Risk-rated economic values for production and functional traits of Small East African goat using profit functions

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ABSTRACT: The study reports the effect of incorporating risk in the derivation of economic values for traits of the breeding goal of Small East African goats under the pastoral production system. A model previously used to derive conventional economic values was revised to incorporate variances of profit and risk attitudes of livestock keepers in estimation of risk-rated economic values. This resulted in a decrease in the estimated economic values by -14.7% (milk yield), -2.7% (12-month live weight), -23.9% (consumable meat percentage), -6.6% (mature doe live weight), -98% (mature buck live weight), -8.6% (kidding frequency), -8.2% (pre-weaning survival rate), -8.9% (post-weaning survival rate), -8.1% (doe survival rate) and 0% (residual feed intake). The decrease in the economic values implied that livestock keepers who were risk averse were willing to accept lower expected returns to avoid the opportunity of unfavourable outcomes.

Keywords: Economic values; Small East African goat; Pastoral production systems

Introduction

Livestock production in the tropics and subtropics is a major source of livelihood among the livestock keepers, and is usually characterised by direct and collateral effects like frequent water and feed shortages, which ultimately lead to low production. Among the livestock species, indigenous goats are important for the majority of households found in the arid and semi arid lands (ASALs). Successful genetic improvement programmes for these goats should directly address the needs and objectives of the livestock keepers (Sousa et al. 2011)). The breeding objective is a combination of economic weights and the genetic information of all characters to be improved. The economic values (EVs) are found by expressing profit and liquid margins as a function of the traits in the breeding objective and using partial differentiation of profit and liquid margins with respect to the trait in question (see e.g. Tolone et al. 2011)). However, detailed economic analysis of expenses and incomes for low-input livestock production systems are rare due to technical, logistical and financial challenges.

Breeding goals exist in many livestock species; usually these comprise production and functional traits. Breeding objectives have been defined for various livestock species in different countries e.g., for Valle del Belice dairy sheep (Tolone et al. 2011)), indigenous chicken (Okeno et al. 2012)), Creole goat (Gunia et al. 2013)) and Aberdeen Angus cattle (Campos et al. 2014)) but are lacking for of Small East African goat **(**SEAG). Appropriate EVs are important for selection within a population, evaluation of gene effects and for design of optimum breeding programmes.

To be useful, agricultural models must account for risk (variance in profitability) and risk attitude of the producers due to environmental changes and uncertainty in low-input production systems (Pannell et al., 1995)). The present study estimates economic values with and without incorporating risk and farmers' risk attitude for traits of the SEAG population reared under pastoral production system in Kenya.

Materials and Methods

Model overview. A deterministic static model was developed using the Fortran 95 programming language written in Microsoft Windows for the evaluation of economic aspects of important traits of the SEAG under pastoral production systems. The model described quantitative relationships between levels of genetic merit for the production and functional traits considered, and levels of inputs and outputs under the pastoral production circumstances. The profitability of the system was described, where the total annual profit of the flock was computed as the difference between costs and revenues of the system. The annual revenues and costs of the pastoral production systems were expressed on a per doe per year basis to account for both production and reproduction.

Flock composition and flows. It was assumed that the flock consisted of a constant number of breeding does, N, present over one year and different goat categories were identified according to age. The size of the flock was kept constant over time by equating the number of replacement females with culled does and their respective survival rates. The ratio of breeding bucks to breeding does was assumed to be 1:35.

Profit equation. The total profitability of the SEAG flock per year (P_f) (Kes) was expressed as a function of k biological traits (that are to be genetically improved), with the related costs and output values described by the following general equation 1 shown below;

$$P_f = \sum_{i=1}^{k} n_i (R_i - C_i) t_i - F \qquad (1)$$

where n_i is the number of expressions for trait *i* in a year, R_i the revenue per unit per expression of trait *i* (t_i), C_i, the cost per unit per expression of trait *i* (t_i), and F the fixed cost per flock per year (fixed costs in the current study were negligible and, therefore, ignored). All the costs and prices were stated in Kenya shillings (Kes).

Estimation of conventional economic values. Conventional economic values (CEVs) for the traits considered were calculated for the base situation with constant number of does (fixed flock-size) using equation 2 below.

$$EV_{flock\text{-}size} = \left[\frac{\delta R - \delta C}{\delta t}\right] \quad (2)$$

where, $EV_{flock\text{-}size}$ are the economic values per unit change in the trait of interest, δR and δC the marginal changes in revenues and costs after a 1% increase in the trait of interest and δt the marginal change in trait after 1% increase.

Estimation of risk-rated economic values. A model and input variables utilised in the estimation of CEVs above for traits of SEAG under pastoral production circumstances were used. The model was revised to incorporate risk and producers' risk attitude. Equation 3 below was used in the derivation of risk-rated profit by incorporating an Arrow-Pratt coefficient of risk aversion to represent farmers' risk attitude and variance of profit to represent risk.

$$y_r = E(y_t) - 0.5\lambda E\left[y_t - E(y_t)\right]^2 \quad (3)$$

where y_r is a risk-rated profit, $E(y_t)$ is the expected profit, λ is the Arrow-Pratt coefficient of absolute risk aversion and $E[y_t - E(y_t)]^2$ is the variance of profit.

Variances on prices and price indices (Kenya shillings – Kes, where 1 USD= Kes 80) for the period 2009–2013 were adjusted to 2007 and their co-variances were assumed to be positive (Republic of Kenya, 2013). Standard deviations of output prices and input prices were: material input price indices = Kes 9; service inputs price indices = Kes 9; milk prices = Kes 2.28/kg and meat prices = Kes 12.54/kg.

Results and Discussion

Estimated revenues, costs and profitability. Revenues, costs and profits for the fixed flock-size situation evaluated are presented in Table 1. The cost for 0.63 surplus yearlings was Kes 442.73 (feed), Kes 337.50 (husbandry) and Kes 272.76 (marketing). The cost of breeding does per doe per year was Kes 653.49 (feed) and Kes 1,250.00 (husbandry), whereas the total profit per doe per year was Kes 194.98. The highest contribution of breeding does to these costs is associated with their high numbers throughout the year. Variable costs were the most important costs of production, with husbandry costs (53.80%) being the highest.

The revenue arose from meat sources and were Kes 1,540.68 (sale of 0.63 surplus yearlings), Kes 960.96 (sale of 0.21 cull-for-age does) and Kes 143.63 (sale of 0.03 cull-for-age bucks). Surplus yearlings sold for meat contributed higher revenue because of the high off-take, while cull-for-age bucks contributed the least because of their low numbers. Breeding does had an advantage over the other categories of animals because of the extra revenue from milk of Kes 1,800.00. Revenue from meat accounted for 59.51%, while the rest was realised from milk. Generally, on average per doe per year, the use of SEAG was profitable under the pastoral production system (Kes 194.98 per doe per year).

Economic values for traits. Table 2 shows economic values (Kes per doe per year) for traits derived with and without considering risk and producers' risk attitude with constant number of does. The economic values for production traits (yLW, CM and MY) were highest and positive in the base situation evaluated in this study. The economic value for CM was relatively high (40.69), and this was expected because it was not used in the estimation of feed intake for the different categories of animals. The yLW had the highest economic value (62.35) as expected.

Interestingly, the economic values for functional traits (DoLW, LWb, KF, PoSR, DoSR) were positive except for RFI (-3.00). Among the functional traits, PoSR (16.60) and DoSR (16.69) had the highest positive economic values in the system evaluated. Improvement for these traits would result in a greater influence on revenues than on costs in these systems because of the increased off take rates of surplus animals. The PrSR had a positive economic value (17.38) and that was expected because survival traits influenced the flock composition and the replacement rates in a production system. The negative economic value for the RFI (-0.30) was not a surprise because an increase in genetic merit of the trait did not affect revenue, but resulted in an increase on feed costs only.

The order of importance of traits did not vary by either considering risk or the livestock keepers' risk attitude. However, the value attached to different traits considered important in the goat industry in the way they affect profitability decreased when risk and risk attitude were incorporated in the profit models used in their derivation. For example, the economic values for production traits, yLW, CM and MY, decreased by -2.8%, -23.9% and -14.7%, respectively, when subjected to risk at λ = 0.02. Similarly, the economic values for functional traits, DoLW, LWb, KF, PoSR, DoSR, decreased by, correspondingly, -20.6%, -35.6%, -8.6%, -8.2% and -8.1%. Interestingly, LWb (-35.6%) had a relatively higher level of risk aversion because it does not affect profitability significantly because only few males are required for breeding.

General discussion. The economic values for production traits (yLW, CM and MY) were positive, which implies that genetic improvement of these traits would have a positive effect on the profitability in pastoral production systems. In the ASALs, majority of offal is consumed, which affects the actual meat output in pastoral production circumstances. This suggests that CM might become more relevant due to market dynamics in the long-run and may trigger its inclusion in the breeding goal at some later stage (Wolfová and Wolf, 2013)).

The positive economic value for DoWT indicates that breeding for increased live weights could still increase the profitability of does under pastoral production systems. However, it would be necessary to determine the optimum size of a doe under pastoral production systems where feed is scarce (Renaudeau et al. 2012)). An increase by one unit in genetic merit of PrSR, PoSR and DoSR resulted in an increase in profit per doe per year in the system evaluated.

Table 1. Estimated costs, revenues and profits (Kes)a per doe per year under the pastoral production system

	Animal category									
	Kids	Yearlings offtake	Replacement Females	Replacement Males	Breeding does	Cull does	Breeding bucks	Cull bucks[c]	Total[b]	Percentage of the total
Proportion of animals to ewes	1.32	0.63	0.51	0.03	1.00	0.21	0.03	0.03		
Input										
Feed	-	442.73	418.13	24.60	653.49	-	56.64	-	1,595.59	37.54
Husbandry	326.07	337.50	318.75	18.75	1,250.00	-	35.71	-	2,286.78	53.80
Marketing	-	272.76	-	-	-	84.00	-	11.16	367.92	8.66
Total (a)	326.07	1,052.99	736.88	43.35	1,903.49	84.00	92.35	11.16	4,250.29	100.00
Output										
Milk	-	-	-	-	1,800.00	-	-	-	1,800.00	40.49
Meat	-	1,540.68	-	-	-	960.96	-	143.63	2,645.27	59.51
Total (b)	-	1,540.68	-	-	1,800.00	960.96	-	143.63	4,445.27	100.00
Profit (b-a)	-	474.19	-749.63	-44.1	-153.49	960.96	-93.78	132.47	194.98	

[a]USD 1 = Kes 80.00 at the time of the study.
[b]Weighted by animal proportions.

The improvement of survival later in life (DoSR) resulted in higher profits than a similar improvement in survival early in the life of an animal (PrSR).

The resultant risk-rated economic values when an Arrow-Pratt coefficient of absolute risk aversion (λ) of 0.02 was applied were comparable to the economic values estimated without risk. With consideration of a higher risk aversion of 0.02, these changes were approximately -2.8%, -23.9%, -14.7%, -20.6%, -35.6%, -8.6%, -8.2%, -8.1% and -8.2% for yLW, CM, MY, DoLW, LWb, KF, PoSR, DoSR and PrSR, respectively. This clearly implies that livestock keepers who are risk averse were willing to accept lower expected returns to avoid the opportunity of unfavourable outcomes.

Variance of profit differentiates simple profit models (without risk) from certainty equivalent profit models (incorporating risk) (e.g. Okeno et al. 2012)). Variances on input and output prices for the five year period considered (2009–2013) were moderate. Higher fluctuations imply greater uncertainty, and therefore, a greater risk to the livestock keepers. However, larger differences in economic values for traits predicted (see also Bett et al. 2012)) suggest that when risk is not accounted for, the economic values for traits are overestimated, and therefore, risk should be included in their estimation.

Table 2. Conventional and risk rated (λ = 0.02) economic values for traits evaluated in the study

Trait	[b]CEVs	[c]REVs
Milk Yield (MY)	34.46	29.41
Consumable meat percentage (CM)	40.69	30.99
12-month live weight (yLW)	62.35	60.62
Mature doe live weight (DoLW)	15.28	12.14
Mature buck live weight (LWb)	2.84	1.83
Kidding frequency (KF)	8.69	7.94
Pre-weaning survival rate (PrSR)	17.38	15.96
Post-weaning survival rate (PoSR)	16.60	15.24
Doe survival rate (DoSR)	16.69	15.33
Residual feed intake (RFI)	-3.00	-3.00

[b]Conventional economic values.
[c]Risk-rated economic values.

Conclusion

This study found most of the production and functional traits important, justifying their inclusion in the breeding goal to improve on the overall production efficiency of the pastoral production systems utilising the SEAG. The main challenge would be actualizing the concept of "production adaptability", and detail on how to balance higher productivity with improved functional traits like survival, reproductive and feed intake related traits at the same time in order to achieve a more sustainable production. Overall, the primary policy would, therefore, be to encourage the establishment of easy-to-manage genetic improvement programmes for the SEAG that could later be upgraded overtime under pastoral production systems and other areas with similar production circumstances.

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