Pastoralists Preferences for Cattle Traits: Letting them be heard

Emily Ouma[1*], Awudu Abdulai[1] and Adam Drucker[2]

[1] Department of Food Economics and Consumption Studies, University of Kiel, Germany
[2] School for Environmental Research, Charles Darwin University, Darwin NT 0909, Australia

Paper Contribution for the Conference on Pastoralism and Poverty Reduction in East Africa: A Policy Research Conference to be held in June 27-28, Nairobi, Kenya

[*] Contact author, Email: eouma@food-econ.uni-kiel.de

Abstract

This paper investigates preferences for cattle traits among a pastoral community in a trypanosomosis prevalent area in Kenya. Choice experiments and mixed logit models are employed to estimate economic values of preferred traits which could be introduced through systematic breeding in breed improvement programs that utilise trypanotolerance trait. The findings suggest preference for traits linked to drought tolerance, high live weight, trypanotolerance and fecundity. Identification and estimation of preferred traits provides useful information for breeding policy and provides a framework for promoting conservation of breeds that possess adaptability traits, critical for arid and semi-arid areas.

Key words: Trypanotolerance; Cattle trait preferences; Choice experiment; Mixed logit

1. Introduction

Pastoralists who inhabit the African arid and semi-arid areas are among the world's poorest populations. They lack vital infrastructure in the form of accessible roads, electricity and telecommunications, leaving them increasingly isolated. Large livestock holdings including sheep, goats, cattle, and sometimes camels comprise the bulk of their limited wealth and are an integral part of their socio-cultural life. Herd size is often directly correlated to wealth and social status in the pastoral societies. Pastoral systems in Africa are exposed to varied shocks ranging from recurrent droughts, livestock diseases to banditry, which too often claim part or whole livestock herds making the population increasingly vulnerable to food insecurity, often forcing them to frequently rely on famine relief aid. The frequency and severity of the shocks vary over time and over space (Smith et al., 2000). Coping strategies adopted by pastoralists include adoption of nomadic or transhumant grazing[2] practices in search for water and pasture during drought periods and accumulation of stock during favourable climatic conditions to balance high losses usually experienced during major droughts and disease outbreaks (Lybbert, 2000).

The pastoral production system is an important source of meat for domestic consumption in sub-Saharan Africa. In Kenya, 70% of livestock is raised in the arid and semi-arid rangelands, under pastoral systems and account for about 50% of local beef consumption (Institute of Policy Analysis and Research, 2004). Demand for meat in the country has continued to increase since the 1980s and is still projected to rise. Aklilu et al. (2002), note that much of the increase in demand since the 1980s has been met

---

[2] Transhumance is the regular movement of herds between fixed points to exploit seasonality of pastures.

through unofficial cross border trade with Kenyan neighbors. Pastoralism has been shown to be an efficient means of production in the arid areas of Africa and if enhanced, it can be used to meet the growing demand for livestock and livestock products while improving the livelihoods of the pastoralists. One way of enhancing pastoralism is by addressing productivity issues associated with the livestock enterprise. Productivity of cattle kept under pastoral systems is generally considered to be low (Institute of Policy Analysis and Research, 2004). Productivity improvement is predicated upon identifying and removal of constraints that impact negatively on the production systems and processes.

Animal diseases, especially those caused by parasites, are severe constraints to livestock productivity in pastoral areas resulting in high mortalities and a profound negative impact on livelihoods in terms of livestock losses and high expenditures on treatment drugs. Kristjanson et al. (2002), report up to 48% of total annual household expenditures on livestock health expenses in Kitengela pastoral area in Kenya. Trypanosomosis[3] is one of the most important disease constraints in pastoral areas as it limits livestock productivity due to poor growth, weight loss, low milk yield, infertility and abortion (Itty, 1996). The major pathogenic trypanosome species in livestock are transmitted by the tsetse fly. Trypanosomes infect not only livestock but also wild animals. The latter are the natural hosts of tsetse flies and do not suffer severe clinical disease but become carriers and constitute an important reservoir of infection for livestock especially in pastoral areas where there is co-existence of livestock and wildlife.

[3] Trypanosomosis is caused by trypanosomes, which are minute protozoan parasites specially adapted for life in the blood of a vertebrate. In sub-Saharan Africa, the disease is transmitted by tsetse flies.

Total annual expenditures on curative and preventive treatments for trypanosomosis in sub-Saharan Africa by livestock keepers and governments, has been estimated at about US$ 35 million, administering 25–35 million curative and prophylactic treatments of trypanocidal drugs at a price of approximately US$ 1 per treatment (Kristjanson et al., 1999 and McCarthy, et al., 2003). These are colossal amounts that could be invested in alternative development efforts such as improvement of dilapidated physical infrastructures common in rural areas in Africa. de Haan and Bekure (1991) estimate that control of trypanosomosis would result in substantial increases of milk and meat supply of sub – Saharan Africa by a substantial 17%. Control of trypanosomosis in pastoral areas relies largely on the use of chemotherapeutic drugs. However, this method of control is only partially effective and remains very costly owing to the large cattle herd sizes kept by the pastoral communities.

Exploitation of genetic resistance to trypanosomosis through the use of existing African trypano-tolerant[4] breeds of cattle is one control approach that has increasingly attracted significant attention (Itty, 1996 and d'Ieteren et al., 1998). The advantage of genetic control over other methods of control is that genetic changes are cumulate and permanent. The prospects for producing cattle with genetic tolerance to trypanosomosis is high, given that some cattle breeds such as the Orma Boran, N'dama and the West African Shorthorn breeds are known to have developed a genetic capacity to cope with trypanosomosis resulting from their long survival in tsetse fly infested areas (Dolan,

---

[4] Trypanotolerance has been defined by d'Ieteren et al (1998) as the relative capacity of an animal to control the development of the parasites and to limit their pathological effects, the most prominent of which is anaemia, the primary cause of death of infected cattle. Trypanotolerant animals are able to survive, reproduce and remain productive under trypanosomosis risk without the aid of curative or prophylactic drugs.

1997). In addition, advanced genomics researches have selected and identified a number of heritable genes, controlling trypanotolerance using deoxyribonucleic acid (DNA) technology in some trypanotolerant African cattle breeds. This provides potentially viable and sustainable opportunities for improving cattle productivity in areas at risk of trypanosomosis, by utilising trypanotolerance trait through systematic breeding in a breed improvement program.

Although exploitation of trypanotolerance trait provides a potentially viable pathway for improving livestock productivity through control of trypanosomosis disease while also enhancing competitiveness of pastoral production systems by lowering the costs of production associated with treatment drugs, it is imperative to identify other traits that fulfil broader pastoral livestock system functions, while also taking into account the climatic and environmental extremities associated with pastoral areas. Besides milk and meat production, in pastoral systems livestock are a source of wealth and confers social status (Lybbert, 2000), they are a source of insurance against income shocks (Fafchamps et al., 1998) and are used in social-cultural functions (Mwacharo and Rege, 2002). Definition of a breeding objective which comprises identification of traits and calculation of their economic values is the first step towards designing breed improvement programs (Kahi and Nitter, 2004). There is need to involve cattle keepers in identification of important traits to be included in the breeding objective, since cattle perform multiple functions in the household livelihood system. Some of the important functions are often embedded in traits without market values. Too often, breeding objectives are defined based on a few market driven traits, without the involvement of cattle keepers. Yet, their participation would contribute towards development of sustainable breeding programs.

This paper examines pastoralists' preferences for cattle traits which could be introduced through breeding programs that utilize trypanotolerant genotypes. In additions, pathways by which the pastoral communities can access the improved genotypes are discussed. Choice experiment surveys and mixed logit model are employed to identify and estimate economic values of preferred cattle traits in a pastoral system in Kenya.

Choice experiment is a multiple trait stated preference method that applies the probabilistic theory of choice, where choices made by individuals from a non-continuous set of alternatives are modeled in order to reveal a measure of utility for the traits of the choices (Ben Akiva and Lerman, 1985). It enables valuation of single traits of a bundled good by using individuals' stated preference in a hypothetical scenario (Louviere et al., 2000). Cattle can be viewed as a bundled good with multiple phenotypic traits with potentials to meet multiple objectives. In choice experiments, the traits to be valued as well as their levels are identified and combined according to some experimental design then presented to respondents in the form of profiles. The method is particularly useful in valuing traits without market prices since preferences are measured directly, and trade-offs between traits can be evaluated. Price in the market is simply the willingness to pay for an additional unit of a good. Without markets for non-market traits, we do not have prices, but trade-offs that people make often demonstrate a willingness to pay.

Choice experiments have recently been applied to value livestock traits in developing countries (e.g. Scarpa et al., 2003a and Scarpa et al., 2003b). Scarpa et al. (2003a) compare value estimates from choice experiments data for cattle traits in a pastoral system in Kenya with those from hedonic analysis of actual market transactions by the same sample population. Using an external test of preference consistency, they show that the method may be a promising tool for valuing traits expressed by indigenous animal genetic resources in developing countries. The rest of the paper is organised as follows. The next section presents the data sources and study area while the third section discusses the choice experiment and household survey. The fourth section presents the mixed logit modelling specifications while the empirical results are discussed in section five. A potential dissemination mechanism of improved cattle is discussed briefly in section six. The final section presents a summary and implications of the findings.

2. Data Sources and Study Area

Baseline surveys were carried out in selected sub-locations in Mara and Ololunga divisions of Narok district in Kenya in order to assess prevailing disease constraints and to identify cattle traits that the pastoralists prefer based on their prevailing environmental conditions. The identified traits were then used in design of the choice experiment survey instrument which was administered as part of a household level questionnaire survey. Results from the baseline survey based on group discussions utilising participatory rural appraisal methods indicate that common cattle diseases include trypanosomosis, which was highly ranked as most prevalent, Contagious Bovine Pleuro-Pneumonia (CBPP), Redwater and Lumpy Skin disease. Environmental conditions, economic and socio-cultural reasons largely influence cattle keeping objectives and consequently, the traits preferred. Cattle are kept for both socio-economic as well as cultural reasons. Milk consumption and income from sales are important reasons for keeping cattle. Blood is also an important product as it is consumed, especially by invalids. Socio-cultural reasons for keeping cattle include bride price payment, use of cattle for ceremonial purposes such as slaughtering during age-set graduation and in settling disputes. Preferred traits for bulls and cows were identified and pairwise ranking used to rank the most important traits that were then used to construct the choice experiment. A total of eight preferred traits for cows and six for bulls, each with two to three levels were identified and the qualitative trait levels effect coded for inclusion in design of the choice experiment. Table 1 presents the traits included in the choice experiment and their levels.

Table 1: Traits and Trait Levels used in Choice Experiments

Cows		**Bulls**	
Traits	**Levels**	**Traits**	**Levels**
Trypanotolerance	1. Tolerant 2. Susceptible	Trypanotolerance	1. Tolerant 2. Susceptible
Milk yield	1. 1-2 litres/day 2. 2-4 litres/day	Fertility	1. High 2. Low
Reproduction potential	1. 1 calf every year 2. 1 calf in two yrs	Coat colour	1. Light-colored 2. Dark-colored
Coat colour	1. Light-colored 2. Dark-colored	Purchase price at 4yrs	1. KSh 11,000 2. KSh 20,000 3. KSh 27,000
Purchase price at 2 yrs	1. KSh 10,000 2. KSh 15,000 3. KSh 19,500	Watering frequency	1. Once in 2days 2. Once a day 3. Twice in a day
Watering frequency	1. Once in 2days 2. Once a day 3. Twice in a day	Live weight at 4 yrs	1. 200Kg 2. 320Kg 3. 450Kg
Live weight at 2 yrs	1. 120Kg 2. 190Kg 3. 250 Kg		
Feeding requirements	1. Need supplements 2. No need for supplements		

The choice experiment surveys were carried out in Mara and Ololunga divisions of Narok district in November 2004. Narok district is situated in the south-western part of Kenya bordering the republic of Tanzania to the south, Trans-Mara district to the west, Bomet and Nakuru districts to the north and Kajiado district to the east. The district occupies a total land area of 15,088 km^2 (Government of Kenya, 2002) and is divided into eight administrative divisions (Figure 4).

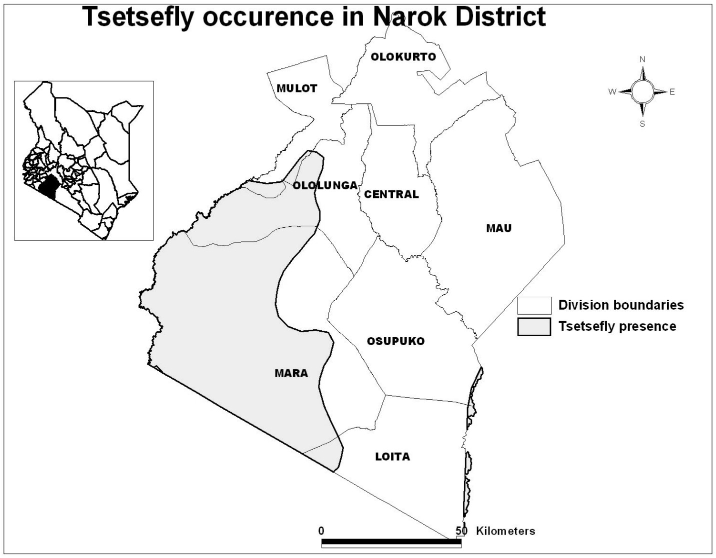


Figure 1: Tsetse fly distribution in Narok district
Source: ILRI GIS Database

The district has a varying topography with altitude ranging from 3,098 meters above sea level; in the highlands to 1,000 meters above sea level in the lowlands. The highlands, consisting of Mau, Olokurto and Mulot divisions, have a high potential for wheat, barley, maize, beans and potatoes. This is attributed to fertile soils, reliable rainfall ranging from 1200-1800 mm per annum and temperatures ranging from 10º to 15º centigrade (ibid.). The lowland areas, consisting of Ololunga, Mara, Loita and Osupuko divisions have a high potential for livestock rearing. However, trypanosomosis pose a serious challenge to livestock production in Mara and parts of Ololunga divisions due to high tsetse fly occurrence as shown in Figure 1. The lowland areas lie in semi-arid zones with low potentials for cropping due to poor soil quality and unreliable rainfall. Temperature ranges from 5º in July to 28º in November and February. The Maasai people, who practice nomadic pastoralism and small scale subsistence agriculture, inhabit the lowland areas.

Human population in the district according to the population census was 403,812 in 1999 with a population density of 24 persons per km^2 up from 14 persons per km^2 in 1989, indicating a significant increase over the last 10 years (Central Bureau of Statistics, 2003). The highland areas have the highest population densities in the district due to favourable agro-climatic conditions. There are relatively high poverty incidence levels in the district, with 52% of the rural population living below the national rural poverty line[5] (ibid.). The Maasai Mara game reserve, which houses a variety of wildlife species falls partly within the district boundaries in the lowland areas, leading to livestock and wildlife co-existence in the area. Some of the wildlife species are natural hosts to tsetse flies, constituting an important reservoir of trypanosomosis infection to livestock.

3. Choice Experiment and Household Survey

The administration of the choice experiment was conducted in the following manner. Each respondent was first introduced to the choice task and then he/she was presented with twelve sets of pair-wise choice profiles for cows or eleven sets for bulls describing the differences in traits and the levels. The profiles were drawn from orthogonal main effects only design of the effect coded traits and trait level combinations for bulls and cows. Each choice task required the respondent to choose one animal profile he would prefer to buy for rearing from the two profiles presented for each choice task. If neither of the profiles was found satisfactory, the respondent could choose the "none"

[5] Based on a monetary poverty line derived from the cost of a basic basket of goods that allows minimum nutritional requirements to be met (set at 2,250 calories per adult equivalent (AE) per day) in addition to the costs of meeting basic non-food needs (Government of Kenya, 2000). In Kenya, this poverty line was estimated to be about KSh 1,239 and 2,648 for rural and urban households respectively.

option and state that he preferred neither. The respondents were then required to indicate the reasons for their choices, to ensure that they had understood the choice task. The choice tasks are designed to elicit the trade-offs that individuals make between traits and to facilitate estimation of values for each trait. An example of one choice task for cows and bulls used in this paper is presented in the appendix. The choice experiment was administered as part of a household level questionnaire survey, on a random sample of 172 pastoral households in Narok using in-person interviews. Two questionnaires were incomplete and thus excluded from the choice experiment analysis.

A total of 82 complete choice experiment interviews were carried out for bulls and another 88 for cows yielding 902 completed choice sets for bulls and 1,056 for cows. A household questionnaire covering aspects such as cattle breeds reared, available cattle breeding services and cattle breeding practices by farmers as well as market and resource access was also administered hand in hand with the choice experiment.

Information on the socio-demographic characteristics of the sample households is presented in Table 2.

Table 2: Characteristics of Sample households

Variable name	Description	Mean	S.D.
Dist_road	Distance to a road open to vehicles all year (Km)	3.5	8.6
Travtimu	Travel time taken to the nearest large urban centre[6] (Hours)	4.5	1.9
Pop5Km	Human population density within a radius of 5km	30.6	29.2
Educyrs	Number of formal education years of hh head	3.8	5.2
Cat_herd	Cattle herd size	87.6	106.2
Tryp_freq	Frequency of trypanosomosis disease in a year	182.9	183.2
Dist_waterpt	Distance to the nearest livestock water point dry season	3.0	4.3

[6] The urban areas are defined on the basis of population densities i.e. population densities of more than 2500 people km-2

The households are located far from urban centers as indicated by the variable "Travtimu", a GIS derived variable based on road quality type and travel speed (Staal et al., 2002). This is a location based characteristic indicating access to output and input markets as well as livestock services On average, a household has to travel for 4.5 hours to reach the nearest large urban centre. Human population is sparsely distributed in the sample population, with a density of 30.6 persons within a radius of 5Km from the household. The Maasai pastoral communities in the sample population live in sparsely distributed hamlets (*manyattas*) where cattle are kept in common kraals at night. Milk production is largely for home consumption, though minimal sales to neighbors and local shops are reported.

Illiteracy levels are high in the sample population. The average number of schooling years for a household head is 3.8 years. Majority of the household heads, 61% have no formal education at all. Average cattle herd size per household is 87.6 animals, though the variation is high in the population with some households owning relatively large herds of up to 450 to 600 cattle. The main cattle breed kept is the local Maasai Zebu, though a few farmers also have Boran-Zebu crosses as well as Sahiwal-Zebu crosses. Natural uncontrolled mating of cattle is practiced since artificial insemination service is not available in the area. Trypanosomosis disease is highly prevalent in the area. The pastoralists report an average occurrence of 183 times in an average year. Treatment usually involves purchase and self administration of drugs by the farmers.

4. Econometric Model Specification

The choice experiment modeling approach used here is based on the multinomial logit and mixed logit models. The usual assumptions supporting the multinomial logit model are applied, the most prominent being that each error term is independently and identically distributed extreme value with a cumulative distribution; $F(\varepsilon_n) = e^{-e^{-\varepsilon_n}}$ (Train, 2003). The probability of individual *n*, choosing alternative (profile) *i*, is specified thus;

$$P_{ni} = \frac{e^{\alpha_{ni} + \lambda_j s_n + \beta_n x_{ni}}}{\sum_j e^{\alpha_{nj} + \lambda_j s_n + \beta_n x_{nj}}} \tag{1}$$

while the sample log-likelihood function is;

$$LL(\alpha_{nj}, \beta_n, \lambda_j) = \sum_{n=1}^{N} \sum_{i=1}^{J} y_{nj} \ln P_{nj} \tag{2}$$

Where α_{ni} is the intercept or individual *n's* intrinsic preference for choice *i*, s_n contains the socio-economic characteristics of the individual, and the coefficient λ_j captures the systematic heterogeneity among the individuals in the sample. X_{nj} is a vector of the traits and β_n the taste parameters of the traits. Maximum likelihood estimates for the parameter vector can be obtained by maximizing the likelihood function in equation 2. The limitation of the multinomial logit model is that it assumes that all cattle keepers share the same set of taste parameters, β_n for the cattle traits. This is rather limiting if taste parameters are indeed heterogeneous in the population. In addition, it does not account for stability of coefficients over repeated choices by the same individual due to its assumption of independence of each observation. Our choice experiment data consist of up to twelve repeated choices by individuals, which are likely to exhibit some degree of correlation. To relax this restrictive assumption, mixed logit model has been employed, making it possible to account for random taste variation.

In mixed logit, the taste parameters β, are allowed to vary in the population with density $f(\beta_n \mid \theta)$, where θ are the parameters of the population distribution. Each individual's coefficient β_n, differs from the population mean β, by some unobserved amount, constituting an additional source of randomness (Ben-Akiva and Lerman, 1985) which is assumed constant over repeated choices made by an individual. The random β's allows the mixed logit model to capture a larger variety of substitution patterns than the widely used multinomial and nested logit models (Train, 2003). The focus in mixed logit shifts from finding estimates of β_n to finding the estimates of θ, the population parameters (e.g. location and spread parameters), which determine the behaviour of β_n. These estimates can be obtained by maximizing the likelihood function in Equation 2. The value is simulated from random parameter draws from the postulated distribution $f(\beta_n \mid \theta)$. In the case of repeated choices per respondent as in our case, the same random draw is used across all the choices made by the same respondent in order to account for correlation across repeated responses (Revelt and Train, 1998). The joint probability of a set of t repeated choices by respondent n and conditional on the drawn value for β is a product of logits;

$$S_n(\beta_n) = \prod_t \frac{e^{\beta'_n x_{nit}}}{\sum_j e^{\beta'_n x_{njt}}} \tag{3}$$

Given that the values of β_n are unknown to the analyst, the unconditional probability[7] is employed. This is specified as:

$$P_n(\theta) = \int S_n(\beta_n) f(\beta_n \mid \theta) d\beta_n \tag{4}$$

[7] The unconditional probability is the integral of the conditional probability over all possible values of β_n, which depends on the parameters of the distribution of β_n.

Since there is no closed form solution for equation 4 in the estimation, $P_n(\theta)$ is approximated via simulations by summing over values of β generated by Halton draws. Halton draws are superior to random draws in simulations. 100 Halton draws produce the same approximation as 1000 pseudo-random draws (Train, 2003). The simulated probability is presented thus;

$$\tilde{P}_n(\theta) = \frac{1}{r} \sum_{r=1,..,R} S_n(\beta^{r|\theta}) \tag{5}$$

Where r is the number of draws of β from $f(\beta_n \mid \theta)$ and $\tilde{P}_n$ is the simulated probability of person *n's* choices. The simulated log-likelihood function is $SLL(\theta) = \sum_n \ln(\tilde{P}_n(\theta))$ and the estimated parameters are those that maximize the function. Various population distributions from which β is drawn can be assumed; this includes normal, lognormal, triangular and uniform distributions. In this paper, we assume normally distributed random parameters.

5. Empirical Results

The simulated maximum likelihood estimates for the mixed logit model[8] are reported in Tables 3 and 4 for cows and bulls respectively. Following Hensher et al. (2005), we used zero-based, asymptotic *t*-test for individual parameter standard deviations to determine the set of random parameters. From this, the traits; trypanotolerance, fertility, feeding requirement, live_weight and reproduction ability were entered as random parameters in the mixed logit estimations, while watering frequency, coat colour and purchase price were assumed fixed.

[8] The mixed logit models were estimated using NLOGIT version 3.0 by William Greene

Associated with each of the mean coefficient estimates of the random parameters are derived standard deviations calculated over the *R* draws, indicating the amount of spread that exists around the sample population. Statistically significant parameter estimates for derived standard deviations for a random parameter suggest that different individuals possess individual-specific parameter estimates that may be different from the sample population mean parameter estimate. Conversely, statistically insignificant standard deviation estimates suggest that the dispersion around the mean is statistically equal to zero, suggesting that all the information in the distribution is captured within the mean and the preference parameter is constant across the population. Results in tables 3 and 4 indicate considerable heterogeneity in preferences with significant variation around the mean estimates for the random parameters with an exception of milk yield trait parameter which has an insignificant standard deviation. The heterogeneity cannot be captured by the fixed multinomial logit parameter models. A likelihood ratio test is performed to test the null hypothesis that the multinomial logit fits the data better than the mixed logit. The sample values of the likelihood ratios are 151.7 and 123.5 with a critical value of $\chi^2_{20,\,0.01} = 37.6$ and $\chi^2_{9,\,0.01} = 21.7$ for cows and bulls traits respectively, thus rejecting the null hypotheses.

The model results in table 3 reveal preference for cows that are trypano-tolerant, heavy, high milk yielding and have high reproduction ability. Cows that need supplementary purchased feeds are not preferred, as indicated by the negative coefficient on feeding requirement. Table 4 indicate preference for bulls that are trypano-tolerant, heavy and highly fertile. The non-random parameter, watering frequency is positive and significant for cows (at p=0.1) and bulls (at p=0.001), implying that there is preference for animals that are tolerant to drought (need to water only once in two days). Coat colour, a trait regarded by the pastoralists as important during focus group discussions is not statistically significant in the model. Purchase price coefficient for both bulls and cows is positive and statistically significant, implying that purchase of cattle results in an increase in utility which outweighs the decrease in utility from spending monetary resources on the purchase of the animal. The benefit associated with owning cattle is likely to be one of the reasons why the pastoralists view this as a worthwhile expense. The constant variable represent the "none" choice option and is the base for the choice model, as it is associated with "zero" utility. It takes a value of one if the option is "none" and zero otherwise. The results for bulls indicate a strong negative preference for this option, implying that the respondents preferred to select the other two choice options associated with various trait levels.

The implicit values (willingness to pay values) of the traits are presented in table 5. The implicit value associated with a trait is calculated as the ratio of the trait to the parameter estimate of the cost parameter. In this paper, conditional individual parameter estimates have been used in the calculation. The estimates indicate that a trypano-tolerant cow or bull is valued at US$ 11 more than a trypano-susceptible one. This compares with the treatment cost for trypanosomosis per annum which is calculated from the survey results to be an average of US$ 8.7 per animal[9]. Live-weight increase, which is associated with meat production, is valued at US$ 1.15 per Kg. The value of 1Kg of slaughter weight is approximately US$ 1.07 (KSh 80) (Aklilu, 2002). An important trait highly valued by pastoralists is fecundity. A cow that has the ability to calve every year instead

[9] Calculated based on fortnightly treatments for 180 days per year when there is high trypanosomosis occurrence using the drug Novidium which is purchased at US$ 0.7 (KSh 50) per tablet.

of once in two years is even more valued than one that produces up to 4 litres of milk per day during its lactation period. Since a large herd size is an indicator of wealth in the pastoral community, reproductive performance is highly valued as it ensures fast herd increases. Tano et al. (2003), find a similar preference structure for cow trait preferences in Burkina Faso where high reproductive performance of cows is the most preferred trait compared to other traits such as milk yield and disease resistance. Cattle keepers are reluctant to raise cows requiring purchased feed concentrates to boost milk production. They are willing to accept US$ 9.4 as compensation for utility reduction arising from purchased supplementary feeds.

6. Potential Dissemination Mechanisms of Improved Cattle with Preferred Traits

Group breeding schemes have been identified in economic literature as potential pathways to achieve measurable genetic gains of livestock traits in subsistence systems of developing countries (e.g. Wollny, 2003). In pastoral systems, characterized by large cattle herd sizes per household, measurable gains may be achieved with individual herds. Since natural mating is the common practice in pastoral systems, this could be done by availing bulls of proven genetic merit, capable of meeting the demands and preferences of the pastoralists from a government nucleus herd through cash or animal loans. Pastoralists may be willing to participate in such breeding programs as indicated in a separate study in Mara division to assess pastoralists' perceptions and demand for experimental animals from a USAID funded KARI-ILRI collaborative project. The study reports pastoralists' unwillingness to participate in communal breeding schemes due to potentials for conflict arising from group member differences and management issues.

They prefer individual management where animals are obtained from a nucleus herd on credit repayable within a specified time period.

In addition, the nucleus may be opened and agreements drawn so that potential bull calves are returned back to the nucleus for selection of potential bull replacements. In order for the breeding scheme to be successful, other bulls in the herd would need to be castrated or culled to ensure exclusive breeding by proven bulls from the nucleus herd.

7. Conclusions and implications

Choice experiments and mixed logit model are employed to assess pastoralists' preferences for cattle traits in an environment with trypanosomosis disease prevalence. Genetically controlled tolerance of the disease offers a sustainable route for controlling the disease and improving livestock productivity in pastoral areas through systematic breeding in breed improvement programs that utilise trypanotolerance trait. However, focussing on single traits such as trypanotolerance in isolation of other traits preferred by the pastoralists may deem such programs unsustainable. Choice experiments is a useful stated preference technique as it enables quantification of preferred traits as well as the trade-offs between traits using econometric modelling. This permits priority setting in cattle breeding programs, by utilizing the trait values.

The empirical results suggest that pastoralists have high preference for traits linked to high live weight, trypanotolerance and herd increase such as high fertility in bulls and reproductive performance in cows. High reproductive performance in cows is highly valued compared to milk production. Traits associated with drought tolerance are also important to the pastoralists due to environmental constraints associated with feed and water resources. This implies that livestock breeding policies aimed at improving livestock productivity through integration of disease resistant traits such as trypano-tolerance ought to integrate other traits of preference to the livestock keepers in order to be effective and sustainable. In addition, breeds that possess superior adaptation traits such as disease resistance, heat and drought tolerance, though not highly productive, need to be conserved as these superior traits may be used to produce future viable breeds. Support for breeding societies can be an important incentive that contributes to conserve and highlight breeds with superior adaptive traits.

Farmer participatory breeding programs provide a viable pathway for accessing breeds with preferred traits from a nucleus herd. Performance recording is essential in order to monitor genetic gain achieved through such programs. High illiteracy levels are predominant in pastoral systems. This reveals the need for strengthening of local capacity through relevant and rudimentary training and awareness of the importance of performance recording. In addition, local capacity strengthening through provision of extension advice regarding breeding management is vital.

In order for productivity improvements to have an impact on the livelihoods of the pastoral communities, there is the need for development of supportive infrastructure. Infrastructural development such as establishment of slaughter houses close to the communities need to be considered so as to improve market access for the pastoralists. An option would be to support entrepreneurs investing in slaughterhouses, cold storages and other premises in order to improve livestock marketing. These policy issues are in line with the policy options identified at the Angola/Mozambique animal genetic resources (AnGR) conferences of 2002/2003.

Acknowledgements

The authors gratefully acknowledge funding support provided by the Swiss Centre for International Agriculture (ZIL).

References

Aklilu, A. (2002). An Audit of the Livestock Marketing Status in Kenya, Ethiopia and Sudan (Volume 1). Community-Based Animal Health and Participatory Epidemiology Unit, Pan African Programme for the Control of Epizootics, Organization of African Unity/Inter-African Bureau for Animal Resources.

Ben-Akiva, M. and Lerman, S. (1985). Discrete Choice Analysis. Massachusetts Institute of Technology Press, Cambridge,.

Central Bureau of Statistics (2003), Geographic Dimensions of Well-Being in Kenya: Where Are the Poor (Volume 1)? The Regal Press, Kenya, Ltd. Editors: Ndeng'e, G., Opiyo, C., Mistiaen, J. and Kristjanson, P.

de Haan, C., and Bekure, S. (1991) Animal Health Services in sub-Saharan Africa: Initial Experiences with Alternative Approaches. Washington D.C.: World Bank.

d'Ieteren, G., Authié, E., Wissocq, N., and Murray, M., (1998). Trypanotolerance, an Option for Sustainable Livestock Production in Areas at Risk of Trypanosomosis. *Rev. Sci. tech. Off. Int. Epiz*,, 17, 154-175.

Dolan, R.B. (1997) The Orma Boran - a trypanotolerant East African breed. *World Animal Review 89-1997/2*, Editor: B.S. Hursey

Fafchamps, M., Udry, C. and Czukas, K. (1998). Drought and Saving in West Africa: Are Livestock a Buffer Stock? *Journal of Development Economics*, 55, 273-305.

Government of Kenya (2002). Narok District Development Plan 2002-2008 Government Printer, Nairobi.

Hensher, D.A., Rose, J., and Greene, W. (2005). Applied Choice Analysis, 1st edn. Cambridge University Press, Cambridge.

Institute of Policy Analysis and Research (2004). Strategies for Improving the Contribution of Livestock Sector to Food Security and Increased Incomes in Kenya: The Case of Red Meat. *Policy Brief* 10, Issue 2.

Itty, P. (1996). Profitability, Efficiency and Comparative Advantage of African Cattle Meat and Milk Production: the Case of Trypanotolerant Village Cattle Production. *Agricultural Economics*, 14, pp 33-44.

Kahi, A. and Nitter, G. (2004). Developing Breeding Schemes for Pasture-based Dairy Production Systems in Kenya. Derivation of Economic Values using Profit Functions. *Livestock Production Science*, 88, pp 161-177.

Kristjanson, P., Swallow, B., Rowlands, J., Kruska, R. and de Leeuw, P. (1999) Measuring the costs of African animal trypanosomosis, the potential benefits of control and returns to research. *Agricultural Systems*, 59, 79-98.

Kristjanson, P., Radeny, M., Nkedianye, D., Kruska, R., Reid, R., Gichohi, H., Atieno, F. and Sanford, R. (2002). Valuing Alternative Land-use Options in the Kitengela Wildlife Dispersal Area of Kenya. ILRI Impact Assessment Series 10. A joint ILRI/ACC Report. ILRI, Nairobi, Kenya. 61 pp.

Louviere, J. J., Hensher, D. A. and Swait, J. D. (2000). Stated Choice Methods, Analysis and Application, Cambridge University Press.

Lybbert, T., Barrett, C. Desta, S. and Coppock, D. (2000). Pastoral Risk and Wealth-Differentiated Herd Accumulation Patterns in Southern Ethiopia. Working Paper, Cornell University.

McCarthy, N., McDermott, J., and Coleman, P., (2003). Animal Health and the Role of Communities: An Example of Trypanosomosis Control Options in Uganda, Rep. No. 103. IFPRI, Washington D.C.

Mwacharo, J. and Rege, E. (2002) On-farm Characterisation of the Indigenous Small East African Shorthorn Zebu Cattle (SEAZ) in the Southeast Rangelends of Kenya. *Animal Genetic Resources Information*, 32, pp73-86.

Revelt, D. and Train, K. (1998). Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level. *The Review of Economics and Statistics*, 80 No.4. pp 647-657

Scarpa, R., Ruto, E., Kristjanson, P., Radeny, M., Drucker, A., and Rege, E., (2003a). Valuing indigenous cattle breeds in Kenya: an empirical comparison of stated and revealed preference value estimates. *Ecological Economics*, 45, 409-426.

Scarpa, R., Drucker, A.G., Anderson, S., Ferraes-Ehuan, N., Gomez, V., Risopatron, C.R., and Rubio-Leonel, O., (2003b). Valuing genetic resources in peasant economies: the case of 'hairless' creole pigs in Yucatan. *Ecological Economics*, 45, 427-443.

Smith, K., Barrett, C. and Box, P. (2000). Participatory Risk Mapping for Targeting Research and Assistance: With an Example from East African Pastoralists, *World Development*, 28 No. 11 pp 1945-1959

Staal, S. J., Baltenweck, I., Waithaka, M. M., deWolff, T.and Njoroge, L. (2002). Location and Uptake: Integrated Household and GIS Analysis of Technology Adoption and Land Use, with Application to Smallholder dairy farms in Kenya. *Agricultural Economics* 27(3): 295-315.

Tano, K., Kamuanga, M., Faminow, M., and Swallow, B. (2003). Using Conjoint Analysis to Estimate Farmer's Preferences for Cattle Traits in West Africa. *Ecological Economics*, 45, 393-407.

Train, K., (2003). Discrete Choice Methods with Simulation, 1st edn. Cambridge University Press.

Wollny, C. (2003) The Need to Conserve Farm Animal Genetic Resources in Africa: Should Policy Makers be concerned? *Ecological Economics*, 45, pp 341-351.

Appendix

Table 3: Mixed Logit Model of Cow Trait Preferences

	Coefficient	Std. Error	P-value
Random parameters in utility function			
Trypanotolerance			
Mean	0.5913	0.1063	0.0000
Standard deviation	0.5000	0.1016	0.0000
Feeding requirement			
Mean	-0.4913	0.1345	0.0003
Standard deviation	0.5205	0.1125	0.0000
Milk yield			
Mean	0.5936	0.0798	0.0000
Standard deviation	0.1817	0.1268	0.1520
Reproduction potential			
Mean	0.5044	0.1173	0.0000
Standard deviation	0.6193	0.1992	0.0019
Live_weight			
Mean	0.6689	0.2251	0.0030
Standard deviation	0.8208	0.1736	0.0000
Non-random parameters in utility function			
Purchase price	0.0617	0.0152	0.0000
Watering frequency	0.1496	0.0853	0.0794
Coat colour	-0.0466	0.0847	0.5824
Constant	-0.0397	0.5232	0.9395

Likelihood ratio test[a]	151.7 ($\chi^2_{0.99}(20) = 37.6$)
Log likelihood at start values (Multinomial logit)	-693.2170
Simulated log likelihood at convergence	-617.3669
Number of observations	1056
Halton draws	100

[a] The likelihood ratio test is given by $2(L_\Omega - L_\omega)$, where L_Ω is the unrestricted maximum log-likelihood from the mixed logit estimation and L_ω is the restricted maximum log-likelihood from the multinomial logit estimation. It has an asymptotic $\chi^2(k)$ distribution where k is the number of required restrictions.

Table 4: Mixed Logit Model of Bull Trait Preferences

	Coefficient	Std. Error	P-value
Random parameters in utility function			
Trypanotolerance:			
Mean	0.3658	0.1299	0.0049
Standard deviation	0.6453	0.1112	0.0000
Fertility:			
Mean	0.9536	0.1283	0.0000
Standard deviation	0.7268	0.1484	0.0000
Live_weight:			
Mean	0.2944	0.0805	0.0003
Standard deviation	0.3118	0.0844	0.0002
Non-random parameters in utility function			
Purchase price	0.1194	0.0607	0.0492
Watering frequency	0.2777	0.0770	0.0003
Coat colour	0.0692	0.0709	0.3288
Constant	-1.6677	0.3260	0.0000

Likelihood ratio test[a]	123.5 ($\chi^2_{0.99}(9) = 21.7$)
Log likelihood at start values (Multinomial logit)	-524.2785
Simulated log likelihood at convergence	-462.5207
Number of observations	902
Halton draws	100

[a] The likelihood ratio test is given by $2(L_\Omega - L_\omega)$, where L_Ω is the unrestricted maximum log-likelihood from the mixed logit estimation and L_ω is the restricted maximum log-likelihood from the multinomial logit estimation. It has an asymptotic $\chi^2(k)$ distribution where k is the number of required restrictions.

Table 5: Implicit price estimates[a] of Cattle Traits

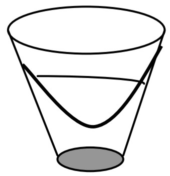
Trait	$E(\beta_k / \beta_p)$	Std. Deviation
Trypanotolerance	11.1041	7.6093
Purchased feed supplementation	-9.4353	7.1968
Milk production	8.6865	4.6483
Reproduction potential	11.1802	8.8378
Live_weight (per 10 Kg)	11.5360	9.0146
Watering frequency	3.7156	0.0000
Bull fertility	7.8031	4.9996

[a] Prices are in US$ (1 US$=74.7 KES)

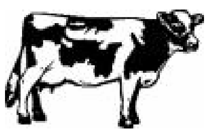
Cows: Choice task 1 (Option1)

Tolerant to Tryps: able to be in good condition despite infection. No need for treatment drugs

Average milk Yield per day (2-4 lts)



Weight at 2 yrs: 120 Kg



Reproductive potential: One calf every **two years**

Yr 1	Yr 2	Yr3	Yr4	Yr 5
√		√		√

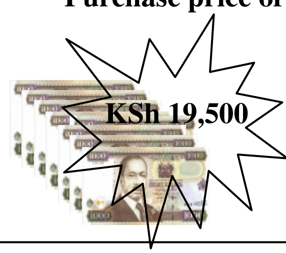
Moderate watering frequency: Need to be watered **once** a day

Dark coat

Feeding

No need for supplementary purchased feed rations

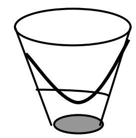
Purchase price of cow



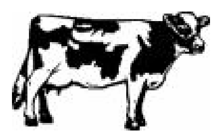
Cows: Choice task 1 (Option2)

Susceptible to Tryps: Poor condition after infection, need treatment drugs

Average milk Yield per day (1-2 lts)



Weight at 2 yrs: 250 Kg



Reproductive potential: One calf **every year**

Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
√	√	√	√	√

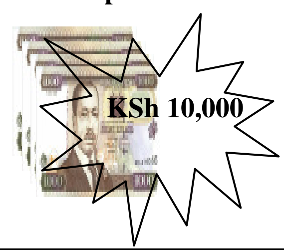
Moderate watering frequency: Need to be watered **once** a day

Light coat

Feeding requirements

Need for supplementary purchased feed rations

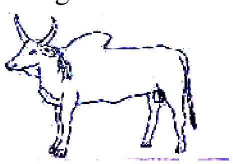
Purchase price of cow



Bulls - Choice Task 1 (Option 1)

Susceptible to Tryps: Poor condition after infection, need treatment drugs

Weight at 4 yrs: 320 Kg



Highly fertile: Semen results in pregnancy **after 1-2 sessions with cow**

High watering frequency: Need to be watered **twice in** a day

Dark coat colour

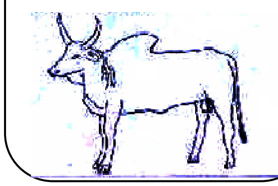
Purchase price of bull at 4 years

KSh 11,000

Bulls - Choice Task 1 (Option 2)

Tolerant to Tryps: able to be in good condition despite infection. No need for treatment drugs

Weight at 4 yrs: 320 Kg



Low fertility: Semen does not easily result in pregnancy **(success after more than 3 sessions with cow)**

Low watering frequency: Need to be watered **only once in two days day**

Light coat colour

Purchase price of bull at 4 years

KSh 27,000