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

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Abstract

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

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

Introduction

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

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

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

Material and Methods

Animals and Management

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

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

Data Collection

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

Statistical Analysis

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

Results

Phenotypic, Genetic and Environmental trends

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

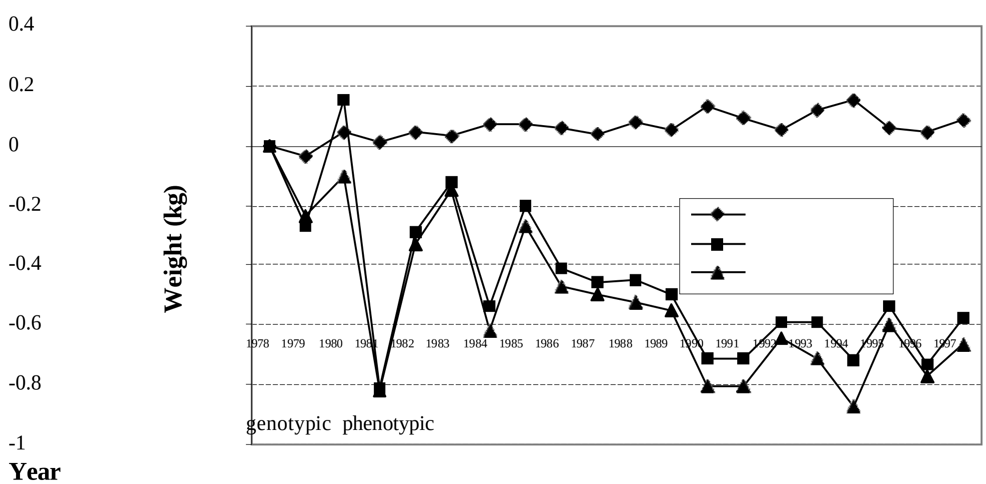

Figure 1. Phenotypic, Genetic and Envrionmental trends in BW of Horro sheep between 1978 and 1997 at Bako Research Center.

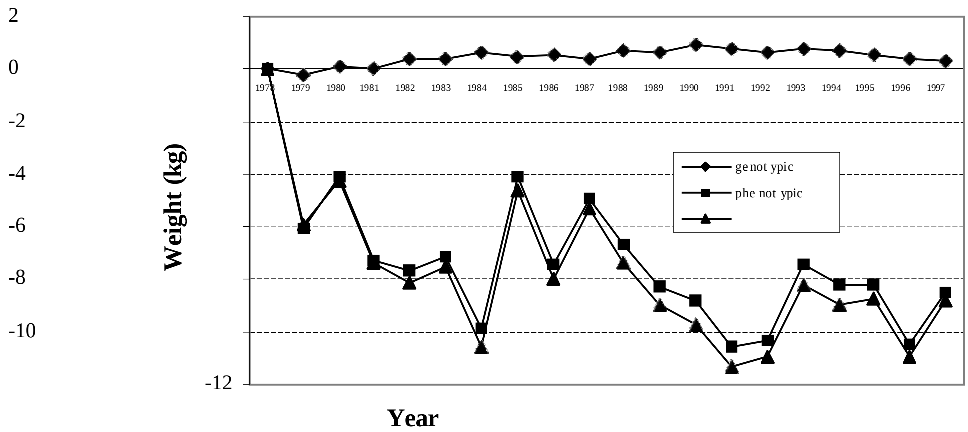

Figure 2. Phenotypic, Genetic and Environmental trends in WW of Horro sheep between 1978 and 1997 at Bako Research Center.

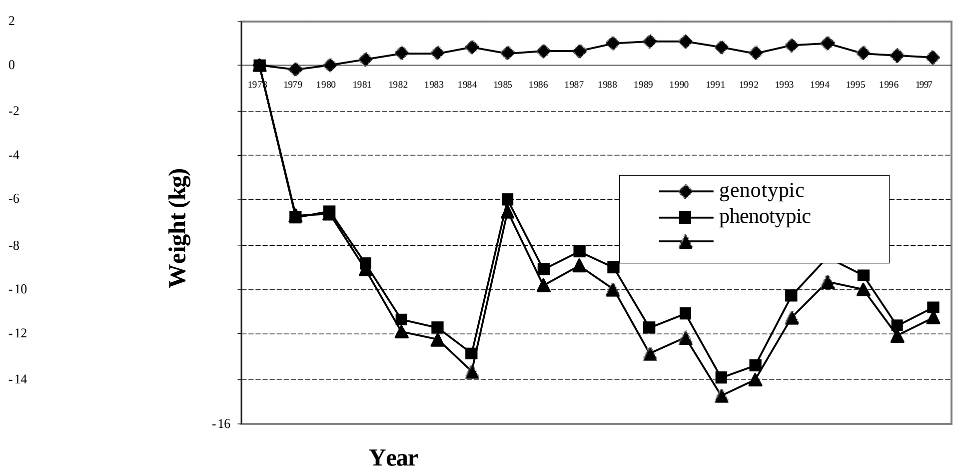

Figure 3. Phenotypic, Genetic and Environmental trends in 6MW of Horro sheep between 1978 and 1997 at Bako Research Center.

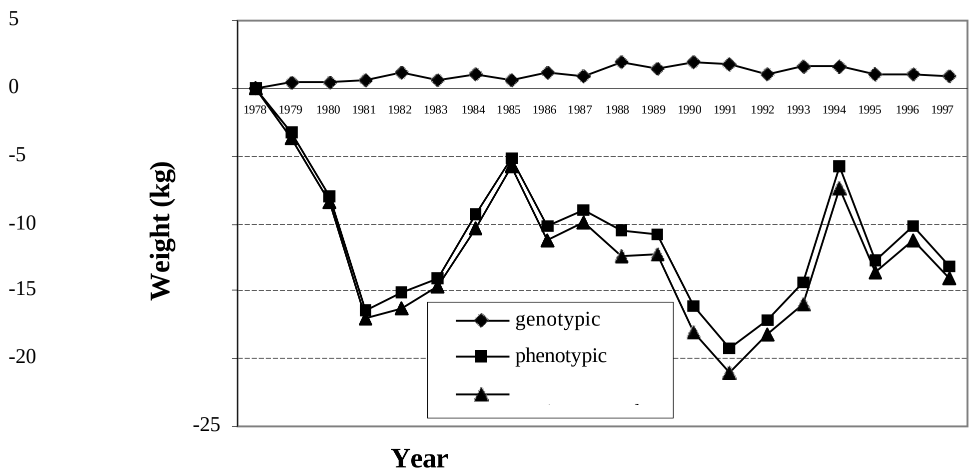

Figure 4. Phenotypic, Genetic and Environmental trends in YW of Horro sheep between 1978 and 1997 at Bako Research Center.

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

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

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

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

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

Discussion

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

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

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

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

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

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

Conclusion

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

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