Design and Application of Bio-economic Modelling in Livestock Genetic Improvement in Kenya: A Review

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Received: 4th Mar., 2011; Revised: 22nd Aug., 2012; Accepted: 5th Oct., 2012

Abstract

Bio-economic modelling in livestock production systems presents the opportunity for incorporating some elements of human decision making and simulates the impact of such decisions using mathematical relationships produced from biological and economic parameters. This paper has reviewed the processes of bio-economic modelling as applied to livestock genetic improvement especially in simulating profitability of alternative enterprises as well as estimation of biological and economic weights. A collection of country specific bio-economic models developed for different species of livestock have been critically analysed in describing their design and application. Participation of target group farmers in design and implementation of the models with respect to their reliability has been presented. It is found that most models were generated from animal life-cycle on farm while considering animal age groups, biological and economic parameters influencing revenues and costs. The differences in the level of participation closely related to the production system of target farmers. Bio-economic models have remained a tool for professional animal breeders with little extension of the technique to fit farmers' preferences. In most cases, livestock farmers had very little control of the estimates of parameters generated from bio-economic modelling. Farmer-based option (accounting for risks) of bio-economic modelling could increase acceptability and utilisation of estimates derived from them. Therefore design and application of bio-economic models for livestock genetic improvement could greatly benefit from participation of target groups and incorporation of sensitive systemic variables to improve repackaging of information that enhance sustainable adoption by actors in the livestock industry.

Key words: bio-economic modelling,economic evaluation, tropics, livestock

Introduction

Bio-economic modelling as applied in agriculture presents the opportunity for incorporating some elements of human decision making and simulates the impact of such decisions using mathematical relationships produced from biological and economic parameters of a production system. The bio-economic models as discussed by Brown (2000) are basically a continuum with one extreme representing models that are primarily biological process models to which an economic analysis component has been added while the other extreme are the economic optimisation models which include various bio-physical components as activities among the various choices for optimisation. Between these two variants are the integrated bio-economic models (BEMs), e.g. Kahi and Nitter, (2004) on dairy cattle and Rewe *et al.,* (2006) on beef cattle production systems in Kenya. The BEMs are a measure of human decision through assessment of the feedback of human activity and natural resources. Because of the complexity of agricultural systems, a trade-off between simplicity and usefulness emerges when integrated models are used.

This paper focuses on the critical outlook of BEMs used for livestock genetic improvement in Kenya. The aim is to analyse the appropriateness of model design and its influence on application towards answering production questions.

Materials and Methods

Six integrated BEMs applied in the development of breeding objectives for different livestock species in Kenya were reviewed and analysed for design and application. These included Kahi and Nitter, (2004) on dairy cattle, Kosgey *et al.,* (2003) on small ruminants, Rewe (2006) on beef cattle, Bett *et al.,* (2007) on dual purpose goats, Menge *et al.,* (2005) on chicken, Mbuthia *et al.,* (2012) on pigs and Bett *et al.,* (2012) on dual purpose goats. Justified by the recommendations from Kahi *et al.,* (2010) and Brown (2000) on socio-economics of livestock genetic improvement programmes and classification of bio-economic models respectively, this work considered relevant analytical levels for an in-depth analysis of the models as indicated below.

Analytical Levels

a) Purpose of model, estimation of economic values or biological values of traits
b) Estimation criteria, use of subjective or objective calculations

c) Model drivers, is the model output driven or input driven
d) Scale of application, farm specific, production system specific and extended (adaptability to other regions)
e) Risk analysis, consideration of the fact that knowledge is imperfect and economic circumstances are dynamic in time
f) Participatory approaches, incorporation of farmer preferences in development of breeding objectives (intangible benefits)
g) Target group, the farmer category benefitting from the usefulness of the estimates

Analysis

Table 1 shows the summary of results obtained after analysing the six BEMs. Most of the BEMs were adequately complex and have orientation towards profitability. However, it was difficult to assess the level of producer group participation in deriving the BEMs.

Table 1: Design and application of various bio-economic models (1-7) developed for livestock genetic improvement in Kenya

Parameter	**Subset**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Livestock species		**Dairy Cattle**	**Sheep**	**Beef Cattle**	**Goats**	**Chicken**	**Pigs**	**Goats**
Purpose of model	Economic value	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Biological value	No	No	No	No	No	No	No
Estimation criteria	Objective	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Subjective	No	No	No	No	No	No	No
Model drivers	Inputs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Output	No	No	No	No	No	No	No
Scale of Application	Farm specific	No	No	No	No	No	No	No
	Production system specific	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Extended	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Risk analysis		No	No	No	No	No	No	Yes
Participatory approaches		-	-	-	-	-	-	-
Target group		Large Scale	Small Holder	Large Scale	Small Holder	Small Holder	Small Holder	Small Holder

Model/Author Sources: 1.Kahi A.K. 2004, 2. Kosgey I.S. et al, 2003, 3. Rewe T.O. et al, 2006, 4. Bett R.C. et al, 2007, 5. Menge E. et al, , 2005, 6. Mbuthia J. et al, 2012, 7. Bett R.C. et al, 2012

Most of the models were production system specific and could be extended to fit other production circumstances in the tropics. The main control was through the input levels rather than set output targets whereas the estimation was basically objective based on on-farm parameters representing the economic and biological characteristics of production, marketing and technical environments.

Discussion

The livestock species considered in the development of the BEMs reflected some of the major livestock utilised for food in Kenya (EPZ, 2005). The overall aim in all the studies was economic in nature, showing that the direction of resource allocation will tend towards profitability. This scenario alludes to the fact that biological performance of livestock systems could be assessed using economic indicators (e.g. economic values of inputs).

The BEMs under study avoided the use of subjective methods, it has been shown that when the economic values of traits are calculated by "ad-hoc approach" where economic values are defined by a subjective decision of the breeders, then there is risk of overestimation of benefits from genetic improvement (Krupova *et al.,* 2008). Setting the required genetic gain for each trait (desired gain method) (Groen, 1989) could probably be used instead of subjective methods. The BEMs utilised objective methods whereby one or more equations that represent the behaviour of a production system were developed and optimised using appropriate inputs to calculate economic values based on resultant outputs from the models. The objective approach is considered non-biased and has the potential to closely predict the real-life situation. The dependency on inputs to generate particular levels of outputs was evident. The models were therefore driven by inputs requiring different decision making processes to attract desirable outputs. This was probably aided by the fact that in Kenya no output quotas exist and therefore no immediate need to set output limits. In such production environments, BEMs will most often be described as effort- or performance-dependent models (Larkin *et al.,* 2011).

Application of model outputs was more inclined towards the specific production system under which the model was defined with provisions for adaptation to other similar production systems elsewhere. The risk of this assumption is that replicating a production system *vis a vis* marketing and technical environment is in most cases unrealistic. This is confounded in the fact that model outputs inform management strategy for purposes of changing decisions or enhancing good ones. This is the process of optimisation that requires finding an optimal solution (maximization of profits, incomes, welfare, or minimization of costs or social costs) given a set of limitations (Prezello *et al.,* 2009). Only one model of the ones studies analysed risk as a possible effect that influences economic values of animal traits (Bett *et al.,* 2012). Animal breeders in calculating economic values from production system parameters are expected to take into account the fact that knowledge is imperfect and economic circumstances are dynamic in time (Kullak *et al.*, 2003). In that study Kullak *et al.,* (2003) showed that incorporation of risk, which is defined as the variance of profit and producer's risk attitude, revealed differences in traditional economic values and risk-rated economic values.

Generally, estimating economic values for breeding objectives of large scale livestock production units had lesser systemic challenges than for small holder systems since biological and economic parameters were more difficult to assess in small holder systems (Kosgey *et al.*, 2003; Menge *et al.*, 2005; Bett *et al.*, 2007).

Conclusion

Real life questions in livestock production are diverse, answering them requires a diversity of models that account for the internal and external systemic differences. Among the BEMs evaluated, goat production systems benefitted from estimation of traditional and risk rated economic values. It would be important for all livestock production system to have model options for use in evaluating management strategies. Including risk preferences in breeding objective description is known to affect the profitability of breeding programs and therefore is expected to impact the direction for selection (Kullak et al., 2003). Development of bio-economic models geared towards livestock genetic improvement should therefore account for all systemic variables that influence the accuracy of estimated economic values.

References

Bett R. C., Kosgey I. S., Bebe B. O. and Kahi A. K., (2007). Breeding goals for the Kenya Dual Purpose goat. II. Estimation of economic values for production and functional traits. *Tropical Animal Health and Production* 39: 467-475

Bett R.C., Okeyo A. M., Kosgey I. S., Kahi A. K. and Peters K. J., (2012). Evaluation of alternative selection objectives and schemes for optimisation of village goat improvement programs. *Livestock Research for Rural Development 24 (1).*

Brown R. D., (2000). A Review of Bio-Economic Models. Paper prepared for the Cornell African Food Security and Natural Resource Management (CAFSNRM) Program.

EPZ (Export Processing Zones) (2005). Meat production in Kenya. Export Processing Zones Authority (EPZA) Nairobi, Kenya. Cited on January 31st 2012 from http://www.epzakenya.com/UserFiles/File/MeatIndustry.pdf.

Groen, A. 1989. Cattle breeding goals and production circumstances. Dissertation, Wageningen Agricultural University, the Netherlands. 1989, 167 p.

Kahi A. K. and Nitter G., (2004). Developing breeding schemes for pasture based dairy production systems in Kenya. I. Derivation of economic values using profit functions. *Livestock Production Science 88: 161-177.*

Kahi A. K., Bett R. C. and Rewe T. O., (2010). Socio-economic Drivers of Successful Breeding Programs in Developing Countries. In: The 9th World Congress of Genetics Applied to Livestock Production, Leipzig, Germany. http://www.kongressband.de/wcgalp2010/assets/pdf/0011.pdf

Kosgey I. S., van Arendonk J. A. M.., Baker R. L., (2003). Economic values for traits of meat sheep in medium to high production potential areas of the tropics. *Small Ruminant Research 50:* 187–202

Krupová Z., M. oravcová, E. Krupa, D. PEšKovicová., 2008. Methods for calculating economic weights of important traits in sheep. *Slovak J. Anim. Sci., 41,* 2008 (1): 24 – 29

Kulak K., Wilton J., Fox G., Dekkers J., (2003). Comparisons of economic values with and without risk for livestock trait improvement. *Livestock Production Science,* pp183 – 191.

Larkin S. *et al.,* (2011). Practical Considerations in Using Bioeconomic Modelling for Rebuilding Fisheries, *OECD Food, Agriculture and Fisheries Working Papers,* No. 38, OECD Publishing. http://dx.doi.org/10.1787/5kgk9qclw7mv-en

Mbuthia J. M., Rewe T. O., Kahi A. K., (2012). Breeding Objectives for Pigs in Kenya. II: Economic Values Under Different Smallholder Production Systems. *Journal of Animal Breeding and Genetics.*

Menge E. O., Kosgey I. S. and Kahi A. K., (2005). Bio-economic model to support breeding of indigenous chickenin different production systems. International Journal of Poultry Science 4: 827-839.

Prezello R., Accadia P., Andersen J. L, Little A., Nielsen R., Andersen B. S., Röckmann C., Powell J. and Buisman E., (2009). Survey of existing bioeconomic models: Final report. Sukarrieta: AZTI-Tecnalia. 283 pages.

Rewe T. O., Indetie D., Ojango J. M. K. and Kahi A. K., (2006). Economic values for production and functional traits and assessment of their influence on genetic improvement in the Boran cattle in Kenya. *Journal of Animal Breeding and Genetics* 123: 23-36.