Economic assessment of the performance of trypanotolerant cattle breeds in a pastoral production system in Kenya

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ABSTRACT

Cattle are the major source of food security and income for pastoral farmers in sub-Saharan Africa. However, infectious and parasitic diseases remain a major constraint to improved cattle productivity in the region. The use of animal health economics to support decision-making on cost-effective disease control options is increasingly becoming important in the developing world. Trypanotolerant indigenous Orma/zebu cattle in a trypanosomosis-endemic area of Kenya were evaluated for economic performance using gross-margin analysis and partial-farm budgeting. Orma/zebu and Sahiwal/zebu cross-bred cattle were exposed to similar husbandry practices and monitored for growth rate, incidence of common infections (trypanosomosis, anaplasmosis, babesiosis, East Coast Fever and helminthosis) and the cost of treatment assessed. Interview questionnaires were also used to assess the preference rating of the 2 breeds. Results indicated that incidence of infection was trypanosomosis 3 %, anaplasmosis 58 %, babesiosis 11 %, East Coast Fever 22 % and helminthosis 28 %, with no significant difference between breeds. The Orma/zebu and Sahiwal/zebu breeds had comparable economic benefits, hence a pastoralist in Magadi division is likely to get similar returns from both breeds. This study therefore recommends adoption of not only the Sahiwal/zebu but also the Orma/zebu breed for cattle improvement in trypanosomosis endemic areas and conservation of indigenous genetic resources.

Keywords: agro-pastoralists, gross-margin analysis, Orma/zebu, partial-farm budget analysis, Sahiwal/zebu, trypanotolerance.

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INTRODUCTION

The economics of livestock production in sub-Saharan Africa, particularly in pastoral settings, are dependent on weather events, diseases, vector infestations, general economic conditions, development and adoption of technological innovations as well as public and private institutional policies, which interact to create a unique decision-making environment[6]. Effects of these factors and uncertainty of markets contribute to the price, yield, or net return variability to livestock producers[8,32]. Farmers in rangelands of the developing world face higher production risks and hence have fewer incentives to engage in commercial farming[13]. This notwithstanding, there is increased use of animal health economics to support decision-making processes for enhanced livestock farming in pastoral areas[3]. Producers need to use a systems approach and understand the biological and economic consequences of management options to identify enterprises that lead to relatively high economic losses or that produce limited impact on investment[1,10,30]. Economics of livestock production are not principally concerned with monetary values but with making rational choices in the allocation of scarce resources vis-à-vis competing alternatives[2,28].

There are high recurrent losses in livestock productivity due to infectious and parasitic diseases whose effects may either be direct or indirect[24, 33]. Livestock production is projected to have higher returns than other farming enterprises in the Kajiado district of Kenya. It is thus expected that if livestock production is well utilised it can provide meaningful self-employment that will stem rural–urban migration and reduce poverty[17]. Provision of better market outlets and use of trypanotolerant Orma Boran cattle may promote sustainable use of trypanosomosis-endemic rangeland resources[27]. In order to promote effective livestock production, however, economic valuation of local animal genetic resources will help in their sustainable development, conservation and effective utilisation[15,20,24].

Partial-farm budgeting (PFB) and gross-margin analysis (GMA) have been used to assess financial implications of livestock disease control in Kenya[26,31]. These methods have shown that East Coast Fever (ECF)-immunised groups in an atypical management system of the Kenyan coast were more profitable due to lower mortality and higher weight gains than the non-immunised groups. Despite the higher biological benefits of intensive dipping, higher gross margins were obtained in the animals dipped less frequently. In most cases, high input control strategies tend to be the least profitable[26]. The development of alternative disease control strategies has justified the need to re-evaluate the benefits of each option on various breeds of cattle through economic analysis[20]. PFB and GMA were used to compare the economic benefits of integrated control of trypanosomosis, babesiosis, anaplasmosis, ECF and helminthosis in Orma/zebu (O/Z) and Sahiwal/zebu (S/Z) cattle breeds in the agro-pastoral production system in the Kajiado district of Kenya, assuming that enhanced trypanotolerance in the O/Z crosses would reduce cost of treatment and raise profit margins.

The objective of this study was to assess the economic efficiency of the O/Z and S/Z cross cattle raised in a trypanosomosis endemic area of Kenya.

MATERIALS AND METHODS

This study was conducted on the Olkiramatian and Shompole group ranches in the Kajiado district, southwestern Kenya,

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which is a semi-arid area inhabited by Maasai pastoralists.

Longitudinal data collection

Data were collected from 225 O/Z and S/Z cross calves between January 2004 and July 2005. Fourteen farmers had previously acquired Orma Boran bulls, the sires of the O/Z calves in a pilot study to assess trypanotolerant technology in the area. However, the predominant cattle breed in the area is the S/Z. O/Z and S/Z cohorts were then purposively selected whereby all O/Z calves and a matching (in terms of age and sex unless unavailable) S/Z cohort born were recruited for longitudinal follow-up. Breed identification was confirmed by genotyping of blood DNA.

To assess the profitability of integrated control of trypanosomosis, helminthosis, babesiosis, anaplasmosis and ECF infections, the O/Z and S/Z calves were exposed to similar husbandry practices. Tick control was done by hand-spraying every 2 weeks with an appropriate acaricide, alpha-cypermethrin (Dominex®, Highchem, Philadelphia, USA) while all calves were tactically dewormed with albendazole (Vermi-prazol®, Murphy Chemicals, Spain) at 10 mg/kg body weight when mean faecal eggs per gram (EPGs) were >500 (moderate infection) to minimise effect on growth. No additional labour was sought as a result of adopting the Orma Boran cattle breed, nor was frequency of acaricide wash and deworming affected, and therefore they were not considered as variable costs. The animals were weighed monthly with an electronic weigh scale (Griffith, Elder, Suffolk UK) and these weights were regressed on age in days to estimate the average daily gain (ADG).

Approximately 70 $\mu\ell$ of blood was collected monthly by venipuncture of the ear vein into 2 heparinised microhaematocrit capillary tubes for determination of the prevalence of trypanosomosis, ECF, babesiosis and anaplasmosis infections. Packed cell volume (PCV) was determined using the microhaematocrit reader, and trypanosomosis infection was determined using the buffy coat technique and PCR[22,23,35]. Anaplasmosis, babesiosis and ECF infections were determined using antibody detection ELISA[16] and Giemsa-stained thin blood smears. The salt flotation technique for the faecal egg count (FEC) procedure was used to estimate EPG of faeces[12]. Treatment of infected animals with PCV below 20 % with diminazene aceturate (Veriben®, CEVA, Libourne, France) was the only variable cost considered for this analysis.

Data on costs (drugs and labour) and returns (reduced drug purchases, additional calves surviving to end of experiment, extra weight gain) were recorded for both breeds. Farm-gate value of inputs (costs) and outputs (products) were used in order to cater for transaction costs such as commissions, livestock levies, transportation and marketing. Mortality-related losses incurred in the production process were also considered in the economic analysis.

Questionnaire survey

An interview questionnaire was administered to 35 respondents to capture aspects of herd inventory (particularly as affected by the 2004–2005 drought), breed perceptions and production constraints encountered during the study period (Jan 2004–July 2005). Of the 35 respondents interviewed, 14 were selected on purpose as they were involved in the longitudinal study and therefore owned the O/Z cross calves. The remaining 21 pastoralists were randomly selected from the sampling frame of 176 households (86 in Olkiramatian and 90 in Shompole) using the simple random procedure aided by computer random number selection. At least 30 questionnaires were targeted in an effort to achieve representativeness of the target population. Questionnaire responses on farmer perception of the O/Z cattle breed were used to assess challenges facing breed improvement using the Orma Boran cattle and adoption of trypanotolerant genetics.

Data analysis

Descriptive statistics were used to summarise herd inventory, production constraints and perceptions about breeds from the questionnaire data and production traits from the longitudinal data. Breed comparison of traits with continuous variables such as weaning weight at 9 months and body weight at 18 months were compared using *t*-tests, while the average daily weight gain (ADG) was compared using repeated measures analysis of variance. Weaning and mortality rates between the O/Z and S/Z breeds were, however, compared using the Walds (χ^2) test. Observed differences were deemed significant when the indicated probability for the test of equality was less than 5 % ($P < 0.05$). Data obtained from the longitudinal study were used for the partial-farm budget and gross-margin analysis.

Partial-farm budget analysis (PFB)

Partial-farm budget was used to evaluate components of livestock production income (additional returns, costs no longer incurred) and costs (foregone returns, additional costs) that were influenced by the use of O/Z cross calves with enhanced trypanotolerance and integrated control of trypanosomosis, helminthosis, babesiosis, anaplasmosis and ECF infections[5,19]. Average daily gain was calculated from monthly body weight by dividing monthly weight change by 30 days. Gross return per breed was calculated by multiplying the mean price per kilogram live weight (which was derived based on a selling price of Ksh20 000* for a 390-kg steer) with the corresponding live weight at 18 months. Treatment was the only variable component affected by the introduction of O/Z breed in the livestock production enterprise. Therefore, drugs used to treat the O/Z and S/Z calves during the study period were enumerated and valued as volume used multiplied by unit prices. The observed production traits were factored in the partial-farm budget analysis in a computer spreadsheet in order to demonstrate financial implication of adoption of trypanotolerance technology.

Gross-margin analysis (GMA)

Whereas PFB was used to assess whether a farmer benefited from improvement in herd health, GMA was used to assess effectiveness of integrated health management[19]. The method used for computing gross margin was[21]:

$$GM = (\text{net trading} + \text{inventory change}) - \text{variable costs},$$

where net trading (Ksh) = sales – purchases; inventory change (Ksh) = (closing number – opening number) × per head market value; and variable costs = cost of health care and labour.

RESULTS

Questionnaire survey

Herd inventory and observed production constraints

Results of the questionnaire survey are shown in Tables 1 and 2. Herd growth was observed over the 3-year study period. Mean total livestock holding was 335 per farmer with 91 cattle and 244 sheep and goats in 2005/6. Livestock production constraints were cost of treatment of various diseases, as well as drought- and death-related animal losses (Table 1). Analysis of the questionnaire data showed that trypanosomosis, ticks and tick-borne diseases (TBDs) and helminthosis resulted in high treatment costs. Annual cost of trypanocidals (Veriben) was the highest at Ksh57 per animal (range

*Ksh (Kenyan shilling) is the Kenyan currency. 1 US $ was equivalent to 72 Ksh at the time of the study.

Table 1: **Livestock numbers and production constraints on the Olkiramatian and Shompole group ranches, Magadi division, Kajiado district.**

Category	Variable	Mean (2002/3)	Mean (2005/6)	SE (2005/6)	Range (2005/6)
Herd inventory (No.)	Total livestock	220	335	56	14–1222
	Cattle	60	91	22	0–522
	Sheep and goats	160	244	37	0–815
Livestock lost/herd/yr (No.)*	Cattle	NA	16	3.3	0–77
	Sheep and goats	NA	60	12	0–252
Annual treatment cost/animal (Ksh)	Trypanocides (Veriben)	50	57	9.3	0–203
	Oxytetracycline (Adamycin)	37	39	7.4	0–169
	Penstrep®	2.3	1.3	0.73	0–21
	Butalex®	3.2	4.3	3.8	0–115
	Vermiprazol®	23.4	19	5	0–140
	Blanthrax®	2.3	0.33	0.16	0–3
	FMD vaccine	0.71	0.83	0.43	0–11.3
	Dominex	35	41.4	7	0–188

NA = not available; * Livestock lost from herd either due to gift, loan, sale or death.

Ksh0–203) in 2005/6 which was an increase from Ksh50 in 2002/3. This was followed by cost of acaricides (alphacypermethrin), oxytetracycline (Adamycin®, Assia, Teva, Israel) and dewormers, Albendazole (Vermiprazol®) in this order of priority (Table 1). (Treatment of EFC with Butalex® (Cooper, Kenya) and Blanthrax® (KEVABI, Nairobi) and FMD vaccines (KEVABI, Nairobi) was minimal as shown in Table 1.) However, the actual cost incurred in the longitudinal study was far less, being Ksh0.9 of trypanocides (Veriben®) and Ksh1.26 of Oxytetracycline per animal. Period prevalence of infection was trypanosomosis 3 %, anaplasmosis 58 %, babesiosis 11 %, ECF 22 % and helminthosis 28 % with no significant difference between the O/Z and S/Z calves. Monthly variations in infection rates were also not different.

There was no significant difference in general cost of treatment and cost of trypanosomosis treatment between O/Z and S/Z cattle breeds ($P = 0.46$ and $P = 0.16$, respectively) (Table 5). Although the O/Z had higher TBD infections, the frequency and corresponding cost of treatment was similar to that of the S/Z ($P = 0.19$).

Agro-pastoralist perception of the O/Z cattle breed

Twenty-three per cent of farmers appreciated the capacity for disease resistance of the O/Z cattle and 27 % of the respondents agreed that trypanotolerance appeared to be an important trait in the breed. Furthermore, the O/Z breed was most attractive for its hardiness (37 %), particularly in withstanding droughts and being less recumbent than the S/Z when extremely starved. Seven per cent of the farmers sampled observed and acknowledged that unlike the S/Z crosses, the O/Z cattle were endowed with the ability to significantly multiply during periods of nutritional stress, resulting in high herd turnover (Table 2). However, 53 % of the respondents complained of the low body weights and small frame of O/Z calves compared to those of the S/Z calves. Seven per cent of the respondents did not appreciate the whitish dull color of the O/Z cattle. Reported high potential for milk production of more than 2 ℓ/day by the O/Z breed was acknowledged by 7 % of the respondents.

Table 2: **Farmer responses with regard to attributes of the O/Z crosses on the Olkiramatian and Shompole group ranches, Magadi division, Kajiado district.**

Favourable attributes	Score (%)	Unfavourable attributes	Score (%)
Appropriate body weight	10	Low body weight	53
General disease resistance	23	Unattractive color	7
Hardy	37	Unknown milk production	7
Trypanotolerant	27		
Temperament	3.3		
Marbling fat	13		
High herd turnover	7		

Performance of the O/Z and S/Z cross calves

Partial-farm budget output for the O/Z and S/Z calves in the Kajiado district

The O/Z and S/Z cross calves showed comparable production parameters; weaning weights ($P = 0.29$), average daily weight gains ($P = 0.91$), weaning rate ($P = 0.84$), body weight at 18 months ($P = 0.82$) and mortality rates ($P = 0.18$) (Table 3). As shown in Table 4, gross returns were higher for the S/Z (Ksh 7025.6) due to their higher body weight compared with the O/Z (Ksh6563.8).

Gross-margin output for the O/Z and S/Z calves in the Kajiado district

As presented in Table 5, results showed that raising the O/Z cattle increased the enterprise gross margins/animal to Ksh 37 707 as compared with Ksh32 788 from the S/Z cattle. Thus, in this study, farmers with O/Z animals realised a higher gross margin of Ksh5081 which was not significantly different from the S/Z. It was also generally observed that incomes from livestock sales were proportional to herd sizes. Variable costs consisted of drug inputs, mainly trypanocides at Ksh40 and oxytetracycline at Ksh54 per farmer. Other drugs included multivitamins (Norbrook, The Green, Great Corby, UK) which were used as a health booster

Table 3: **Production traits of the O/Z and S/Z calves on the Olkiramatian and Shompole group ranches, Magadi division, Kajiado district, 2004–2005.**

Production parameters	O/Z	S/Z	*P*-value
Weaning weight at 9 months (kg)	77	81	0.29 ($t = -1.07$)
Weaning rate (%)	68.6	69.7	0.84 ($\chi^2 = 0.07$)
Body weight at 18 months/head (kg)	128	137	0.82 ($t = -0.22$)
Mortality rate (%)	8.1	4.8	0.18 ($\chi^2 = 1.95$)
Average daily weight gain (ADG) (kg/day)	0.17	0.18	0.91 ($F = 0.013$)

Table 4: **Results of health management of O/Z and S/Z calves on the Olkiramatian and Shompole group ranches, Magadi division, Kajiado district, 2004–2005.**

Parameter	O/Z	S/Z
Mean price/kg live weight (Ksh)	51.3	51.3
Mean live weight productivity at 18 months (kg)	128	137
Gross return (Ksh)	6566	7028
Cash costs (Ksh)		
Trypanocides (Veriben) (Ksh)	0.80	1.06
Oxytetracycline (Adamycin) (Ksh)	1.26	1.27
Other treatments (Ksh)	0.15	0.10
Total cost that vary (VC) (Ksh)	2.21	2.43
Net return (NR) (Ksh)	6563.8	7025.6

during periods of drought and nutritional stress, and penicillin/streptomycin combination (Penstrep®, Norbrook, The Green, Great Corby, UK). Generally, variable costs were low and comparable between the 2 cattle breeds (Table 5).

DISCUSSION

Objectives of the pastoral production system

Subsistence livestock producers have broad production objectives where biological survival and established cultural traditions may define the essential values of a subsistence community[33]. Hence, for a long time, survival of pastoralists has been dependent on large livestock numbers to provide daily food requirements, security and social status. However, a diminishing resource base for large livestock numbers, changing pastoral lifestyle and the need for economic and biological efficiency have necessitated keeping fewer cattle of more productive breeds[25]. Other income generating options (alternative livelihood options) are increasingly becoming available with increasing literacy levels. As a result, cost of hired and family labour required for livestock production is bound to increase to match the opportunity costs for the alternative best use of that labour. However, the supporting environment (climate and infrastructure) suggests that livestock production is currently the most viable economic activity in the study area.

Herd growth and production constraints in Magadi division, Kajiado district

Observed herd growth over the 3-year period could be harnessed to improve farmers' welfare. Some farmers in Magadi division have engaged in commercial beef cattle production and have become role models to many others in the area. Although questionnaire responses indicated a significant increase in the cost of treatment using oxytetracycline and trypanocides from 2002/3 to 2005/6, the observed actual cost of treatment for trypanosomosis, anaplasmosis, babesiosis, and ECF for the O/Z and S/Z animals in the longitudinal data was minimal, perhaps an indication of unnecessary drug use in the area. Supportive therapy with multivitamins used during dry periods increased cost of treatment.

Animal mortalities and poor growth could be attributed to a combination of starvation and the endemic nature of trypanosomosis, anaplasmosis, babesiosis, ECF and helminthosis infections observed during the study. Farmers spent least on vaccines, indicating that voluntary population-based disease control (except for ticks) has not been embraced in Magadi division. Annual exit of 16 (18 %) cattle and 60 (25 %) sheep and goats in a herd at prevailing market rates was likely to have significant impact on the livestock enterprise. Animal exchanges in the form of loans, gifts and fines were a form of security and social responsibility that had been in place for a long time to cater for the less fortunate in society. Limited market outlets for live cattle and poor prices offered further reduced profit margins for pastoral farmers. However, it is expected that appropriate disease control could enable the farmer's access to premium export markets.

Profitability of the O/Z and S/Z calves within the pastoral production system in the Kajiado district

The endemic nature of trypanosomosis, anaplasmosis, babesiosis, ECF and helminthosis infections are likely to be an important health constraint in the O/Z and S/Z calves. The PFB showed that O/Z cattle achieved higher returns of about Ksh5000 per animal than the S/Z cattle in this study. In terms of economic returns, O/Z cattle could be the breed of choice under the communal pastoral production management system. However, the 2 breeds were comparable in terms of body weight and ADG that were taken into account for purposes of the PFB. This

Table 5: **Gross-margin analysis for O/Z and S/Z crosses on the Olkiramatian and Shompole group ranches, Magadi division, Kajiado district, 2004–2005.**

Income/Cost	Breed	Number (*a*)	Average on-farm prices/head (Ksh) (*b*)	Total (Ksh) (*a* × *b*)
Cattle sales	O/Z and S/Z	6.6	15 153	100 007 (A1)
Cattle purchases	O/Z and S/Z	8.9	6 809	60 603 (B1)
Net sales	O/Z and S/Z			39 404 (C1)
Inventory change	O/Z and S/Z	58.8	11 000	646 800 (D1)
Value of enterprise (TR)	O/Z and S/Z			686 204 (E)
Variable costs				
Trypanocides (Veriben)	O/Z	20	0.80	16.0
	S/Z	23	1.06	24.4
Oxytetracycline (Adamycin)	O/Z	20	1.26	25.2
	S/Z	23	1.27	29.2
Others	O/Z	20	0.15	3.0
	S/Z	23	0.10	2.3
Total variable costs (TVC)	O/Z			44 (F1)
	S/Z			56 (F2)
Gross margin	O/Z	20		686 160 (G1)
	S/Z	23		686 148 (G2)
Gross margin per animal	O/Z			34 304
	S/Z			29 833

C1 = A1 – B1; E = C1 + D1; G1 = E – F1, G2 = E – F2.

finding complements other observations that have shown superior production traits of the Orma Boran cattle breed compared with the Kenyan Boran and Maasai zebu cattle breeds, particularly during high trypanosomosis prevalence[9,18] Notwithstanding, the Sahiwal cattle breed produced marginally higher body weights than the Orma Boran breed. However, the Sahiwal cattle are known not to achieve maximum production potential in the arid and semi-arid lands, especially during prolonged dry spells. Therefore, the O/Z cattle that are known to possess lower metabolic requirements than the Sahiwal cattle may be a suitable substitute for the pastoralists who make minimal capital investments in supplementation or pasture improvement.

Low variable costs observed in this study were consistent with extensive pastoral production systems[7,11]. However, caution has to be exercised when using average costs of disease to support farm-level decision-making under risk because the distribution of such costs is often skewed[4,29]. Perhaps this was reflected in this study, where cost of treatment in the longitudinal study was far less than the cost of treatment reported in the questionnaire. This was particularly so with respect to the use of trypanocides and oxytetracycline drugs, which suggests unnecessary drug use owing to the lack of diagnostic facilities in the area that is likely to impinge on profit margins. More drugs were used during dry periods, perhaps due to increased stress as a result of nutritional deficiencies.

Farmers have to make decisions about the allocation of limited resources, have a combination of 3 often conflicting goals, namely increasing profits, increasing personal welfare and avoidance of risk. For the Maasai community in Magadi division, increasing profits has proved true with the Sahiwal cattle breed but disease risk has been high, which has impinged on profit margins. However, the O/Z crosses are being used for risk aversion due to their trypanotolerance. There is need therefore to strengthen extension of research results in a highly participatory manner, considering adaptive farming systems and taking account of farmer circumstances and constraints[33]. Special attention to biological as well as economic efficiency of livestock production to raise profit margins is recommended.

Preference rating of O/Z and S/Z cattle breeds in Magadi division, Kajiado district

Although no significant differences were observed in prevalence of trypanosomosis, anaplasmosis, babesiosis, ECF and helminthosis infections between the O/Z and S/Z cattle breeds, 27 % of the respondents indicated that the O/Z was more tolerant to diseases, hence its cost of treatment was lower compared to the S/Z breed. Smaller body frames of the O/Z cattle breed was discouraging to farmers raising steers for fattening since they would realise less income than the S/Z steers. This observation is consistent with the use of Sahiwal and Boran bulls popularly referred to as Bull Camps to breed for large size animals in the Kajiado district. However, this practice needs to be matched with pasture improvement or feed supplementation in order to harness high growth potential of the improved genotypes. Otherwise, with unimproved pastures, locally improved and selected indigenous breeds would be more appropriate and productive[29]. Owing to the Maasai's preference for brown-coloured animals, the white coat color of the O/Z breed is a negative attribute, yet it is an adaptation to repel tsetse fly[14]. High milk production potential of the S/Z and O/Z breeds is a positive influence on their adoption[34].

In conclusion, pastoral farmers in Magadi division of Kajiado district have for a long time lacked appropriate information about making informed choices on breed improvement. Since the O/Z and S/Z cattle breeds were economically comparable, a pastoralist in Magadi division keeping either of the breeds is likely to have similar returns. Trypanocidal drug expenditure further suggests that the O/Z is more suited in trypanosomosis-endemic rangelands, while the S/Z would do better in trypanosomosis-free lands. Expenditure per animal was almost twice as much for the S/Z than O/Z in trypanosomosis-endemic areas. In addition, based on breed appraisal, it is recommended that the O/Z breed has potential for effective reclamation and utilisation of tsetse-infested lands.

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