their microbial properties is limited. The aims of this study are te generate basic information on the quantification of total bacterial load, coliforms and lactic acid bacteria of cow's milk and *Irgo* collected from different dairy product shops and producer groups.

Materials and Methods

Study area

The study was carried out in Addis Ababa (altitude: 2320 masl; annual rainfall: 1200 mm; average temperature min., max.: 10.7°C, 23°C) and four major towns around it, namely Debre Zeit (altitude: 1900 masl; annual rainfall: 851mm; average temperature min., max.: 11°C, 29°C), Sebeta (altitude: 2260 masl; annual rainfall: 1100 mm; average temperature min., max.: 10°C, 25°C), Selale (altitude: 2500 - >3000 masl; annual rainfall: 1200 mm; average temperature min., max.: 6°C, 21°C) and Holetta (altitude: 2400 masl; annual rainfall: 1100 mm; average temperature min., max.: 6°C, 24°C). Ethiopia is found in East Africa at a latitude of 3°24'N to 14°53'N and longitude of 33°00'E to 48°00'E).

Methodology

Survey. A semi-structured questionnaire was used to assess the hygienic conditions of milk and *Irgo* during production, processing, preservation, transportation and marketing. One-hundred-twenty-four respondents (109 randomly selected smallholder producers; 12 large-scale dairy farms; 3 Research Centers) were interviewed. Most of the producers were involved in all stages of the dairy chain. Laboratory microbial analysis of milk and *Irgo* samples followed the survey.

Sampling and study procedure. Milk and *Irgo* were sampled, transported and analyzed following standard procedures (Richardson, 1985). Milk in this study refers to unpastuerized whole (for small-scale producers, large-scale producers and research centers) and pasteurized or unpasteurized whole, semi-skimmed or skimmed cows' milk (for dairy product shops). At the time of sampling from 5 dairy product shops in Addis Ababa, products were not labeled with the details of the manufacturing and packaging conditions, except one or two of the samples. Information was gathers through informal discussion with sellers. As dairy product shops were so limited in number, categorizing the milk into the types (pasteurized, unpasteurized, skimmed, semi-skimmed, whole) may not give more sense from statistical point of view. It was therefore decided to consider rather the source of the samples as dairy product shops. The samples were collected aseptically in sterile bottles, kept in an icebox (at <5°C) and transported to laboratory for analysis within 8 hours of sampling.

Samples were collected from three groups of producers (Small-scale 'SS', Large-scale 'LS' and Research Centers 'RC') and Dairy Product Shops 'DPS'. Small-scale producers in this study are those that possessed <25 cows and most of them processed milk using locally available traditional technologies. Large-scale producers are those that possessed >25 cows. Research Centers refer to governmental and non-governmental research stations that are engaged in research activities targeted to improve the overall productivity of the livestock sector. Dairy product shops refer to kiosks of dairy products, and most of them belonged to Large-scale producers. Each of the analysis was made in duplicates and for each of them there was a control. All the analyses were performed within 24 h of sampling.

Microbial analysis

A total of 32 (fresh milk = 16 and *Irgo* = 16), samples were collected from the three producer groups and dairy product shops. The microbial analysis considered included: Aerobic Mesophylic Bacteria Count (AMBC), Coliform Count (CC) and Lactic Acid Bacteria Count (LABC). For AMBC, dilutions were selected so that the total number of colonies on a plate was between 30 and 250, while for CC, dilutions were selected for plate counts of between 15 and 150 (Richardson, 1985). For LABC, dilutions were selected so that colonies could be counted on a plate. One mL of fresh milk and *Irgo* samples were homogenized in 9 mL of 0.1% peptone water (Oxoid) using a vortex-mixer for 1 min before undertaking the microbial analysis. Peptone water and media prepared for each test [except Violet Red Bile Agar (VRBA) for which boiling for 2 min was employed] were autoclaved for 15 min at 121°C (Richardson, 1985). Media used were prepared according to the directions given by the manufacturers.

Aerobic Mesophylic Bacteria Count (AMBC). After autoclaving as mentioned earlier, Standard Plate Count Agar (SPCA) (Oxoid, UK) was cooled to 45^{o}C in a water bath. AMBC was made after incubating appropriate decimal dilutions of the samples in the SPCA medium at 32°C for 48 h (Richardson, 1985).

Coliform counts (CC). Two tests were made to determine CC. Appropriate decimal dilutions of milk and *Irgo* samples were plated on VRBA (Oxoid, UK) and counts were made after incubating at 32°C for 24 h (Richardson, 1985). Typical dark red colonies normally measuring at least 0.5 mm in diameter were considered as coliform colonies. This was followed by a confirmatory test by transferring five colonies from each plate to tubes of 2% Brilliant Green Lactose Bile Broth (BGLBB) (Oxoid, UK). Gas production after 24 h of incubation at 32°C was considered sufficient evidence of presence of coliforms (Richardson, 1985).

Lactic Acid Bacteria (LAB) count. One mL of appropriate serial dilutions in peptone water of *Irgo* samples were added into a sterile dish. A molten MRS Agar (Oxoid, UK) (45°C) was then poured onto the dish and mixed thoroughly. After the medium had set, another layer of MRS Agar was poured over the surface to produce a layer-plate. Colonies were counted after plates were incubated at 35°C in an atmosphere of 5% CO_2 for 48 hours (Savadogo *et al.*, 2004).

Acidity: Acidity of milk and fermented milk samples was measured by titrating 10 mL of the product with 0.1N NaOH to a phenolphthalein end point. Acidity is expressed as % lactic acid (1 mL of 0.1 N NaOH = 0.009 g of lactic acid) (O'Connor, 1994; Richardson, 1985).

Statistical analysis

The qualitative data collected during the survey were described using chi-square test, while, the quantitative data were analyzed using the Means procedure of the Statistical Analysis System (SAS) version 8.2 (SAS, 2001). The number of microorganisms (colony forming units) per milliliter of milk and *Irgo* samples was calculated using the following mathematical formula (IDF, 1987).

$$\sum C / (1 x n_1 + 0.1 x n_2) d$$

Where,

$\sum C$ = Sum of all colonies on all plates counted

n_1 = Number of plates in first dilution counted

n_2 = Number of plates in second dilution counted

d = Dilution factor of the lowest dilution used

The results of microbial counts were first transformed to logarithmic values (log 10) and these transformed values were analyzed using the General Linear Model (GLM) for least squares means in SAS version 8.2 (SAS, 2001) using a fixed effect model. The Least Significant Difference (LSD) test was used to separate the means and differences were considered significant at P<0.05. The model used is presented below.

Model: $Y_{ij} = \mu + M_i + P_j + e_{ij}$

Where, Y = AMBC, CC and LAB count

M_i = effect of i^{th} market type

P_j = effect of j^{th} producer group

e_{ij} = random error, which is assumed to be independent and randomly distributed

Results

Handling of dairy products

Hygiene during milking. The three research centers considered, and about 79% of SS and 91% of LS producers, respectively reported to wash the udder of the cow before milking. However, about 52% of SS and 58% LS producers, respectively used collective towel to clean the udder or they didn't clean at all and 47% of SS and 33% of LS producers used river and/or bore hole water to clean the udder and milk utensils (Table 1). A few of these producers filtered the water, while most of them used the water without any treatment (Table 1).

Treatment of milk. Forty-five % of SS producers consumed milk without any treatment, while, filtration before sale was reported to be the only type of treatment by about 67% of LS producers (Table 2).

Preservation of dairy products. Over 70% of the SS producers kept dairy products at room temperature before consumption or marketing, while LS producers and RC kept dairy products either in refrigerator when products stayed long time or at room temperature when products were disposed immediately after production (Table 3). Organoleptic properties of dairy products are the commonly used quality tests. LS producers kept both milk and *Irgo* longer as compared to the other producer groups (Fig. 1).

Table 1. Frequency distribution of milking related hygienic practices taken by three producer groups in central Ethiopia

Hygienic practice	Producer					
	Small-scale		Large-scale		Research Center	
	Freq.*	%	Freq.	%	Freq.	%
Udder washing						
Washing udder before milking	86	78.9	12	90.9	3	100
Washing udder after milking	10	9.2	-	-	-	-
No hygienic practice	13	11.9	-	-	-	-
Total	109	100	12	100	3	100
Use of towel						
Collective towel	28	25.7	1	8.3	-	-
Individual towel	52	47.7	5	41.7	3	100
With bare hand	16	14.7	6	50	-	-
No hygienic practice	13	11.9	-	-	-	-
Total	109	100	12	100	3	100
Source of water						
Tap	58	53.2	8	66.7	3	100
River	14	12.8	-	-	-	-
Bore hole	37	33.9	4	33.3	-	-
Total	109	100	12	100	3	100
Treatment of water						
Heating	58	53.2	6	50	3	100
Filtration	14	12.8	-	-	-	-
No treatment	37	33.9	6	50	-	-
Total	109	100	12	100	3	100

*Frequency

Table 2. Treatment of milk and *Irgo* by different producers in central Ethiopia

Treatment	Producer					
	Small-Scale		Large-Scale		Research Center	
	Freq.*	%	Freq.	%	Freq.	%
Milk						
Pasteurization	-	-	1	8.33	1	33.3
Boiling	52	48	-	-		-
Fermentation	8	7	-	-		-
Filtration	-	-	8	66.67	2	66.7
No treatment	49	45	3	25	-	-
Total	109	100	12	100	3	100
Fermented milk						
Pasteurization	-	-	1	8.3	-	-
Boiling	-	-	1	8.3	-	-
Fermentation	102	93.6	4	33.3	3	100
No practice	7	6.4	6	50	-	-
Total	109	100	12	100	3	100

*Frequency

Microbial load of milk and Irgo

AMBC of milk and Irgo didn't vary significantly by producer group (Table 4 and 5). The lowest AMBC was recorded for samples obtained from RC; however, the highest AMBC was obtained for samples from LS producers (Table 4 and 5). CC of Irgo sampled from RC was 1.06 log cfu mL^{-1} lower (P<0.05) than that sampled from LS producers (Table 5). The difference in CC between SS and LS producers, however, was not significant (P>0.5). LAB count of milk (Table 4) and Irgo (Table 5) were higher for LS producers; though the difference was apparent (P<0.05) only for milk (Table 4). Coliform count of Irgo was significantly (P<0.05) lower for SS producers than the other two producer groups (Tables 5).

Table 3. Condition of keeping fresh and fermented milk produced by different producers

Dairy product	Condition of keeping								Total	
	In refrigerator		In water		At room temp.		No practice[1]			
	Freq.[2]	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Milk										
Small-scale	7	6.4	25	23	77	70.6	-	-	109	100
Large-scale	6	50	-	-	6	50	-	-	12	100
Research center	6	66.7	-	-	1	33.3	-	-	3	100
Fermented milk										
Small-scale	7	6.4	4	3.7	91	83.5	7	6.4	109	100
Large-scale	6	50	-	-	-	-	6	50	12	100
Research center	2	66.7	-	-	1	33.3	-	-	3	100

[1] refers to the absence of the practices (e.g. 7 of the small-scale farmers interviewed did not ferment milk, they rather disposed the fresh milk), [2]Frequency

Table 4. Least squares means (± s.e.) of microbial counts of ***milk*** for dairy product shops and different producers

Variable	Producer							Dairy product shops
	SS	LS	RC	Mean	C.V%	L.S.D	SL	
No. of observation	5	3	3	11				5
AMBC, log cfu mL^{-1}	8.34±0.17	8.63±0.23	8.18±0.23	8.38	4.8	0.70	NS	6.97±0.28
Coliform, log cfu mL^{1}	6.68±0.18^{a}	6.82±0.23^{a}	5.76±0.23^{b}	6.57	6.30	0.71	*	5.41±0.04
LABC, log cfu mL^{-1}	7.82±0.183^{ab}	7.16±0.236^{b}	7.16±0.236^{b}	7.68	5.33	0.72	*	6.81±0.21

Means with different superscripts within the same raw are significantly (P<0.05) different SS=Small-scale, LS=Large-scale, RC=research center, C.V.=Coefficient of variation, LSD=Least Significant Difference, SL=significance level , AMBC=Aerobic Mesophylic Bacteria Count, LABC=Lactic Acid Bacteria Count, NS=Non significant, *=P<0.05

Acidity

Titrable acidity of milk and *Irgo* samples collected from DPS was 0.27 and 0.87%, respectively. Samples of *Irgo* collected from SS, LS and RC had a titrable acidity of 0.85, 0.67 and 0.95%, respectively, while values observed for milk were 0.3, 0.34 and 0.21%, respectively. Milk might have been kept long at ambient temperature between milking and sampling at the farm extending the time between milking and analysis attributing to the high milk acidity.

Table 5. Least squares means (± s.e.) of microbial counts of ***Irgo*** for dairy product shops and different producers

Variable	Producer							Dairy product shops
	SS	LS	RC	Mean	C.V%	L.S.D	SL	
No. of observation	5	3	3	11				5
AMBC, log cfu mL^{-1}	8.14±0.26	8.40±0.34	7.77±0.34	8.38	7.2	1.02	NS	7.1±0.28
Coliform, log cfu mL^{-1}	4.22±0.168[b]	5.40±0.217[a]	5.22±0.217[a]	6.57	7.80	0.66	*	4.47±0.40
LABC, log cfu mL^{-1}	6.71±0.232	6.91±0.301	6.49±0.301	7.68	7.80	0.91	NS	6.89±0.21

Means with different superscripts within the same row are significantly (P<0.05) different SS=Small-scale, LS=Large-scale, RC=research center, C.V.=Coefficient of variation, LSD=Least Significant Difference, SL=significance level , AMBC=Aerobic Mesophylic Bacteria Count, LABC=Lactic Acid Bacteria Count, NS=Non significant, *=P<0.05

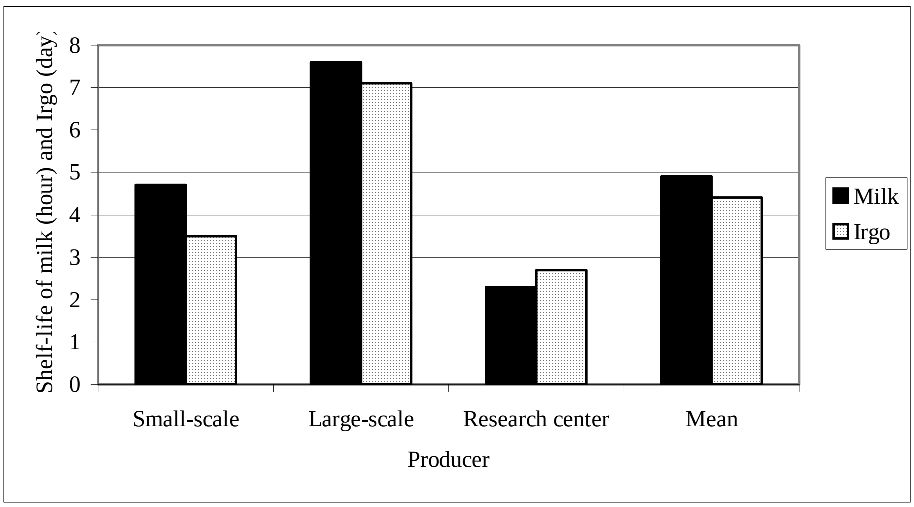

Fig. 1. Shelf-life of milk and *Irgo* before consumption and/or sale under different production systems

Discussion

Handling of dairy products

The sanitary measures taken by the producers during handling of milk and milk products at different stages were generally substandard. This holds true particularly for small-scale and large-scale producers where the use of collective towel for udder cleaning was common and most of this former groups responded not to treat surface water before use. The organoleptic properties of products used as a quality test by most SS producers doesn't guarantee the absence of pathogenic organisms. The sanitary procedures practiced for manufacturing an apparently similar product varied considerably among producer groups, even within the same group. Fekadu Beyene (1994) and Duteurtre (1998) also reported similar results.

Microbial load of raw milk and *Irgo*

AMBC in milk was associated with ambient temperature, time elapsed since milking and level of hygiene. AMBC obtained for milk in this study were generally high (6.97 log cfu mL^{-1} for DPS and 8.38 log cfu mL^{-1} for the three producers) as compared to the acceptable value ($1x10^5$ bacteria per mL of milk) (O'Connor, 1994). As indicated earlier in the Material and Methods section, types of milk samples collected from DPS were different. However, no apparent difference was observed in microbial load among the samples indicating either the absence of pasteurization, incorrect pasteurization or post pasteurization contamination. This high bacterial concentration could be associated with the original heavy load of bacteria in raw milk before pasteurization. Pasteurization usually reduces the percentage of bacteria to about 1%, but this number can be substantial if the original bacterial load in raw milk is high. In addition, bacterial cells can recover after thermal injury under the favorable tropical temperatures that prevail during transportation or at retail outlets that do not have chilling facilities such as kiosks (Omore *et al.*, 2001). The utensils holding the raw and pasteurized milk and the plastic sacs used for bagging the pasteurized milk as indicated by Mahari Tetemke and Birhanu Abegaz Gashe (1990) could also contribute to further contamination. A number of workers reported similar values of aerobic mesophilic counts that ranged between 4×10^7 and 3×10^9 cfu mL^{-1} (Kurwijila *et al.,* 1992; Mogessie Ashenafi, 1995; Taye Tolemariam *et al.*, 2000; Bekele Godefay and Bayleyegn Molla, 2000). Fekadu Beyene (1994), however, obtained lower counts (1×10^3 - 7.5×10^5 cfu mL^{-1}) and higher values up to 8.7×10^9 cfu mL^{-1} were reported for milk sampled from markets in central Ethiopia (ILCA, 1993). AMBC of 10^6 cfu mL^{-1} were also reported for camel milk (Teshager Semereab and Bayleyegn Molla, 2001).

Coliform count, on the other hand, is especially associated with the level of hygiene during production and subsequent handling since they are mainly of fecal origin (Omore *et al.,* 2001). Coliforms comprise all aerobic and facultative anaerobic, gram-negative, non-spore-forming rods able to ferment lactose with the production of acid and gas at 32°C within 48 hours (Feng *et al.*, 1998).

Milk sampled from DPS and the three producer groups had proved high level of contamination with CC of 5.41 and 6.57 log cfu mL^{-1}, respectively. CC of >100 cells/mL of raw milk shows that the production condition is unhygienic and the products are unsafe for consumption (Ingalls, 1998). The high AMBC and CC obtained in this study might be attributed to poor hygienic handling practices leading to initial contamination and/or related to udder infections, the case of which needs further investigation. Coliforms are inhabitants of the intestinal tract of warm-blooded animals and most of them are classified in the genera *Escherichia*, *Enterobacter, Klebsiella* and *Citrobacter*. Application of the test for coliforms is intended to measure the quality of practices used to minimize bacterial contamination of dairy products. Such tests are also conducted following pasteurization to detect bacterial contamination of milk, cream and other processed dairy products (Richardson, 1985).

The higher CC of milk samples obtained for SS and LS farms as compared to RC might be due to differences in hygienic measures taken during production. Although LS farms produce milk, they also collect a considerable amount from SS producers. This could justify the similar results obtained for these two producers. Coliforms could contaminate milk from manure, bedding materials, contaminated water, soil and inadequately cleaned milking utensils (Lampert, 1975; Kalogridou-Vassiliadou, 1991). According to the survey result, around 34% and 33% of SS and LS producers used bore hole water for cleaning the udder before milking and for washing milk utensils. About 34% of SS and 50% of LS producers, respectively, used the water without any treatment. This type of management obviously renders further contamination possible. Of course, it is not practical to produce milk that is always free of coliforms. Their presence in raw milk may therefore be tolerated. However, if present in large numbers, say over ten coliform organisms per milliliter of pasteurized milk, it means that the milk was produced under improper procedures (O'Connor, 1994; Walstra *et al.*, 1999).

The reason for the low CC of fermented milk samples for SS producers as compared to LS producers and research centers is not clear as their acidity was similar. However, variations in holding time at ambient temperature practiced by the different producers could be accountable. Fekadu Beyene (1994) reported ≥ 8.6 log cfu mL^{-1} of AMBC for fermented milk sampled from Southern Ethiopia. CC of >4.4 log cfu mL^{-1} were also reported for fermented milk samples by the same author. Tarik Kassaye *et al.* (1991) reported

AMBC of fermented milk (*Ititu*) samples collected from individual households in Borana region (Southern Ethiopia) to be 10^{12} cfu mL^{-1}, mainly dominated by lactic acid bacteria. Taye Tolemariam *et al.* (2000) and Mogessie Ashenafi (1995) on the other hand reported CC of 10^{3}-10^{6} cfu mL^{-1} for raw milk sampled from different parts of Ethiopia. CC of 10^{4} cfu mL^{-1} were also obtained for camel milk (Teshager Semereab and Bayleyegn Molla, 2001). Eyasu Seifu and Fekadu Beyene (2000) indicated that goats' milk after 24 h of storage at 25°C had AMBC, CC and LAB counts of 7.34, 5.46 and 6.78 log cfu mL^{-1}, respectively.

The markedly lower LAB count observed in raw milk for research centers could be attributed to the freshness of the product and the reduced level of contamination due to better management level.

In the study areas, an earthen pot is used for fermentation and butter-making. This pot is usually smoked using burning embers of *weira* (Amharic term for *Olia africana*) before each batch of fermentation and butter-making by most SS producers. This smoking process, as reported by O'Mahoney (1988), Fekadu Beyene (1994) and Mogessie Ashenafi (2002), has anti microbial properties. Mogessie Ashenafi (2002) for instance reported 12 more hours to be needed to reach total non LAB counts of $>10^{8}$ cfu mL^{-1} in milk kept in smoked containers than that kept in an unsmoked containers. This may justify the apparently lower concentration of coliforms in *Irgo* samples collected from SS producers as this smoking is commonly practiced by this group of producers.

The mean milk LAB count of 7.68 log cfu mL^{-1} obtained for dairy product shops in this study is comparable with that reported for market milk sampled from the central Ethiopia (ILCA, 1993). Mogessie Ashenafi and Fekadu Beyene (1993) reported that LAB accounted for 50% of the microflora of fermented milk (pH 4.6) from Awassa College Dairy Farm. LAB count of $\geq$ 7.9 log. cfu mL^{-1} were also obtained in 75% of locally produced fermented milk samples from Southern Ethiopia (Fekadu Beyene, 1994).

Among others, lack of knowledge on clean milk production, use of unclean milking equipment coupled with lack of potable water for cleaning purpose might have contributed to the poor hygienic quality of the dairy products. Differences in microbial qualities of dairy products produced by the different groups presumed to be the result of variations in production, processing and preservation practices followed at different stages. There is no as such a standard practice in the method of processing and handling of the dairy products in these farms. The existence of such variation suggests the need for intervention aimed at developing standard code of practice for production of a given product of certain quality based on local production conditions.

Drinking of raw milk is not uncommon in the country in general and in the study area in particular, which is highly inadvisable. However, the consumption of fermented milk and fermented milk products has little deleterious effect on the health of the consumers. The lactic acid bacteria rapidly hydrolyze the lactose found in milk to yield lactic acid, which is not a suitable carbon source for most pathogens. These bacteria also form compounds that are antagonistic to some pathogens. Most pathogens, if present, die within a few weeks in fermented products. However, there is a real danger if pathogens are present in raw milk and products such as soft cheeses made from raw milk (Walstra *et al.*, 1999). Heat treatment such as pasteurization, when applicable, is a reliable means of reducing bacterial load and excluding pathogenic ones. Milk should be boiled using available materials at pasteurization time and temperature.

Acidity

The percentage of acid present in dairy products at any time is a rough indication of the age of the milk and the manner in which it has been handled. Its measurement is affected by any conditions that cause a change in the calcium phosphate of the samples (Richardson, 1985; O'Connor, 1994). *Irgo* samples had over 150% more acidity than milk samples as expected. This had resulted in reduced microbial load of *Irgo* as acidity checks out certain microbes. Lactic acid resulted from the fermentation by LAB is an effective inhibitor for many bacteria if it is undissociated (Walstra *et al.*, 1999). Hardly any bacteria can grow in milk brought to a pH of <4.5 by this acid, but yeasts and molds can (Walstra *et al.*, 1999). Bacteria also can produce other inhibiting substances, such as acetic acid, and antibiotics. Some strains of *Lactococcus lactis subsp. lactics* produce the powerful antibiotic nisin (Walstra *et al.*, 1999).

Conclusion

The sanitary measures taken at different stages in the dairy chain of the study area were generally unsatisfactory and cause deterioration and contamination of the products. Adequate sanitary measures should be taken at all stages from production to consumption. These include measures at the level of the cow, the personnel, milking and processing equipment, milking and milk handling environment, cleaning water, and all other things that come in contact with dairy products from farm to table. Variations in microbial qualities of dairy products produced by various producers were observed. Dairy products sampled from different dairy product shops and producer groups had high counts of aerobic mesophilic and coliform groups of bacteria. Further investigation is recommended to identify contaminants at species level. Such an effort to identify emerging pathogens like Enterohemorrhagic *Escherichia coli* O157:H7 deserve particular concern.

Acknowledgements

The financial support of the French embassy in Ethiopia and the International Foundation for Science (IFS) is appreciated. The authors are also beholden for the facilities and services provided by the Holetta Agricultural Research Center of EIAR and the ILRI Debre Zeit Research Station.

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Eth. J. Anim. Prod. 6(2) - 2006: 83-92

Effect of Phytase Enzyme Supplementation of Maize Based Broiler Diets on Growth Performance, Availability of Minerals and Economic Benefits

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Abstract

A study was conducted to evaluate the role of phytase-2500 enzyme on growth performance; ash percentage, calcium and phosphorus contents of toe and tibia bones; and on the economic benefits of its addition to a maize based broiler chicken diets. Seventy-two New Hampshire broiler chicks were used and distributed randomly into four different treatment groups using a Completely Randomized Design (CRD), with three replicates of six chicks each. Phytase enzyme at the levels of 0(T_1), 200 (T_2), 400 (T_3) and 600 (T_4) Units/kg diet were added. The supplementation of broiler diet with phytase enzyme significantly improved body weight gain (905.87 to 1078.51 gm), reduced average feed intake (2656.99 to 2021.53 gm) and improved the feed conversion efficiency (2.94 to 1.87). Phytase enzyme addition significantly improved the ash, calcium and phosphorus contents in the toe and tibia bones, and increased the net profit to Rs. 13.59 (T3)

Key words: Bone minerals, enzyme, maize diet, performance, Poultry, profit

Introduction

About two-third of the phosphorus in poultry feeds of plant origin is found as phytate-phosphorus, which has low availability to simple-stomached animals. Phytate is a compound that occurs naturally in many foods derived from plants (Paul and Soutugate, 1978; Maga, 1982). There are anti-nutritional factors that hinder the availability, digestibility, absorption and utilization of nutrients in poultry feeds. These have depressive effects on the digestion of protein, carbohydrate, and in the utilization of minerals and vitamins. Of these, phytic acid is ubiquitous in plant-derived feeds in the form of phytate (Lange *et al.,* 2000).

Phytate has been recognized as a toxic nutrient because it binds various essential metals and also reduces their availability for absorption in the diet of monogastric animals, which lack endogenous phytase enzyme. The pretreatment of poultry feeds with exogenous enzymes would increase the bioavailability of the chelated nutrients and improve the nutritional value of the diet (Bedford, 2000). This investigation was initiated to evaluate the effect of phytase enzyme on growth performance of broilers, availability of minerals in toe and tibia bones, and to determine the economic benefits in adding phytase in broiler diets.

Materials and Methods

Study site

The investigation was conducted at the Poultry Research Center (PRC) of G. B. Pant University of Agriculture and Technology, Pantnagar, Uttaranchal during the period 17th January 2002 to 11th March 2002.

Procurement of chicks and their management

A total of seventy-two, New Hampshire broiler chicks were obtained from the Poultry Research Center. The chicks were wing band numbered, individually weighed and distributed randomly into twelve pens with of six chicks each. The chicks were kept on raised wire mesh floors in the brooder house, and had free access to light. Feed and water were given *ad libitum* throughout the experimental period. Individual body weight and feed consumption were recorded on weekly basis for chicks in each pen.

Preparation of experimental diets

The broiler starter feed (Table 1) was purchased from Uttar Pradesh Agro Industrial Corporation, Moradabad. Phytase-2500 enzyme, which was procured from Varsha multi tech, Bangalore was added at the levels of 0 (T1), 200 (T2), 400 (T3) and 600 (T4) Units (U) per kg of the diet and uniformly mixed. The experiment was executed in a Completely Randomized Design (CRD) with three replications comprising of four phytase levels. A unit of phytase is defined as the quantity of enzyme that releases 1 μmol of inorganic orthophosphate per min. from 5.1 mM sodium phytate at pH 5.5 and 37 ^{O}C (Engelen *et al*., 1994).

Sampling of bones for analysis

Twelve birds, three from each treatment were picked randomly at the end of the experimental period and killed by cutting the whole neck. The left and right tibia bones of the birds were collected, separately. The toes samples of the killed birds from both legs were obtained by severing the middle toes through the joint between the second and third tarsal bones from the distal end were collected, separately, yielding two samples of toes per pen. The samples of toes were dried to constant weight at 100^{0}C and then ashed in a muffle furnace at 600^{0}C for 4 hrs. The tibia samples, after oven-drying, were cleaned from all adhering soft tissue. The bone samples were then extracted for about 8 hrs in a soxhlet apparatus using petroleum ether, and ashed at 600^{0}C for 4 hrs in a muffle furnace. The ash obtained was solubilized with hydrochloric acid (1:1, V/V) and made up to volume in a 100ml volumetric flask using distilled water.

Table 1. The composition of the experimental diet *****

Ingredients	Percent
Maize	42
Deoiled soybean meal	22
Deoiled rice bran	12
Rice polish	10
Jwala fish	7
Mineral mixture	1
Lime stone	3
Molasses	3
Total	100

*- Feed additives provided per 100kg diet: Vitamin AB2D3K, 10 gm; Vitamin B- complex, 20 g Neftin-200, 50 gm; other vitamins, 200 gm; Check 'O' Tox, 200 gm; Liveroline, 100 gm and Meridot, 50 gm.

Chemical analysis

Representative samples for the determination of the dry matter and crude protein contents of poultry feeds and their excreta were taken and analyzed according to AOAC (1990) procedures. Acid insoluble ash determinations were performed after ashing the samples and treating the ash with hydrochloric acid (1:1, V/V) (Gupta et al., 1992). Phosphorus was analyzed calorimetrically after digestion of the sample with hydrochloric acid according to the method of Gupta et al. (1992). Gross energy was determined using the chromic oxide method (O'Shea and Maguir, 1962), phytate-phosphorus content (Haugh and Lantzsch, 1983) and calcium with the help of GBC Avanta 1.33 version Atomic Absorption Spectrophotometer.

Statistical analysis

The experiment was conducted in Completely Randomized Design (CRD) with four treatments comprising four phytase levels each replicated three times. The data obtained was statistically analyzed using MSTAT-C computer software (1989). Significance of mean differences was tested using (Duncan,

1955) The Duncan's multiple range test. partial budgeting was used to analyze the benefits of phytase supplementation on the maize based broiler diets.

Results and Discussion

Body weight gain

The effects of various levels of supplementation of phytase enzyme on body weight gain of broilers at the end of seven weeks of the experimental period are presented in Table 2. There were significant differences between the treatment groups due to the addition of various levels of phytase enzyme. Treatment 3 (T_3), which had 400 U of phytase/kg of the diet, had highest weight gain (1078.51 gm). These values were significantly ($P<0.01$) higher than all other treatments; T_2 showed the second highest value (1021.32 gm) followed by T_4 (959.66 gm). Treatment 1 (where no phytase was added) showed the lowest weight gain value (905.87 gm). There was an increase in mobilization of nutrients due to phytase enzyme supplementation.

Phytase-2500 enzyme exerted growth promoting effect on broiler chicks at 400 U of phytase added in the ration. In contrast Arun and Dewgoda (1997) reported non-significant differences in live weight gains in broiler chickens due to enzyme supplementation. These findings are in agreement with previous work by Cabahug *et al.* (1999), who observed that there were little benefits in performance responses due to the addition of phytase enzyme beyond 400 FTU per kg diet. On the other hand, Kornegay *et al.* (1996) found that on maize soybean meal and semi purified soybean meal diets where responses to phytase enzyme reached a plateau were 600 to 700 FTU/kg diet.

Feed intake

The supplementation of phytase enzyme in maize based broiler diet showed an effect on feed intake (Table 2). At all age group birds in T_1 consumed the highest amount of feed followed by T_2, T_4 and T_3. The values differed significantly ($P<0.01$) among each other. Feed intake was least for birds in T_3 (2021.53 gm) followed by those in T_4 (2076.61 gm), T_2 (2339.53 gm) and T_1 (2656.99 gm). Yi *et al.* (1996) indicated that the addition of supplemental phytase at the levels 350, 700, 1050 U/kg of soybean or corn meal increased feed intake from 6 to 25 %.

Feed efficiency

The calculated values of feed conversion efficiency (feed: gain) of broilers in this experiment are presented in Table 2. The best-feed conversion efficiency was recorded in T_3 throughout the experiment. This treatment had 400 U of phytase/kg of diet. The values of feed efficiency also showed significant (P<0.01) differences between the treatments. The values of feed efficiency were noted as 2.94 (T_1), 2.30 (T_2), 1.87 (T_3) and 2.17 (T_4). Supplementing piglet diets with 1500 U phytase activity per kg feed significantly improved the feed conversion efficiency from 1.65 to 1.52 (Jongbloed et al., 1993).

Mortality

No mortality was recorded in broiler chicks consuming diets supplemented with 200 U (T_2) and 600 U (T_4) of phytase enzyme. However, the mortality was higher in birds under the control and 400 U of phytase supplemented diets. A mortality of 5.56 and 16.67% was recorded for the control, and 400 U phytase fed broilers, respectively.

Table 2. Effect of varying levels of supplemental phytase enzyme on broiler performance at the end of the seventh week

Phytase level (U/kg diet)	Body weight gain (gm/bird)	Feed intake (gm/bird)	Feed conversion efficiency
0	905.87^d	2656.99^a	2.94^a
200	1021.32^b	2339.51^b	2.30^b
400	1078.51^a	2021.53^d	1.87^d
600	959.66^c	2076.61^c	2.17^c
Mean	991.34	2273.66	2.32
SEM±	2.89	2.27	0.02
LSD	15.13^{**}	11.89^{**}	0.09^{**}

Values with different superscript within a column differ significantly at 1 %(**), 5 %(*)

Toe mineral contents

Ash, calcium and phosphorus contents of left and right toes of broiler chicks fed on supplemental phytase are summarized in Tables 3. The levels of supplemental phytase affected the ash contents of toes. The ash contents for both left and right toes varied significantly (P <0.05) between the treatment groups. The maximum percentage of ash was recorded at 200 U (left toe), and at 200 and 400 U/kg diet (right toe). The increased ash contents occurred due to the utilization of phytate-phosphorus, which was hydrolyzed by the dietary phytase. The ash content in the right toe at 600 U of phytase/kg diet was similar to that of the control.

It was reported by Tanveer *et al.* (1999) that the addition of phytase enzyme in the diet of birds with normal phosphorus content increased the total ash contents of toe by 12.1%. Kornegay (1994) suggested that toe ash content in broiler and turkey poults were the most sensitive criteria to assess microbial phytase efficacy. Supplementation of phytase enzyme at 350, 700 and 1050

U/kg soybean or corn meal had improved the toe ash percentage from 4 to 18% (Yi *et al*., 1996).

The addition of phytase also increased (P< 0.05) the calcium content in the left toe. This improvement was noted to be the highest in T_2 (200 U phytase/kg diet), followed by T_3 (36.08%), T_4 (35.82%). Lowest value was recorded in T_1 (32.22%). Statistically, there was no difference between T_1, T_3 and T_4. The contents of Ca in the right toes were lower than the left ones except for T_3, where the Ca content in the right toe was higher (47.14%). No statistical difference was observed among T_2, T_3 and T_4 in case of Ca contents of the right toe.

Table 3. Effect of varying levels of supplemental phytase enzyme on the mineral content broilers toes

Phytase level (U/kg diet)	Ash (%)		Ca (%)		P (%)	
	Left	Right	Left	Right	Left	Right
0	10.16^{c}	10.66^{b}	32.22^{b}	23.37^{b}	27.63^{c}	20.73^{b}
200	13.11^{a}	13.14^{a}	45.03^{a}	42.05^{a}	39.33^{ab}	29.73^{ab}
400	12.11^{ab}	13.65^{a}	36.08^{b}	47.14^{a}	47.49^{a}	35.44^{a}
600	11.21^{bc}	10.88^{b}	35.82^{b}	35.41^{ab}	32.93^{bc}	32.93^{a}
Mean	11.65	12.09	37.29	36.40	36.85	29.71
SEM±	0.43	0.54	1.97	3.19	2.87	2.72
LSD	1.51*	9.55*	6.80*	16.75**	9.95*	9.42*

Values with different superscript within a column differ significantly at 1 %(**), 5 %(*)

Tibia bone mineral contents

Supplemental phytase had a remarkable effect on the ash content (table 4). Significantly (P<0.01) low value (39.6%) was noted for the control, but the treatment groups had higher values viz. 56.7% in T_3, 54.47% in T_2 and 46.73% in T_4. The value of T_3 was significantly (P<0.05) higher than the control. The same trend was noted for Ca and P. The values of Ca were significantly (P<0.05) higher compared to the control group. Similarly, phytase levels had significantly (P<0.05) higher values of P compared to the control.

The ash content improved in T_2 and T_3 due to increase in level of phytase supplementation, but a significantly lower value of ash was noted in T_4, which had the highest level of phytase. Calcium content was higher in T_2 and T_3 but significantly (P<0.05) lower in T_4. The P percent in the right tibia showed the lowest value in control group (34.72%), an increase in T_2 (47.76%), and a decrease in T_4 and T_3. The difference between T_1 and T_3 were not significant (P>0.05), however, the value of T_2 was significantly (P<0.05) higher than all other treatments.

Phytase treatment of diets is reported to increase the tibia ash contents (Sebastian *et al*., 1996). Phytase addition in the diets of birds improves the ash content of the tibia by 62% (Tanveer *et al*., 1999), and ash percentage of the tibia bone is considered to be a good indicator of bone mineralization, and increased phosphorus and calcium availability, which leads to increase the calcium and phosphorus contents of the bone (Simons *et al*., 1990). Broz *et al*. (1994) found that phytase supplementation in maize and soybean meal based diets increased the tibia ash percentage in broiler chickens. Kornegay *et al*. (1996) found that tibia might be less sensitive to dietary phosphorus availability than toe ash. Qian *et al*. (1996) reported that both phosphorus and calcium account for more than 50% of the bone ash contents.

This study showed an increase in toe and tibia ash contents in chickens fed on diets supplemented with phytase. Higher contents of calcium and phosphorus in the bones of phytase supplemented chicken were due to increase in the phytate phosphorus utilization.

Table 4. Effect of varying levels of supplemental phytase enzyme on the mineral content of the tibia bones of broilers

Phytase level (U/kg diet)	Ash (%)		Ca (%)		P (%)	
	Left	Right	Left	Right	Left	Right
0	39.96^{b}	40.52^{b}	32.90^{b}	46.88^{b}	32.94^{b}	34.72^{a}
200	54.47^{a}	53.93^{a}	50.54^{a}	61.77^{a}	49.30^{a}	47.76^{b}
400	56.70^{a}	50.80^{a}	55.37^{a}	62.69^{a}	48.72^{a}	37.76^{a}
600	46.73^{ab}	38.99^{b}	55.70^{a}	48.69^{b}	36.94^{a}	39.77^{ab}
Mean	49.47	46.06	48.63	55.01	41.98	40.01
SEM±	2.08	2.55	3.49	2.76	3.40	2.32
LSD	10.93**	8.81*	12.06*	9.55*	11.76*	8.04*

Values with different superscript within a column differ significantly at 1 %(**), 5 %(*)

Economic analysis

Economic analysis showed significant ($P < 0.01$) variation between the treatment groups. The highest economic benefit (Rs. 53.93) was noted for T_3, followed by T_2 (Rs .51.06), and T_4 (Rs. 47.98). The lowest benefit (Rs. 49.57) was recorded for the control group. Based on a value of Rs. 50/kg live weight for a broiler, and a feed cost of Rs. 8/kg, the cost of feed intake was Rs. 21.27, 18.72, 16.17 and 16.61 for T_1, T_2, T_3 and T_4, respectively. These values were statistically different ($P<0.01$). The cost of phytase (based on Rs. 480/kg) in the different treatments was Rs. 0.00 for T_1, 0.09 for T_2, 0.15 for T_3 and 0.24 for T_4.

On the basis of the above calculations, net profit of Rs.8.23, 13.59 and 7.11 per bird, were recorded for T_2, T_3 and T_4 respectively. Hence, the highest profit was from the group on T_3. Gulam (2002) reported the influence of feeding enzyme supplemented rations on the profit per broiler was to be Rs. 2.80 compared to the control group in a 12-day trial.

Table 5 Effect of varying levels of supplemental phytase enzyme on overall costs and benefits of broiler production

Phytase level (U/kg diet)	Cost of chick (Rs 50/kg live wt.)	Cost of feed intake (Rs 8/kg feed)	Cost of phytase (Rs 480/kg phytase)	Gross cost (Rs.)	Gross profit (Rs.)	Net profit (Rs/broiler)
0	45.29^{d}	21.27^{a}	0.000^{d}	21.27^{a}	24.02^{d}	0.00^{d}
200	51.06^{b}	18.72^{b}	0.090^{c}	18.81^{b}	32.25^{b}	8.23^{b}
400	53.93^{a}	16.17^{d}	0.150^{b}	16.32^{d}	37.61^{a}	13.59^{a}
600	47.98^{c}	16.61^{c}	0.240^{a}	16.85^{c}	31.13^{c}	7.11^{c}
Mean	49.57	18.20	0.12	18.32	31.26	7.24
SE±	0.15	0.02	0.002	0.019	0.15	0.15
LSD	0.76**	0.09**	0.095**	0.095**	0.83**	0.83**

Values with different superscript within a column differ significantly at 1 %(**),

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Eth. J. Anim. Prod. 6(2) - 2006: 93-97

SHORT COMMUNICATION:

Early Pregnancy Diagnosis in Cows Using Germination Responses of Different Crop Seeds to Urine Treatment

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Abstract

This study tested pregnancy in cows using differences in germination rates of five crops (maize, wheat, barely, field pea and sorghum) mixed with urine from 3 inseminated and 5 non-inseminated cows. Germination was tested using 25, 50, 75 and 100 % diluted urine There was no germination in 100 and 75% urine in both cases. At 50% dilution, urine from pregnant cows inhibited germination of all crops, but urine from non-pregnant cows inhibited germination of barely, wheat and sorghum and favoured germination of maize and field pea The result showed that germination was affected ($P < 0.001$) by treatment and crop type only. The study indicated that the test could be performed starting from one month of pregnancy using maize and field pea at 50% urine dilution and field pea, sorghum and wheat at 25% urine dilution. Further detailed studies are required, including other species of farm animal, to develop application methods of this simple technology at smallholder farm conditions.

Introduction

It is important to make the right pregnancy diagnosis as soon as possible after insemination so that non-pregnant animals can be observed more closely for heat (Heinonen, 1989). Pregnancy diagnosis in cattle is often done by rectal palpation requires skill and experience and is performed two months after breeding. The ideal pregnancy test would be one that is inexpensive, accurate and easily applicable that could be implemented under farm conditions as early as 17-19 days post breeding. There was an attempt by ancient Egyptians to diagnose pregnancy in cattle using a test that relies on the differential response in germination and shoot growth of wheat and barley seeds to the urine of pregnant and non-pregnant cows (Veena and Narendranath, 1993)..

The objective of this study was to test the validity of the technology in Horro cows using different crops

Materials and Methods

The study was conducted at Bako Agricultural Research Center which is located 258 km west of Addis Ababa at an altitude of 1650 masl. Urine from 3 inseminated and 5 non-inseminated Horro cows was used for the study. Urine was collected once a month for three consecutive months from cows inseminated and confirmed pregnant at the end of third month. The non-inseminated cows had at least three months after parturition. Five ml of urine solution from these two group of cows was prepared with tap water at 25%, 50%, 75% and 100 % urine, and distilled and tap water were used as control.. Clean seeds of five crops (maize, wheat, barley, sorghum and field pea) were used to test germination rates.

Ten treatments were formed by combining four dilutions (25, 50, 75 and 100% urine) and two urine sources (pregnant and non pregnant cows) and an additional two control treatments (distilled and tap water). Enough amount of the treatment solution was applied to petridishes containing twenty seeds of each crop. The treatments were replicated 6 times. The experiment was done three times at the first, second and third month of pregnancy stages. Germination of the seeds was checked for one week. After one week, the germinated seeds were counted and recorded. The treatment combinations are presented in Table 1.

Table 1. Treatment combinations

Treatment	Dilution (% Urine in solution)	Urine source
1	100	Pregnant cow
2	100	Non pregnant
3	75	Pregnant cow
4	75	Non pregnant
5	50	Pregnant cow
6	50	Non pregnant
7	25	Pregnant cow
8	25	Non pregnant
9	Tap water	Control
10	Distilled water	Control

The germinated seeds were counted from week one and percentage germination calculated and the data were transformed to their arc-sign equivalent. The General Linear Model of the Statistical Analysis System

(SAS, 1996) was used for data analysis. To determine the stage of pregnancy at which the method could be used to test pregnancy, data collected from pregnant cows were reduced to four (T1, T3, T5 and T7). The data were then transformed back to percentages .

Results and Discussion

Treatment, crop type, month, and treatment x crop type interaction significantly ($P<0.001$) affected germination percentage (Table 2). Treatment (T) with 100 and 75% urine (T1 to T4) resulted in no germination of the crops (Table 3). The highest germination was observed for distilled (87.9 ± 0.06%) and tap water (88.5 ± 0.06%). Germination increased as the proportion of urine from both pregnant and non-pregnant cows in the solution was reduced. In both 50% (T5 and T6) and 25% (T7 and T8) urine dilutions, urine from non-pregnant cows significantly reduced germination compared to urine from pregnant cows.

Comparison of the treatment x crop type interaction groups indicated that treatments 1 to 4 totally inhibited germination in all crops. At 50 % dilution, urine from pregnant cows inhibited germination of all crops, while urine from non-pregnant cows inhibited germination of barely, wheat and sorghum and favoured germination of maize and field pea. The germination of maize (20.9 ± 0.51% vs 0 ± 0.84%) and field pea (12.2 ± 0.51% vs 0 ± 0.84%) were higher ($P<0.001$) for urine from non-pregnant than pregnant cows. Thus, at 50 % dilution maize and field pea could be used as an indicator of pregnancy. At 25% dilution, urine from non pregnant cows resulted in a higher germination rate of field pea (50.9 vs 19.8%), wheat (78.2 vs 56.6%) and sorghum (19.6 vs 2.6%), respectively compared to urine from pregnant cows.

The effects of stage of pregnancy and its interaction with dilution rate were not significant ($P > 0.05$). The result indicated that the test could be performed starting from one month of pregnancy. A similar study in India by Veena and Narendranath (1993). showed that the urine of pregnant cows dramatically inhibited seed germination compared to that of non-pregnant cows and this persisted for 2-3 months after parturition. Generally, the inhibitory factor in cattle urine on seed germination has not yet been identified. The mammalian urine is known to contain auxins, the plant growth regulators, that have an equivocal effect on seed germination. Therefore, it is likely that the enhanced levels of such hormones in urine during pregnancy of cows might be causing the observed inhibition of seed germination (Veena and Narendranath (1993). Thus, from this study it can be concluded that maize can serve as a good indicator of pregnancy using 50% diluted urine and field pea, sorghum and wheat at 25% urine dilution starting from first month of pregnancy.

Table 2. Least square mean (±SE) germination percentage of five crops using different treatments

Source	N	Germination Transformed Mean ± SE	Germination Percent germination Mean ± SE
Treatments	8	***	***
100% urine from pregnant cow	3	0 ± 1.81 ^{e}	0 ± 0.1 ^{e}
100% urine from non pregnant cow	5	0 ± 2.34 ^{e}	0 ± 0.17 ^{e}
75% urine from pregnant cow	3	0.9 ± 1.81 ^{e}	0.2 ± 0.10 ^{e}
75% urine from non pregnant cow	5	0 ± 2.34 ^{e}	0 ± 0.17 ^{e}
50% urine from pregnant cow	3	10.9 ± 1.81 ^{d}	3.6 ± 0.10 ^{d}
50% urine from non pregnant cow	5	2.9 ± 2.34 ^{e}	0.26 ± 0.17 ^{e}
25% urine from pregnant cow	3	41.4 ± 1.82 ^{b}	43.7 ± 0.10 ^{b}
25% urine from non-pregnant cow	5	27.4 ± 2.34 ^{c}	21.1 ± 0.17 ^{c}
Tap water	6	69.6 ± 1.43 ^{a}	87.9 ± 0.06 ^{a}
Distilled water	6	70.2 ± 1.34 ^{a}	88.5 ± 0.06 ^{a}
Crop type		***	***
Barely	8	18.9 ± 1.40 ^{c}	105 ± 0.06 ^{c}
Field pea	8	20.3 ± 1.40 ^{bc}	12.0 ± 0.06 ^{bc}
Maize	8	23.3 ± 1.40 ^{b}	15.6 ± 0.06 ^{b}
Sorghum	8	18.7 ± 1.40 ^{c}	10.3 ± 0.06 ^{c}
Wheat	8	30.5 ± 1.40 ^{a}	25.8 ± 0.06 ^{a}
Month	8	***	***
1	8	21.85 ± 1.03 ^{b}	
2	8	19.60 ± 1.03 ^{b}	
3	8	25.53 ± 1.03 ^{a}	
Treatment X crop interaction		***	***

Means in a column within a group followed by different superscripts vary significantly (*** P<0.01)

Table 3. Analysis of variance for the effect of different stages of pregnancy on germination

Source	N	Arc Sign transformed	Percent germination
	3	Mean ± SE	Mean ± SE
Month	3	NS	NS
1	3	6.19 ± 1.86	1.2 ± 0.11
2	3	6.29 ± 1.86	1.2 ± 0.11
3	3	10.22 ± 1.86	3.2 ± 0.11
Month X dilution	3	NS	NS
1	3	0 ± 3.73	0 ± 0.42
3	3	0 ± 3.73	0 ± 0.42
5	3	0 ± 3.73	0 ± 0.42
7	3	4.00 ± 3.73	0 ± 0.42
11	3	4.77 ± 3.73	0.7 ± 0.42
12	3	36.13 ± 3.73	34.7 ± 0.42

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Eth. J. Anim. Prod. 6(2) - 2006: 99-103

FEATURE ARTICLE:

Getting the Incentives Right: Concerns Associated with Expansion of Cattle Export Markets in Ethiopia

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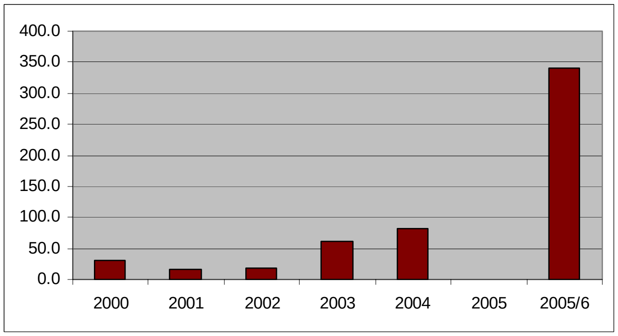
Incentives drive positive change and continued excellence in all walks of life. Various actors in livestock markets, not least cattle keepers, also see to their additional benefits that accrue to them from their participation in the expanding domestic and export markets. Official data from the Ministry of Agriculture and Rural Development as well as the Ethiopian Customs Authority on the volume and diversity of Ethiopian agricultural exports show unprecedented rises in the size of exports of livestock and livestock products in recent years. The rapidly expanding livestock exports generate greater revenues to the millions of livestock producers and the national economy in general. But the sudden surges in off take raise three issues. First, there are concerns on whether these expansions are sustainable at least in the long term. Second, there are serious concerns about the effects of rising off takes on supplies of replacement breeding stock and plough oxen. Third, there is a growing concern about escalations of prices of meat and live animals in the local market.

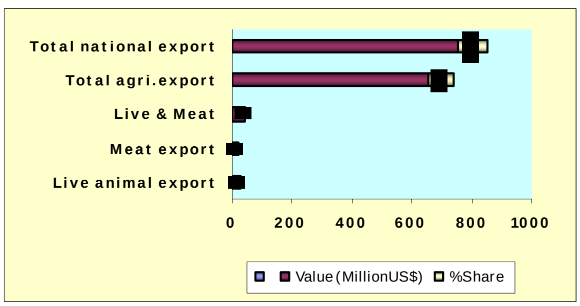
During the 2005/06 fiscal year, the total revenue from official exports was close to Birr 350 million, a nearly three fold rise from that of 2004/05, most of which was in the form of chilled goat and sheep meat and live cattle (Figure 1). Yet, the contribution of livestock to the total national export earnings, even during this fiscal year, could reach only a mere 5% (Figure 2). When these are compared with available estimates on the potential off take made available in 2003 by the former Livestock Marketing Authority, there is still a lot more room for expansion and diversification. Based on the estimated national off take rates of 10% for cattle, 38% for goats, 35% for sheep and 6.5% for camels pastoral areas of the country alone, which according to official sources have traditionally been supplying up to 95% of export livestock, could produce 734 thousand heads of beef cattle, 5.4 million goats, 2.3 million sheep and 78 thousand camels per annum. When these are compared to the current demand in the Middle East, they meet only half of the demand for goats and sheep, 42% for beef and 82% for camel meat, whereas the live beef cattle supplies are well over the demand (144%), requiring new markets outlets. This being the potential for export, the actual performance has remained very low, leaving most (55 to 85%) of the projected livestock off take for the unofficial cross-border export and the domestic market. The unofficial cross-border livestock export of live animals and skins & hides was estimated in 2003 by the former Livestock Marketing Authority to worth over US$100 million, which is about two and half times more than total export earnings in the whole of 2005/6 fiscal year, the best annual export performance so far.

Recently, Ethiopian exports of livestock products, especially chilled meat, have expanded both within and outside the Middle East. Apart from Egypt, which is emerging as a major meat export market, exports now reach West Africa, parts of Europe and even the Far East. The challenge now is getting easy access to sufficient numbers of good quality meat animals even from pastoral areas. Livestock traders are therefore exploring particularly cattle market opportunities in hitherto underutilized highlands. So much so that because of the attractive market prices, it is feared that the smallholder cattle keepers may give away too many of their young oxen and bulls at risk of compromising their short-term needs for traction and breeding bulls. In other words, current market prices may offer greater incentives in the short-term than the longer-term advantages of retaining inputs for traction and breeding. A more rational approach to understanding the incentives is to consider whether plough oxen and breeding bulls generate better livelihood security in their traditional service functions than in their alternative role as sources of beef. The case of breeding bulls can be more intriguing: if the cattle keepers get the right incentives for raising genetically superior breeding bulls that can serve not just their own herds but also those of their wider community, then the added benefits in owning a high-value genetic material will also come into picture. Individual cattle keepers in both pastoral and highland areas do make management choices in this regard to maximize their net aggregate incomes.



Source: Sintayehu (2003); Belachew Hurriessa, Pers. Comm. (2006)

Figure 1: Size of official livestock export (Million Birr) by year (complete data missing for year 2005)



Source: Belachew Hurriessa, Pers. Comm. (2006)

Figure 2: Contribution of livestock to total agricultural export during first 9 months of this fiscal year

So the expanding export markets should be seen rather as opportunities to individual cattle keepers and indeed to the country's livestock sector in general to raise the contribution of livestock to the household and hence the national economy. Even then, several core technical problems continue to constrain the expanding livestock markets:

- Most of the livestock keepers have a very weak market orientation. Their mode of production is largely subsistent; they do not have easy access to up-to-date market information; they rely heavily on the limited and seasonal domestic livestock markets. These increase their transaction costs even when they get opportunities to participate in livestock markets. As a result, most of market-age animals in smallholder herds and flocks are found in poor shape, as the producers lack the incentives to raise them to desired standards.

- Livestock diseases continue to limit Ethiopia's access to attractive markets. Increasingly stringent Sanitary and Phytosanitary Standards (SPS) are being set for access to major markets, when the country still has a very low capacity for meeting these standards at least in major sources of meat animals.
- Livestock market support services and infrastructure are very weak or non-existent. Public investment in these areas has to grow significantly.
- Up to now, involvement of the private sector in development of the livestock resources has remained very cautious, and still needs more substantial incentives to build investor confidence.
- There is not a single private beef ranch to at least demonstrate the production of prime beef for the export and domestic market. Even beyond their demonstrative role, ranches could also open up markets for young beef stock of surrounding cattle keepers, in order that the young stock can go through conditioning and fattening in the ranches and reach major markets. This effectively means improving market access to individual cattle keepers in remote areas where private cattle ranches may operate. Special policy support and attractive investment incentives, as with the mushrooming private flower farms, need to be put in place, to reassure serious investor confidence in livestock ranches.
- The relatively slow rate of reproduction of livestock, especially cattle, coupled with heavy initial investment requirements, means that the livestock sub-sector is at a disadvantage in attracting substantive investment from the private sector. This needs to be taken into account in policy formulation and development of investment guidelines.

Some immediate interventions, like better delivery of market information to producers, infrastructural improvements in existing major livestock markets, better organized linkages of producers with traders and putting in place long-term strategies for gradually meeting SPS goals could lead to yet stronger rises in the expansion of the livestock export trade through stronger incentives to the range of actors in the market chain. Robust public awareness activities are needed to sensitize policy makers on lost opportunities in untapped development potential of livestock in the country. The concern on limited supplies in the highlands of plough oxen cannot be served by limiting access to markets. Oxen in any case are productive only for a small part of the year while continuing to share the scarce feed resources for the rest of the year. The logic of individual farmers in keeping plough oxen throughout the year should be explained by their inability to bear the cost of getting oxen traction services during the peak work, i.e. the incentives of keeping them in house are higher than purchasing the service as needed when almost everybody else also needs it. At the time when oxen are already scarce, a more sustainable solution would be to search for alternative sources of traction power.

The desire for maintenance of adequate breeding animals at community level is seen both an individual as well as community development goal. However, the direct costs of maintaining breeding animals should ideally be off set by immediate and medium term benefits for individual breeders. Individual livestock keepers will have to be convinced of the merit of raising and keeping superior breeding animals. In other words, it is the benefits that accrue to the producers that justify the maintenance of breeding stock, and not the longer term need for genetic conservation, a concern not necessarily shared by individual livestock keepers. It is therefore the additional market incentives coming with expanding export markets that encourage individual livestock keepers and communities to raise and maintain superior performing breeding stock that cater for market demand. Limiting participation in export markets, as implied by the widespread fears arising from the growing off takes, does not serve the purpose of conservation, if not become counter-productive. To be consistent with the free-market economic policy of the country, we need to get the incentives right to the range of actors participating in the under-performing livestock sector.

These issues were taken up in a panel discussion hosted by the Ethiopian Economics Association on 12 June 2006 during its International Conference on the Ethiopian Economy. The panel discussion on "*Sustainability issues in diversification and rise of agricultural exports in Ethiopia*" was jointly organized by the Ethiopian Association of Agricultural Professionals (EAAP), the Ethiopian Society of Animal Production (ESAP), the Ethiopian Society of Agricultural Economics (ESAE) and the Ethiopian Crop Science Society (ECSS). The discussion reached a consensus that the issues be raised in similar forums to sensitise the range of relevant stakeholders at national and regional levels.

Information for Contributors

General

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

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

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

Objectives

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

Columns of the Journal

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

Research articles

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

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

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

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

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

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

Frequency of publication
Once a year (May)

Guidelines to Authors

General

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

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

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

Format for Manuscripts

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Acknowledgements: Should be briefly stated following the conclusion.

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

Ethiopian names should be in direct order, i.e., the full first name followed by the father's name and should not be abbreviated. E.g. Zinash Sileshi and not Sileshi, Z.
(Tesfu Kassa and Azage Tegegne, 1998).
(Alemu Yami and Kebede Abebe, 1992; Alemu Gebre Wold and Azage Tegegne, 1995; Zinash et

al., 1996) – Chronologically
According to Zinash Sileshi and Siyoum Bediye (1995)
Where more than two authors are quoted in the text: - Zinash Sileshi et al. (1990) or (Zinash Sileshi et al., 1990). However, all authors' names should be given in the Reference list.

Examples

Journal article:

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

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

Book

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

Chapter in a Book

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

Paper in Proceedings

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

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

Abbreviations
Follow standard procedures.

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

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

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

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

Membership to the Ethiopian Society of Animal Production (ESAP)

Membership advantages

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

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

Eligibility for membership

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

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Application for Membership

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First Middle Last

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Company/Institution:_____________________________________

Phone:____

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Type:

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Signature: ____________________Date:_____________________

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Ethiopian Journal of Animal Production (EJAP)

C/o Ethiopian Society of Animal Production (ESAP)

P.O.Box 80019

Addis Ababa

Ethiopia

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