The Estimate of Genetic Correlation and Heritability of Various Traits in Small East African Goats

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Abstract

This study was done on three strains of East African goats namely, Dodoma, Kigoma and Mtwara with the aim of estimating heritability for pre-weaning (4 months), post-weaning (8 months) and yearling (12 months) growth rates. Other heritability parameters measured were for weight at birth, 4, 8, and 12 months of age and helminth resistance traits (faecal egg count or FEC and packed cell volume or PCV) at six and twelve months of age. Genetic correlations were also determined between FEC, PCV and growth rate at six and twelve months of age. Genetic correlation and heritability were estimated using the Restricted Maximum Likelihood (REML) of the variance component (Var Comp) procedure of the Statistical Analysis System (SAS) package. Most of the traits were observed to have moderate heritability ranging from 0.32 to 0.39, with exception of weight at weaning (4 months), 8 months, one year of age and PCV, which had high heritability (0.4-0.44) estimates. Negative genetic correlations were observed between FEC and growth rate at six months (rg =-0.69 ± 0.042) and twelve months of age (rg=-0.8± 0.011), whereas, PCV showed positive genetic correlations with growth rate within the same periods rg =0.59± 0.010 and rg = 0.45± 0.022, respectively. It was concluded that the moderate and high heritabilities obtained for growth rates, weights at different age, FEC and PCV in this study indicate that improvement of growth rate, body size and genetic resistance to helminthosis could be improved through selection and manipulation of both the additive genetic action and non genetic (environmental) components for tropical goat improvement. It was also recommended that genetic manipulation at molecular level should be employed in identifying and isolating quantitative and qualitative trait loci (QTL) linked to economic and desirable traits, which will enable development of goats suitable for different ecological zones.

Keywords: Genetic correlation, heritability, Small East African goats

Introduction

In Tanzania, goats population is estimated to be 12.6 million (MoAFS, 2002, Census, 2002). Among these, 98% are indigenous goats of Small East African (SEA) types. Goats are multipurpose animals as they can produce a variety of products and by-products such as meat, milk, manure, skin, and hair and can be utilised in various social functions such as paying of dowries.

Heritability is one of the most important genetic parameters in breeding which describes the strength with which a quantitative trait is inherited. It is an indicator of the ranges of expected values for use in other genetic computations (Kifaro, 1984). It suggests the best method to use for improving the performance of a trait. For convenience, Herald (1994) categorised heritability estimates as low/weak (0 – 0.2), moderate/medium (0.21 – 0.39) and high/strong (0.4 - 1). On the other hand, genetic correlation

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refers to association between genetic effects that influence two traits. Correlation can either be positive or negative. Positive correlation indicates that selection for an increase in the first trait is associated with an increase in the second one in the progeny. However, if correlation is negative, selection for an increase in the first character will be associated with a decrease in the second character in the progeny.

Generally, animal improvement relies on the exploitation of their genetic potential and variability. Recent development of science and biotechnology has facilitated quick genetic gain through manipulation of molecular genetic technique to ease and hasten the process of identifying, isolating and locating traits of economic importance (Barger, 1989; Smith and Smith, 1993). For example it has been possible to detect/identify animals of desirable traits at early embryonic stage (Backer, 1991).

At the moment, Tanzania relies on the traditional sector to raise her small ruminant industry. The current poor performance of the local breeds is partly due to the fact that genetic potential of indigenous stock has not been developed through selection and other breeding methods and partly to the extremely poor environmental conditions and management practices to which these goats are exposed. In order to improve performance, both genotype and environment have to be improved.

In Tanzania, most work (Madubi 1997; Challya, 1998 and Keyyu, 1998) done on three strains of SEA goats have not determined heritability and genetic correlations of various traits.

The objectives of this study were therefore to estimate genetic correlation and heritability of growth rate, body weight at different ages and gastrointestinal parasite resistance parameters of Small East African goats.

Materials and methods

Study area

This study was carried out at the Department of Animal Science and Production, Sokoine University of Agriculture, Morogoro, Tanzania.

Data collection

Data used in this study were breeding records accumulated between 1997 and 2000 from a flock of Tanzania local goats kept at the Department of Animal Science and Production, Sokoine University of Agriculture. A total of 479, 333, 223 and 187 records of offspring from 15 sires were used to estimate heritabilities for birth weight, weaning weight, weight at 8 and 12 months of age, respectively. The same records were used to estimate heritabilities for pre-weaning, weaning, post-weaning and yearling growth rates. A total of 274 and 186 records of offspring from the same sires were employed in estimating heritabilities for faecal egg count (FEC), packed cell volume (PCV) and genetic correlation of growth rate and gastrointestinal parasite resistance parameters at six and twelve months of age, respectively.

Data handling

The sets of data for FEC and PCV were transformed to LFEC and LPCV before analysis. The transformations were done as follows: LFEC = [$\log_{10}$(FEC + 25), LPCV = $\log_{10}$ (PCV + 10) for FEC and PCV, respectively.

Data analysis

Heritability for growth rates, weights at different ages, FEC and PCV was estimated for half sib analysis using the REML (Restricted Maximum Likelihood) of the variance component (Var. Comp) procedure of the Statistical Analysis System (SAS, 1996) which gave the half sib sire variance components σ^2s) and the error variance component (σ^2_e).

The standard error (se) of the heritability values was obtained using the formula:

$$se = \frac{\sqrt{2(n-1)(1-t)[1+(K_1-1)t]^2}}{\sqrt{K_1^2(n-s)(s-1)}}$$

Where: se = standard error, n = number of individuals, t = interclass correlation, s = number of sires, K_1 = number of offspring per sire.

Since the number of offspring per sire were unequal, K_1 was calculated as follows:

$$K^1 = \frac{1}{s-1(n-\Sigma n^2_1/n)}$$

where: Σn^2_i = sum of squares for number of individuals per sire.

Heritability was obtained by multiplying $\sigma^2 s$ by 4 to get the additive genetic variance divided by σ^2_p which was obtained by summing up $\sigma^2 s$ and σ^2_e.

$$h^2_s = \frac{4\sigma^2_s}{\sigma^2_s + \sigma^s_e}$$

Where: $4\sigma^2 s$ = Additive genetic variance, $\sigma^2 s$ = Sire variance component, σ^2_e = Error variance component, $\sigma^2 s + \sigma^2_e$ = Total phenotypic variance.

Genetic correlation (rg) was estimated using the following model (Falconer, 1998):

$$rg = \frac{Covs_{ij}}{\sigma_{si} X \sigma_{sj}}$$

Where: s_i and s_j refer to sire effects for ith trait and jth sire while σ_{si} and σ_{sj} are square roots for sire variance components for traits 1 and 2.

Results

Heritability estimate for growth rates and weights of goats

Table 1 and 2 show heritability estimates for growth rates of goats between birth and four (pre weaning), 4-8 (post weaning) 8-12 months (yearling) of age, and weights at birth, weaning 4 (months), 8 months and 12 months of age. Heritability was moderate for birth weight (0.32), pre weaning growth rate (0.34) and yearling growth rate (0.28), while those of weaning (0.4), post weaning (0.41) and yearling (0.44) weights were high. Heritability estimates for weights of animals seemed to increase with increasing age.

Heritability estimates for FEC and PCV of goats

Table 3 shows heritability estimates for FEC and PCV of goats at six months and one year of age. Results revealed that heritability of FEC was moderate both at six (0.3) and twelve (0.35) months of age, while estimates for PCV were high at six (0.41) and twelve (0.43) months of age. It was also observed that heritability estimates for FEC and PCV increased with increasing age of the goats.

The estimate of genetic correlation between PCV, FEC and growth rate of goats

The genetic correlation between PCV, FEC and growth rate of goats are shown in Table 4. There was negative genetic correlation, between FEC and PCV (rg =-0.8±0.011) at six and twelve (rg = -0.72±0.031) months of age. FEC also negatively correlated with growth rate at six moths (rg =-0.6±0.042) and twelve months (rg = -0.4 ±0.030) of age, respectively, whereas PCV showed a positive rg (0.59±0.010, 0.45±0.022) with growth rate within the same period.

Discussion

Results on heritability estimates of growth rates and weights at different ages revealed that traits which had moderate heritability (Table 1) were birth weight, pre-weaning growth rate, post weaning growth rate and yearling growth rate. For these traits heritability ranged from 0.28 to 0.38, indicating that non-genetic (environmental) factors play a great role in the overall performance of goats. Traits which had high heritability (0.4-0.44) were weaning, post-weaning and yearling weights. For these traits it seemed that genetic and non-genetic factors contribute almost equally in influencing performance of the animals. According to Herald (1994), traits which are affected by moderate additive gene action (moderate h^2 values) respond moderately to genetic improvement through selection and crossbreeding respond moderately. Therefore, combined improvement methods viz ample nutrition and balanced diet, selection and crossbreeding could be instituted for better achievement of better birth weight and growth performance of the goats. On the other hand,

Table 1: Heritability estimates for pre weaning, post weaning and yearling growth rates of goats

Trait	h^2	s.e.	n
Growth rate (g/day)			
Birth weaning	0.32	0.013	333
Weaning - 8 moths	0.33	0.010	223
8-12 months	0.28	0.012	187

Table: 2 Heritability estimates for birth weight, weaning, post weaning and yearling weights

Trait	h^2	s.e	n
Weights (kg)			
Birth weight	0.32	0.011	479
Weaning weight	0.40	0.048	333
Weight at 8 months of age	0.41	0.015	223
Yearling weight	0.44	0.020	187

traits with high heritability or additive genetic variance have been viewed to respond highly to selection and crossbreeding.

Thus, the relatively high heritability estimates for weaning weight, post-weaning and yearling weights (Table 2) is favourable for working towards improvement of mature body size of the goats through "within breed" selection and proper management practices. The heritability values for live weights and growth rate at different ages observed in this study were higher than those reported by *Das et al.* (1994) in blended goats. They reported heritability estimates to range from 0.099 for weaning weights to 0.155 for birth weights and ranged from 0.10 for growth rate between birth weight and weaning to 0.153 for growth rate between weaning and six months of age. However, the values reported in this study were within the range of heritability values (0.30 –0.45) reported in goat and sheep breeds by other workers (Herald, 1994; Djemali *et al.*, 1994).

However, in developing improvement strategies for these animals, it should be borne in mind that production performance of animals can be affected by genotype x environment interaction. That is, superior individuals in a particular environment may not necessarily be superior in another environment. According to Dalton (1987) it is better to select and breed animals in the environment in which they could perform highly.

Heritability increased with increasing age of animals. This could be attributed to decrease in environmental influence including maternal environmental variation with advancing age. This concurs with the finding by Herald (1994) and Hogue *et al.* (2002) who reported that there is a lot of environmental variations in early life (i.e. rearing environment) which often result in low heritability estimates, but with increasing age such variations cease or decrease. The authors also reported that

Table 3: Heritability estimates for FEC and PCV of goats

Trait	h^2	s.e.	n
Faecal egg count (epgs) at 6months	0.30	0.022	274
Packed cell volume (%) at 6 months	0.41	0.041	274
Faecal egg count (epgs)at 12 months	0.35	0.020	186
Packed cell volume (%) at 12 months	0.43	0.033	185

additive genetic components tend to increase with increasing age of animals. This factor also contributes to an increase in the estimated values.

The FEC and PCV are traits of importance in measuring resistance of animals to helminth infections (Table 3). The moderate heritability estimates for FEC and PCV at six and twelve months are within the range reported by Backer (1991) whose heritability values for FEC ranged from 0.15 to 0.45 in sheep aged between 2 and 8 months. Bisset *et al.* (1995) working with sheep between 6 and 8 months of age reported that heritability estimates for FEC ranges from 0.25 to 0.34. The heritability estimates for PCV were relatively high both at six months and one year of age. This finding concurs with that reported by Backer (1991) who reported an estimate for PCV to be between 0.35 and 0.45 for sheep at 3-6 months of age. Rohrer *et al.* (1991) reported low heritability estimates values (0.22) for PCV for sheep aging between 10 and 12 months.

Since the heritability for both FEC and PCV were relatively high in the present study, it seems that in Small East African goats there is a large genetic variability for resistance to gastrointestinal parasite infection. Thus, it is possible to improve genetic resistance in these animals through selection and good management practices. This is supported by the findings by Woolaston *et al.* (1991) who showed that resistance to gastrointestinal helminth infection is genetically heritable and that there is breed and individual variation in resistance to helminthosis in small ruminants. This could be used for the improvement of resistance to internal parasites. The development of resistant animals seems to be appealing since the use of antihelmintics is threatened by the development of resistance in parasites to most of commonly used drugs (Craig, 1993; Waller, 1994). Also, there has been concern that residues of anti-helmintic chemicals may accumulate in the tissues of host animals and ultimately result in adverse consequences on human health.

The high negative genetic correlation between FEC and PCV (Table 4) at both six and twelve months of age suggests that these parameters are inversely related in influencing the performance of the goats. The negative genetic correlation between FEC and growth rate observed in this study indicated that high load of gastrointestinal parasites may be associated with reduction in performance of the animal. The finding in this study agrees with that of Bisset *et al.* (1996) that animals with low level of egg counts are likely to have low amount of helminths and can have higher growth rate than their counter parts. Further more, positive rg between PCV and growth rate at six months and one year of age means that selection for high level of PCV might result in better growth rate of the animals under study.

Table 4: The estimate of genetic correlation between PCV, FEC and growth rate of goats

Age	Trait 1	Trait 2	rg	se
6 Months	FEC	Growth rate	-0.60	0.012
	FEC	PCV	-0.8	0.011
	PCV	Growth rate	0.59	0.010
12 Months	FEC	Growth rate	-0.40	0.030
	FEC	PCV	-0.72	0.031
	PCV	Growth rate	0.50	0.022

Conclusions

It is concluded that moderate and high heritability in this study indicates that the traits of growth rate, weight at different ages and genetic resistance to gastrointestinal helminths in the goats under study can be genetically improved through within breed selection and crossbreeding combined with improvement in husbandry practices. Also, high positive genetic correlation between growth rate and PCV indicates that the animals had high resistance against helminthosis. Further studies on heritability estimates of various traits of each goat strain at SUA are required to obtain more information on within and between strain variation in production performance and disease resistance.

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References

Barger, I.A. (1989). Genetic resistance of the host and its influence on epidemiology. *Veterinary Parasitology 15: 645 – 649.*

Backer R. L. (1991). Breeding for disease resistance-some historical perspectives, problems and prospects. *Proceedings of the New Zealand Society of Animal Production 51: 1-13.*

Bisset, S.A.; Vlassof, A.; South, B O. R. and Backer, R.L. (1995). Heritability and genetic correlation among faecal egg counts and productivity traits in Rmney sheep. *New Zealand Journal of Agricultural Research* 35:51-58.

Census, (2002). National Census. Tanzania Bureau of Statistics, Dar-es salaam.

Challya, J. N. (1998). Physics and genetic characterization of three strains of goat in Tanzania. *MSc. Dissertation, Sokoine University of Agriculture*, Morogoro, Tanzania. Pp 80 – 114.

Craig, T.M. (1993). Anti helmintic resistance. *Veterinary Parasitology* 46:121-131.

Dalton, D. C. (1987). An introduction to tropical animal breeding. 2nd edition U.K., London. pp 86-88.

Das , S.M.; Rege, J. E. O. and Shibre, M. (1994). Phenotypic and genetic parameters of growth traits of Blended goats at Malya, Tanzania. In: *Proceedings of the 3rd biennial Conference of the African Small Ruminant Research Network*, 5-9th December, UICC, Kampala, Uganda pp 63-69.

Djemali, A.; Aloulou, M. and Ben Sassi, M. (1994). Adjustment factors, genetic and phenotypic factors for growth traits of Barbanne lambs in Tunisia. *Small Ruminant Research* 13:38-41.

Falconer, D.S. (1998). Quantitative genetics, 5th edition. Longman Scientific and Technical, John Wiley and Sons, Inc. New York pp 438.

Herald, W. (1994). The Tropical Agriculturalist. Animal Breeding, *3rd* ed. University of Edinburgh, UK., London pp 250- 370.

Hogue, M.A.; Amin, M.R. and Baik, D.H. (2002). Genetic and non-genetic causes of variation in gestation length, litter size and litter weight in goats . *Asian –Australasian Journal of Animal Sciences* 15:772-776.

Keyyu, J.D. (1998) Genetic Resistance of small East African goats to gastro intestinal nematode parasites. MVM. *Thesis, SUA, Morogoro, Tanzania pp 56-78.*

Kifaro, G. C. (1984). Production efficiency of *Bos Taurus* dairy cattle in Mbeya region. *M.Sc. Thesis, Sokoine University of Agriculture, Morogoro, Tanzania.*

Madubi, M.A. (1997). Physical characterization of three strains of Small East African Goats in Tanzania. *M.Sc. (Agric.). Thesis SUA, Morogoro, Tanzania.* pp 50-63.

MoAFS, Ministry of Agriculture and Food Security (2002). Tanzania Mainland ; Basic Data for Agricultural Sector 1994/95-2000/2001:The United republic of Tanzania; Dar-es salaam.

Roy, R.O.; Prakash, B. and Khanm, B.U. (1989). Genetic sources of variation for growth in Jamnapari kids. *Indian Journal of Animal Science 59: 874 – 877.*

Rohrer, G. A.; Taylor, J. F.; Davis, S. K.; Waruiru, R. M.; Ruvuna, F.; Mwandotto, B. A. J.; McGuire, T. and Rurangirwa, F. (1991). The use of randomly amplified polymorphic DNA markers in analysis of susceptibility to Haemonchus and Coccidia. *Proceeding of the 9th scientific workshop of the Small Ruminant Research Support program pp 71-85.*

SAS, (1996). Statistical Analysis System. SAS/STAT User's guide. *Statistical Analysis Insitute, INC. Carry. NC. USA .pp 1028.*

Smith, C. and Smith, D.B. (1993). The need for close linkages in marker assisted selection for economic merit in livestock. *Journal of Animal Breeding 61: 197 – 207.*

Waller, P.J. (1994). The development of antihelmintic resistance in ruminant livestock. *Acta Tropica* 71: 233-243.

Woolaston, R.R.; Windon, R.G. and Gray, G.D. (1991). Genetic variation in resistance to internal parasites in Armidale experimental flocks. In: Breeding for Disease Resistance in Sheep (eds G.D. Gray and R.R. Woolaston), Australian Wool Research and Development Corporation. Meloure, pp 1-9.