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Definition of smallholder Sheko cattle keepers' breeding objectives through phenotypic ranking and choice experiments in Ethiopia

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This study aimed at identifying Sheko cattle keepers' preferences by way of phenotypic ranking and hypothetical choice experiment in their habitat in order to define the indigenous selection criteria. The ranking experiment report was based on 15 cows and 6 to 9 bulls. Three animals of the same sex were randomly assigned in one group that resulted into five groups for cows and two to three groups for bulls. Thirty cattle keepers belonging to another community were invited to rank the groups of experimental animals according to their own preferences and give the reasons why they had chosen the animals as 1st, 2nd, and 3rd. Then they were provided with life history of each cow, including age, milk yield, parity, calving interval and heart girth measurements; while for bulls, age, milk yield of dam, sire fertility and heart girth measurements were described to determine whether she/he would consider re-ranking them. The results of farmers' preference for traits through both methods are not consistent. In phenotypic ranking, the results indicate that, milk yield, body conformation, body size and coat color were emphasized in the selection of cow while, body size, dairy character, draught character and coat color traits were important traits for selection of bull. Information on life history provided insight in the respondents' ranking decisions. In choice experiments, the maximum likelihood estimates of the parameters for cow selection were significant in both lowland and midland agro-ecological zones (AEZs), except for calving interval in midland. The trait mothering ability was the most preferred trait followed by milk yield in both AEZs. For bulls the estimates were significant with the exception of growth rate in midland. It was found out that by this method breeding bulls are chosen based on milk performance of mother and temperament in both AEZs.

Key words: Breeding objectives, choice experiment, lowland, midland, phenotypic ranking, Sheko.

INTRODUCTION

The taurine Sheko cattle breed is one of the identified indigenous cattle breed in South-west Ethiopia that have been traditionally kept by small number of local farmers in the warm and humid to per-humid Sheko and Bench districts under mixed crop-livestock farming systems. The breed is well adapted to live in warm and humid environment, produce and reproduce in tsetse infested areas and is known for their relative high milk and traction capacity. Sheko cattle are prominent eyes with folded eyelid, possess gently sloping rump, prominent and upward protruding poll, broad and short ear, broad muzzle, compact body size, small to medium sized hump, dominated by red colour, majorities are polled and the rest are stumpy or curved type of floating horns (Takele, 2005). The breed manifests strong favorable trypanotolerant attributes; and has good packed red cell volume (PCV), production and reproduction Stein (2011). There are today areas where it is almost impossible to keep livestock due to trypanosomosis. A broader use of the Sheko breed in tsetse infested areas could improve animal health and household welfare. Today the majority of Sheko cattle manifest small humps that they inherited from zebu cattle. Sheko is now considered endangered by gradual interbreeding with local zebu (Dagris, 2004). Small herd size, indiscriminate interbreeding with local Zebu, critical shortage of breeding bull in many of the herds, early castration of bulls, their unmanageable and aggressive behavior, utilization of breeding bull/s born within the herd, lack of awareness about inbreeding was also the major threats accelerating the extinction of the breed (Takele, 2005; Sten, 2011). Despite the fact that the superior performance of Sheko breed is widely recognized by Sheko keepers, local authorities and Sheko breeders outside the area, the breed faces a number of different threats to their survival. Considering the importance and their endangered status, there is an urgent need to develop a pure-breeding strategy accomplished by a well-organized community based breeding program supported by a nucleus herd of purebred Sheko animals is necessary for breed conservation and sustainable management of these resources. Ideally, both *in situ* and *ex situ* conservation approaches for preserving genetic material should be considered for simultaneous application. The *in situ* conservation is advantageous to conserve the existing genetic diversity and allows further development of adaptive attributes of the breed in its natural habitat; provide an opportunity for permanent observation; ensures continued participation of the community and conserves diversities at all levels of the ecosystem.

Therefore, to develop breed conservation and improvement program in effective and meaningful way farmers' trait preferences in terms of the benefits that they perceive as well as challenges of the production environment were required. In evaluating cattle keepers' traits preferences in breeding animals, two different methods of ranking experiments approach; group-animal ranking and hypothetical choice experiment were used in two different agro-ecological zones of Ethiopia to identify breeding objectives for community-based cattle breeding programs. Thus, this study was aimed at identifying trait preference of smallholder farmers in two different agro-ecological zones of South-west Ethiopia through the use of group-animal ranking and hypothetical choice experiment.

MATERIALS AND METHODS

Study area and sampling framework

The study was carried out in warm and humid to per-humid midland and lowland agro-ecological zones (AEZs) of three districts, namely Sheko, Semein Bench and Debub Bench of Bench Maji Zone (BMZ), South-western Ethiopia, representing mixed crop-livestock production systems. Two peasant associations (PAs) (1 from midland and 1 from lowland) from each district of Sheko (Shayita and Boyita of the corresponding AEZ), Semein Bench (Genja and Garikin) and Debub Bench (Kokin and Kitte) were selected purposively based on concentration of Sheko cattle, their suitability for cattle production, accessibility to market and road, availability of common grazing land and willingness of the farmers to participate in the programs. Bmzardo (2012) briefly described the study areas below.

Sheko: This district lies between a latitude and longitude of 6° 50' N and 35° 00' E coordinates, respectively, and at an altitude that ranges from 950 to 1800 m above sea level (m.a.s.l.). The major area is classified under warm and humid to peri humid. The mean annual temperatures were 22.6°C and the annual rainfall at Mehal Sheko town (the capital of Sheko district) ranges from 1200 to 2200 mm per year. The soil type includes red brown and sandy loam.

***Semein bench*:** This district is classified under humid to peri humid climatic condition. It lies at an altitude ranging from 1050-2400 m.a.s.l. Average annual temperature ranges from 21.3 to 26°C and the mean annual rainfall of the district varied from 1200 to 2200 mm per annum. The soil type includes red brown, deep reddish, sandy loam and clay.

***Debub bench*:** The major area of this district is classified under warm and humid zone to peri humid climatic condition. Its altitude ranges from 980 to 1900 m above sea level. The average total annual rainfall is 1800 mm and the mean annual maximum and minimum temperatures recorded in were 17.25 and 27.5°C. The predominant soil types of the area include red brown, deep reddish and sandy loam.

Phenotypic ranking

Fifteen Sheko cows were purposively selected from each PA, marked and randomly assigned into five sub-groups for each ranking experiment. The bull sample population was not uniform and fulfilled the required number of fifteen in each PA due to higher shortage of bull in the existing herd. A total of 48 bulls; 6 from each PA of Shayita and Garikin; and 9 from each PA of Kitte, Kokin, Boyita and Genja were selected from within and surrounding PA having same production system, marked and randomly assigned into two and three sub-groups of three bulls each, respectively, for

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Table 1. Traits and trait levels for cows and bulls used in the choice experiments traits levels.

Traits	Levels	Reference level
Size (bull and cow)	1=big, 2=small	Small
Coat color (bull and cow)	1=red 2= red-brown, 3=patchy red and brown 4=yellow 5=black	Black
Temperament (bull and cow)	1= docile 2= aggressive	Aggressive
Growth (bull)	1= fast 2= slow	Slow
Milk of mother (bull)	1= high 2= low	Low
Traction (bull)	1= suitable 2= unsuitable	Unsuitable
Mothering ability (cow)	1=good mother, 2=bad mother	Bad mother
Calving interval (cow)	1= short 2= long	Long
Milk yield (cow)	1= high 2= low	Low

each ranking experiment. Each respondent was asked twice to rank the animals within each pen/group; first based on the phenotype of the animals alone, and then after the cattle keepers were provided with additional information on each animal in the form of history previously collected from the owners. The history included for cows were age, milk yield, parity, calving interval and heart girth measurement, while for bulls age, milk yield of dam, sire fertility and heart girth measurement (as a proxy for body size) were described. Five sub-groups of 3 cows each in all the selected PAs and 2 sub-groups of 3 bulls each in Shayita and Garikin PAs; and 3 sub-groups of 3 bulls each in Kitte, Kokin, Boyita and Genja PAs were randomly assigned and then restricted in a pen. Randomization was repeated three times during the course of each experiment after respondents covered ranking of all groups of cows and bulls. Thirty farmers unfamiliar with the experimental animals from other communities were invited to participate in the experiment. Each respondent was asked by an enumerator to rank the animals from 1^{st} to 3^{rd} within each pen according to his or her own preference and then give reasons (attributes and their levels) for his/her rankings in each group. Each person was then provided with additional information on the history of each animal as described above and asked to rank the animals once again.

Choice experiments

Choice experiment (Scarpa et al., 2003; Wurizinger et al., 2006; Ouma et al., 2007; Roessler et al., 2008; Kassie et al., 2009) was used to elicit farmers breeding goals. Attributes and attribute levels for cows and bulls used in the choice sets were identified through choice experiment survey conducted from June 2010 to November 2010 with respondents being asked to list all the attributes of bull and cow that they think are important to them and to rank these attributes in order of importance. Six highest ranked attributes were identified for cows and bulls and then used to design the choice experiment, with five traits having two levels and one trait with five levels. Table 1 presents the various traits and their levels for cows and bulls. Given the number of total possible combinations of 160 (25 * 51, that is, five attributes with two levels and one attribute with five levels) profiles, 25 choice-sets (50 profiles) were generated for each sex. These 25 choice-sets were generated by following the D-optimality or D-efficiency of 99.6% and A-efficiency of 99.2% design criterion procedure in Statistical Analysis System algorithm (SAS, release 9.1, 2003) which enabled to capture the main effects plus two-way interactions (Kuhfeld, 2005). This high efficiency implies that the variance matrix has quite small value with positive implications on the reliability of the estimates to be generated. D-optimality or D-efficiency and A-efficiency design maximizes the determinant of the information matrix, which results in minimizing the variation of the parameter estimates. It is the most popular criterion for generating optimal designs, and it seeks the design that minimizes the variances of estimated parameters in the pre-specified model (Kuhfeld, 2005). After intensive training of enumerators and a pre-test, data were collected from the 30 member households in each PA by development agents (DA) from the department of animal production for a consistent and clear explanation of all the attributes and attribute levels considered. The interviewee was first introduced to the type of choice task required and then he/she was presented with a sequence of twenty five sets of pair-wise choices for bulls and cows each using the actual experimental cards generated from the design. The differences in the levels of traits in the choice sets were also demonstrated using words that supported oral descriptions. Each choice task required the respondent to choose one animal profile he/she would prefer for breeding from the two profiles presented for each choice task and an option to select neither.

Data preparation and analytical methods

Phenotypic ranking experiment

Reasons for ranking on phenotype characters in phenotypic ranking experiment were analysed using frequency procedure of Statistical Analysis System (SAS, release 9.1, 2003) and Chi-Square was calculated to evaluate the influence of attributes on decisions made by respondents. Quantitative characters provided as life history were analysed with MEANS and using the Generalized Linear Model (GLM) procedures of the Statistical Analysis System (SAS, release 9.1, 2003).

Choice experiment

PROC LOGISTIC regression in Statistical Analysis System (SAS, release 9.1, 2003) was used to analyse the data for choice experiments. The application of choice experiments arises from the consumer theory developed by Lancaster (1966) which assumes that preference for goods are a function of the attributes or characteristics possessed by the good rather than the good *per se*. A major implication of this theory is that the overall utility of a good can be decomposed into separate utilities for its constituent characteristics or attributes. According to the random utility model, an individual *n* facing a choice among *j* alternatives would obtain a certain level of utility or profit from each alternative (McFadden, 1974, 2001).

Suppose an individual q (q=1,…,Q) faces a choice amongst *I* alternatives in each of *T* choice situations. Individual *q* is assumed to consider the full set of offered alternatives in a choice situation *t* and has to choose the alternative with the highest utility. The utility associated with each alternative *i* as evaluated by each individual *q* in choice situation *t* is represented in a discrete choice model by a utility function of the general form:

$$Uitq=βqXitq+eitq \quad (1)$$

Where; X_{itq} is a vector of explanatory variables that are observed by the analyst and include attributes of the alternatives, socio-economic characteristics of the respondent and descriptors of the decision context and the choice task itself in choice situation *t*. $ß_q$ and e_{itq} are parameters to be estimated and error terms respectively. In cases, where an economic agent chooses from among a set of multiple choices, multiple choice models have been employed to model choice behaviour. Suppose observed choice *Y* has values 0, 1, …., *m* and X_i includes individual *q*'s characteristics while Z_i are the choice specific characteristics, the multinomial logit model to assess the effect of X_i on the probability that choice *Y* has trait *j*, can be presented thus (Greene, 1997);

$$Prob\ (Y_i = j) = \frac{e^{\beta`_j x}}{\sum_{k=0}^{m} e^{\beta`_k x_i}}, j = 0,1, \ldots.m \quad (2)$$

The independent variable X_i does not vary across choice alternatives but varies across individuals. Whereas the independent variables Z_i varies across individuals as well as choice alternatives. Therefore, to assess the impact of *Z* (choice-specific attributes) on *Y*, the appropriate model to use is the conditional logit model for a total of J alternatives, defined as:

$$Prob\ (y_i|x_i = j) = j\frac{e^{\beta` z_{ij}}}{\sum_{i=1}^{J} e^{\beta` z_{ij}}}, j = 1, 2, \ldots.J \quad (3)$$

In conditional logit, the estimator is the value of ß while in multinomial logit, the estimator is the value of $ß_j$. PROC LOGISTIC regression in Statistical Analysis System (SAS, release 9.1, 2003) was used to analyze the data. PROC LOGISTIC is one of the tools in SAS for multivariate modelling of categorical outcome variables. The most familiar reason to use PROC LOGISTIC is to model binary categorical outcome variables. However, PROC LOGISTIC can handle the case where the dependent variable has more than two categories. PROC LOGISTIC uses a cumulative logit function if it detects more than two levels of the dependent variable, which is appropriate for ordinal (ordered) dependent variables with three or more levels (Elkin, 2004).

RESULTS AND DISCUSSION

Preferences for Sheko cattle attributes using phenotypic ranking experiments

Preferences for Sheko cow attributes

Phenotypic attributes of Sheko cow in phenotypic ranking experiment are presented in Table 2. Milk yield of cow accounted the largest proportion for both midland and lowland Sheko cattle owners accounted for 20 and 20.4%, respectively. Body size, body conformation, and coat color were also identified as important cow attributes with proportion of 14.6, 11, and 8.9%, respectively in midland. In lowland body conformation, body size and coat colour were ranked second, third and fourth important traits each accounted for 12.1, 11.8, and 9.6%, respectively. Moreover, mothering ability, temperament, body width, polledness, reproduction potential, color pattern, appearance, wide hind quarter, longer navel flap and thin and long neck were all considered important in both AEZs. In contrast to our study, Tano et al. (2003) reported on important traits in cattle from West Africa, where reproductive performance was most preferred by farmers and was ranked highly over 6 other traits from both conjoint and explicit ranking. Other traits, body length, reduced hump, concave face, calf size/vigor at birth and age were mentioned in both midland and lowland areas for cow.

Preferences for Sheko bull attributes

The results indicate that body size, draught character, dairy character and coat color traits are the main reasons for selecting bull in both AEZs. These four traits accounted for 62 and 61.7% of the total descriptions used by respondents in midland and lowland agro ecological zones, respectively (Table 3). In midland, the above mentioned attributes appeared with proportions of 19.6, 16.6, 15% and 10.8%, respectively. While in lowland were 17.9, 12.8, 17.2 and 13.8%, respectively. In midland AEZ, appearance (6.9%), body width (6.3%), wide front body (3.9%), body condition (3.7%) and color pattern (3.1%) was also important. Whereas in lowland, respondents identified appearance (9.1%), body width (6.3%), temperament (4.2%), mating ability (3.3%) and body condition (3.1%). Other traits, body length, polledness, age, scrotum size, tail length, wide hind quarter, short tail, prominent neck, hump size and dewlap were mentioned in both midland and lowland AEZs. However, contrary to the present study of farmer preference in bulls was reported by Tano et al. (2003), where disease resistance was highly ranked in West African cattle. For Sheko cattle keepers conformation of a bull were assessed based on dairy character (e.g. milk yield potential, long tail, wide hind quarter and big scrotum) and draught character (e.g. wide front body, short tail and prominent neck). While body size of a bull were assessed based on milk yield. In both AEZs, Sheko cattle breeder prefers bigger size and bull having good conformation. Generally, the proportion for the frequencies of reasons given by cattle keepers for ranking of body size and coat color in bull were of higher magnitude to those in cow.

Generally evaluation of selection criteria in indigenous stocks using phenotypic ranking approaches is new and similar studies are not available so far in cattle. However, higher ranking values for both beauty (color) and size traits for cows and beauty traits (coat colour) for bulls were reported from results of other phenotypic ranking experiment with Ugandan Ankol cattle keepers (Ndumu et al., 2008). The influence of beauty traits (coat colour)

Table 2. Frequency for cow traits preferences with percentage of phenotype in the ranking of cows by agro ecological zones.

Traits	Midland		Lowland	
	Frequency	%	Frequency	%
Size traits				
Body size	591	14.6	479	11.8
Body length	75	1.9	21	0.5
Body width	201	5.0	190	4.7
Conformation traits				
Conformation	445	11.0	490	12.1
Appearance	120	3.0	129	3.2
Wide hind quarter	119	2.9	171	4.2
Longer naval flap	95	2.3	146	3.6
Thin and long neck	81	2.0	86	2.1
Reduced hump	26	0.6	38	0.9
Concave face	19	0.5	3	0.1
Mothering ability				
Mothering ability	263	6.5	195	4.8
Calf size/vigor at birth	65	1.6	71	1.8
Coat color				
Coat color	360	8.9	390	9.6
Colour pattern	123	3.0	146	3.6
Milk yield	809	20.0	827	20.4
Temperament	250	6.2	248	6.1
Reproduction potential	155	3.8	133	3.3
Polled	175	4.3	227	5.6
Age	78	1.9	58	1.4
Sum	4050		4048	

for bulls, and body size and beauty traits (coat colour) for cows as the more important selection criteria for ranking decisions of cattle keepers obtained in this study is in agreement with the results reported by Ndumu et al. (2008) for Ankole cattle. The importance of body size, coat color and milk yield for selection criteria obtained in this study is in agreement with other finding (Tadele, 2010) on different sheep breeds of Ethiopia.

Attribute-levels used by farmers to express their preferences of Sheko cow in phenotypic ranking

Based on the results obtained in Table 2, the total magnitude and order of recurrence was high in combination for milk yield (20 and 20.4%); body size (14.6 and 11.8%); body conformation (11 and 12.1%); coat color (8.9 and 9.6%) and temperament (6.2 and 6.1%) in midland and lowland, respectively. Farmers in both midland and lowland used qualitative descriptions for selection of attribute-levels preferences. Reasons of ranking for attribute-levels chosen relevant to milk yield trait was given in relation to body size and conformation. Generally bigger size and good conformation were preferred trait-levels for Sheko cattle breeder and assumed to result a good milking animal. Similarly, the attribute-levels used for description of cows were ‘big’, ‘moderate’ and ‘small’ for body size and ‘good’ and ‘bad’ for coat color, temperament and body conformation. The proportion of big-size cow was higher in midland AEZ in rank group 1 and 2 than in lowland AEZs. In the first and second rank groups the proportion of choosing medium-size cow was higher in lowland than obtained in midland, whereas, in the third rank group the percentage of medium-size cow were higher in midland than lowland. In both midland and lowland, the proportion of choosing good body conformation in the first rank group was same from each other whereas, the proportion in the second rank group was higher in midland AEZ. At the third rank group, the proportion was lower than obtained in lowland. In both AEZs, farmers gave more attention for the coat color of their animals. The proportion of choosing good coat color in the first and second rank group is almost similar. In case of temperament, the proportion of bad (aggressive) temperament was increased as the rank group decreased from the second to the third rank group in both AEZs. The proportion of the selected attributes and their levels of body size, body conformation, coat

Table 3. Frequency for bull traits preferences with percentage of phenotype in the ranking of bulls by agro ecological zones.

Traits	Midland		Lowland	
	Frequency	%	Frequency	%
Size traits				
Body size	353	19.6	322	17.9
Body length	23	1.3	22	1.2
Body width	114	6.3	114	6.3
Colour traits				
Coat color	194	10.8	248	13.8
Colour pattern	56	3.1	49	2.7
Production character				
Dairy character				
Milk character	270	15.0	309	17.2
Long tail	12	0.7	5	0.3
Wide hind quarter	49	2.7	44	2.4
Big scrotum	3	0.2	14	0.8
Draught character				
Draught character	299	16.6	231	12.8
Wide front body	32	3.9	31	1.7
Short tail	7	0.4	-	-
Prominent neck	50	2.8	21	1.2
Polledness	23	1.3	-	-
Temperament	23	1.3	75	4.2
Age	20	1.1	32	1.8
Mating ability	48	2.7	59	3.3
Body condition	66	3.7	56	3.1
Big hump	27	1.5	14	0.8
Large dewlap	7	0.4	-	-
Appearance	124	6.9	164	9.1
Sum	**1800**	**-**	**1800**	**-**

color and temperament within each rank group of Sheko cow in both midland and lowland AEZs are presented in Figure 1.

Attribute-levels used by farmers to express their preferences of Sheko bull in phenotypic ranking

The proportion of the selected attributes and their levels of body size, dairy character, draught character and coat color within each rank group for Sheko bull in midland and lowland are presented in Figure 2. Like in cow, the highly selected attributes in Table 2, further used by farmers to express their attribute-levels preferences of bull in both AEZs were body size, draught character, dairy character and coat color. The attribute-levels used for description of bull was 'big', 'moderate' and 'small' for body size and 'good' and 'bad'/'poor' for coat color, dairy character and draught character. Generally, the proportion of choosing big-size bull was higher in midland at rank group one, two and three than in lowland. In both AEZs, good draught character at the first rank group was same from each other whereas, the second and third rank group had higher in midland than lowland. Whereas in lowland, the proportion of choosing good coat color was higher than obtained in midland at rank group one, two and three. In case of bull dairy character, the proportion of choosing good (docile) character was same in both AEZs at rank group one, whereas, the second rank group obtained in midland had lower percent value and further decreased as the stage of rank decreased to the third rank group of phenotype and results become higher than the lowland.

Sheko cattle having pure red, red-brown, patchy red

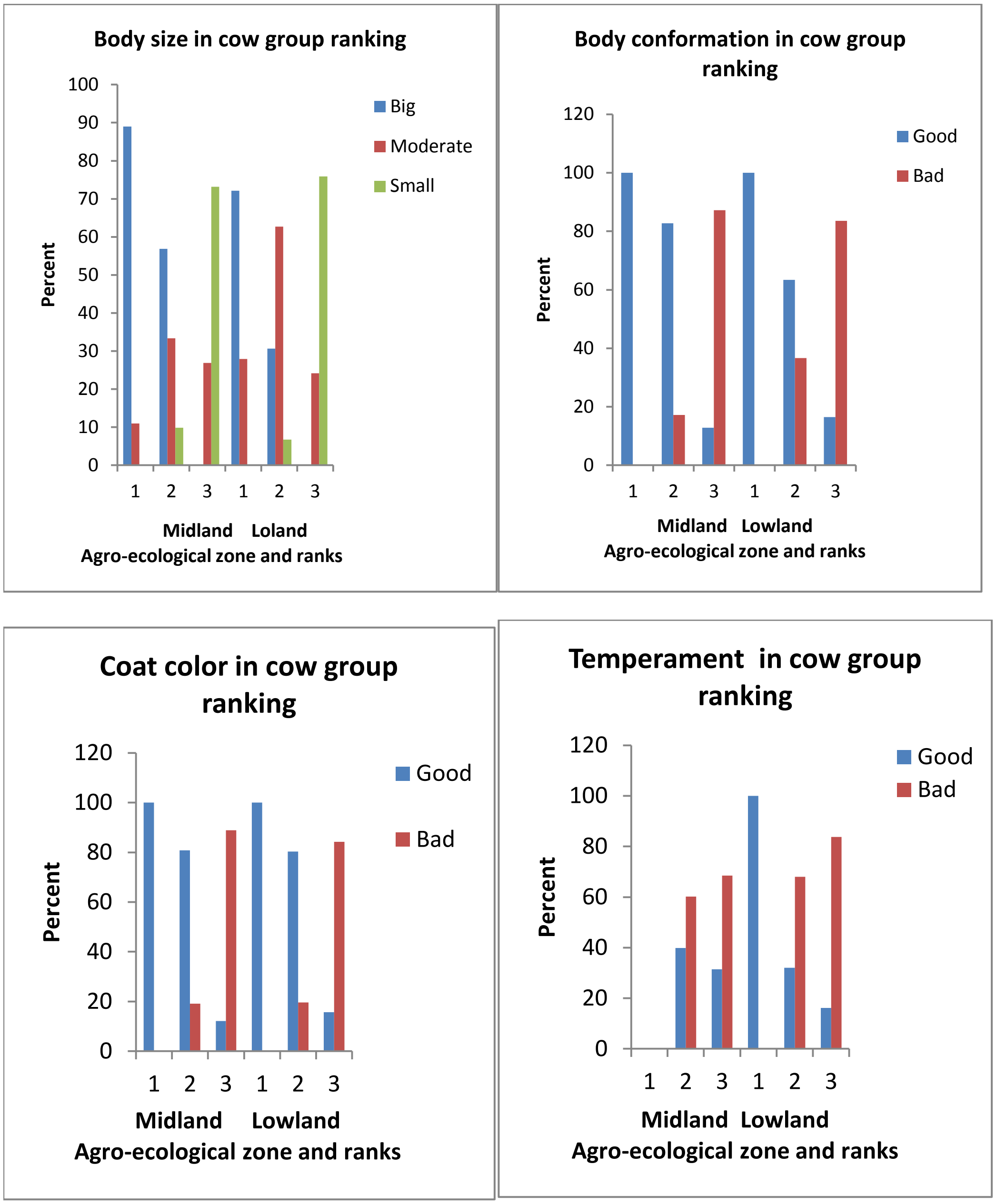

Figure 1. Attribute-levels of cow by agro-ecology and rank group.

and white and yellow in that order over black influenced the ranking decision of the respondents in both midland and lowland AEZs. Report by Ndumu et al. (2008) indicated that beauty traits like coat color and pattern play significant role in ranking decision of Ankole cattle. Ouma et al. (2004) noted Maasai pastoralists in Kenya and Ethiopia prefer dark coat colored. Tesfay (2008) revealed Menz sheep breeders prefer primarily plain white colored sheep and Afar pastoralists prefer creamy/white color with light red patch at the back and plain light red colored. Generally, the proportion of favourable descriptions of attribute-levels was higher in groups of animals ranked first and vice versa. In contrast to this study on body size of animal other than the two AEZs of mixed production environments, Ouma et al. (2004) reported that farmers preferred lighter (medium sized) animals which suit their pastoral system.

Comparisons of rankings with and without life history in cow

Ranking of cow attributes, on the basis of first, second and third rank categories before and after additional

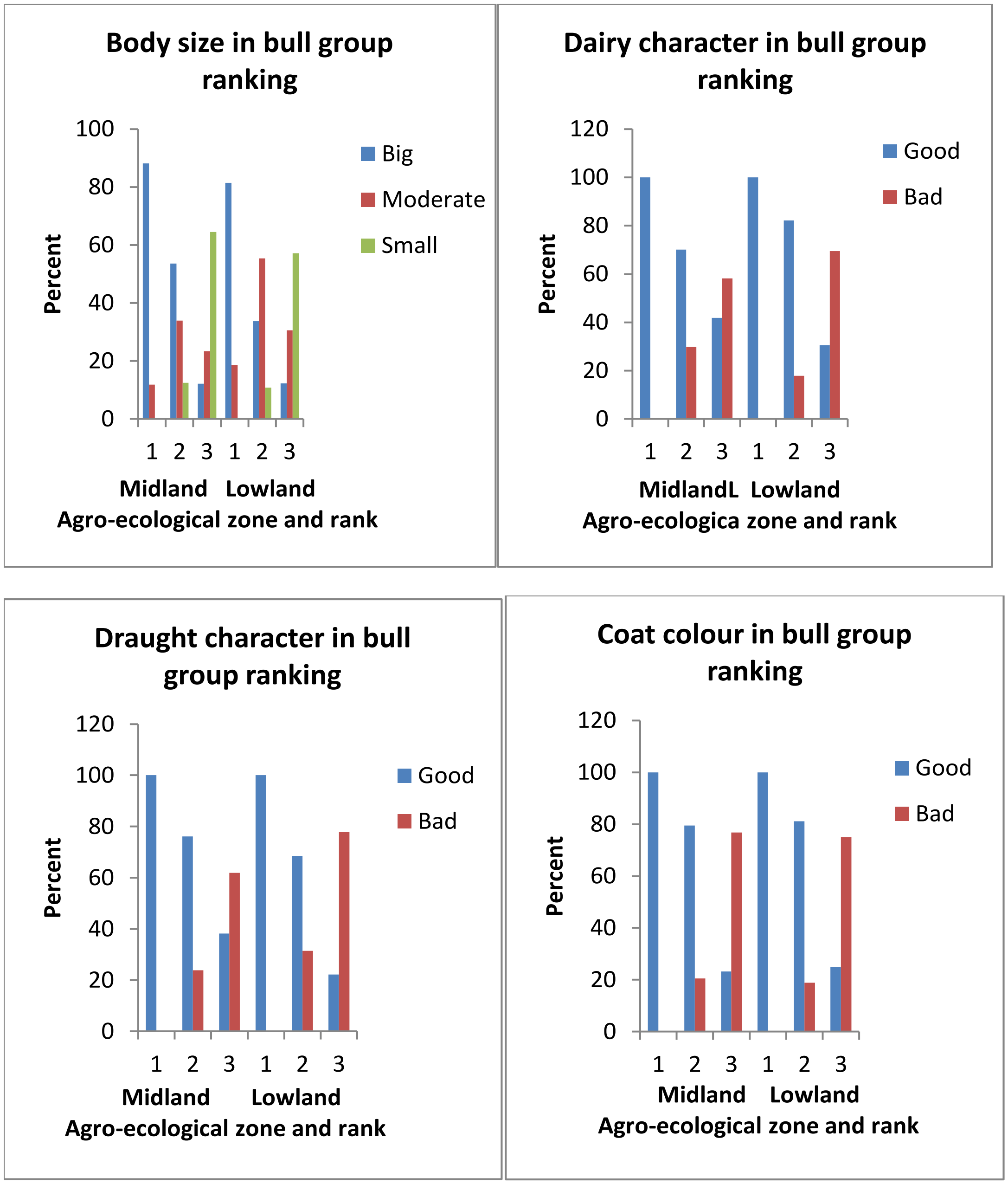

Figure 2. Attribute-levels of bull by agro-ecology and rank group.

information are presented in Table 4. Based on the total mean (standard deviation) obtained in rank groups of phenotypes all traits considered before and after provision of life history, remain significant ($p<0.05$ and $p<0.001$) in the ranking decision of respondents for both midland and lowland Sheko cattle keepers. In midland prior to life history, age, milk yield, parity and heart girth measurement of Sheko cow in the first rank group was significantly higher ($p<0.01$) than the value of the second rank group and third rank group, the third rank group having the least. After provision of life history, only milk yield and heart girth measurement showed the same trend for differences in the values between the rank groups of the first, second and third. The difference was, however, for age and parity between the second and third rank groups ($p>0.05$) after provision of life history. In this area, results without information related to calving interval in the first rank group was higher ($p<0.01$) than the value of the second rank group and third rank group but the first rank group didn't statistically differ with the third rank group. Corresponding results with life history was higher ($p<0.01$) between the first, second and the third rank

Table 4. Ranking of cows before and after provision of life history.

Agro-ecology	Attributes	Without live history					With live history			
		Overall mean	1	2	3	p-value	1	2	3	p-value
Mid	Age	8.19±1.48	8.45±1.41^{a}	8.19±1.39^{b}	7.93±1.59^{c}	***	8.50±1.33^{a}	8.06±1.42^{b}	8.02±1.63^{b}	***
	Milk yield	2.61±0.42	2.71±0.39^{a}	2.63±0.41^{b}	2.50±0.44^{c}	***	2.78±0.38^{a}	2.64±0.40^{b}	2.42±0.40^{c}	***
	Parity	3.02±0.93	3.16±0.87^{a}	3.03±0.87^{b}	2.88±1.01^{c}	***	3.18±0.82^{a}	2.93±0.86^{b}	2.95±1.08^{b}	***
	CI	1.65±0.23	1.66±0.24^{a}	1.64±0.22^{b}	1.65±0.23^{ab}	*	1.68±0.24^{a}	1.64±0.21^{b}	1.63±0.23^{b}	***
	Heart girth	130.82±3.86	131.69±3.7^{a}	130.92±3.62^{b}	129.84±4.03^{c}	***	131.87±3.55^{a}	130.58±3.60^{b}	130.00±4.15^{c}	***
Low	Age	7.96±1.40	8.13±1.38^{a}	7.86±1.34^{b}	7.88±1.45^{b}	***	8.16±1.4^{a}	7.85±1.32^{b}	7.87±1.44^{b}	***
	Milk yield	2.70±0.36	2.76±0.36^{a}	2.68±0.34^{b}	2.66±0.37^{b}	***	2.76±0.36^{a}	2.68±0.34^{b}	2.66±0.37^{b}	***
	Parity	2.89±0.95	3.02±0.95^{a}	2.84±0.92^{b}	2.82±0.95^{b}	***	3.04±0.97^{a}	2.83±0.92^{b}	2.81±0.96^{b}	***
	CI	1.64±0.24	1.64±0.25^{a}	1.61±0.23^{b}	1.66±0.25a	***	1.64±0.25^{a}	1.61±0.23^{b}	1.67±0.24^{c}	***
	Heart girth	133.70±3.93	134.28±3.93^{a}	133.48±3.71^{b}	133.36±4.08^{b}	***	134.33±3.98^{a}	133.39±3.65^{b}	133.37±4.08^{b}	***

Means with different superscripts within the same row and class are statistically different. Ns = Non significant; CI, calving interval; *significant at 0.05; **significant at 0.01 and *** significant at 0.001.

group while the latter two groups are not statistically different (p>0.05) from each other. While in lower altitude, prior to additional information, the results of age, milk yield, parity and heart girth measurement in cows, on thebasis of rank groups stay same trend after provision of additional information. However, provision of life history only altered respondents' decision on CI in rank group between the second and third. The provided life history did not influence the ranking decisions of the respondents' in both AEZs, as indicated no significant differences were observed between the rank groups of first, second and third categories before and after provision of additional information. The reason could be that they have more association with their livestock and consequently developed their own mechanisms of indigenous selection criteria that consider this. This result does not agree to those of Ndumu *et al.* (2008) who reported significant influence of additional information in the ranking decision of Ankole cattle on milk yield.

Comparisons of rankings with and without life history in bull

Results for various attributes before and after provision of life history in bull are given in Table 5. Results indicate all the attributes used in the ranking of bull before provision of additional information were significantly (p<0.05 or p<0.01 or p<0.001) influenced Sheko cattle breeders' preferences in both midland and lowland except for sire fertility (p>0.05) in lowland AEZ. However, the difference was observed for heart girth measurements when considered with additional information showed non-significant (p>0.05) influence in the ranking decisions of the respondents, indicating that variation in ranking results are due to the additional information on heart girth measurements of bulls. While age, milk yield and sire fertility remain significant implied that the provided information did not influence respondents' decision in midland AEZ. Whereas, in lowland after provision of additional information dams milk yield and sire fertility showed the same trend for differences in the values between the rank groups of the first, second and third. However, the differences were observed between ages and heart girth measurements, suggesting that life history influenced selection of bulls. On the other hand, in midland, prior to life history, age, milk yield of dam and sire fertility in the first and second rank groups were not statistically different (p>0.05) from each other, whereas, the third rank group had lower (p<0.01) than the first two. However, only milk yield of dam information altered respondents' decision in the first and second rank group. The significant influence of information in the ranking of bull on sire fertility and milk yield of dam reported by Ndumu et al. (2008) working on Ugandan Ankole cattle disagree with the results of the present study. In midland, milk performance of dam was decreased as the rank groups decreased from the first to the third rank group followed the logical trend in groups of bull ranked from first to third.

Table 5. Ranking of bulls before and after provision of additional information.

Agro-ecology	Attributes	Without live history					With live history			
		Overall mean	1	2	3	p-value	1	2	3	p-value
Mid	Age	6.77±2.43	6.95±2.46[a]	6.89±2.47[a]	6.46±2.34[b]	**	6.93±2.47[a]	6.85±2.47[a]	6.54±2.35[b]	*
	Dam milk	2.76±0.50	2.83±0.49[a]	2.79±0.49[a]	2.67±0.50[b]	***	2.84±0.48[a]	2.77±0.49[b]	2.69±0.51[c]	***
	Sire fertility	0.76±0.10	0.77±0.11[a]	0.77±0.11[a]	0.76±0.10[b]	*	0.77±0.12[a]	0.77±0.12[a]	0.75±0.98[b]	***
	Heart girth	130.91±6.11	131.36±6.15[a]	131.14±6.08[a]	130.24±6.04[b]	**	131.25±6.07	130.98±6.17	130.46±6.05	NS
Low	Age	6.99±2.40	6.89±2.47[b]	6.88±2.32[b]	7.20±2.38[a]	*	6.98±2.48[a]	6.91±2.35[a]	7.08±2.35[a]	NS
	Dam milk	2.65±0.54	2.60±0.50[b]	2.62±0.52[b]	2.73±0.59[a]	***	2.61±0.51[b]	2.63±0.51[b]	2.71±0.59[a]	**
	Sire fertility	0.76±0.13	0.76±0.12	0.77 ±0.13	0.77±0.13	NS	0.75±0.12[a]	0.77±0.13[a]	0.77±0.13[a]	NS
	Heart girth	129.68±5.82	129.39±6.0[b]	129.28±5.54[b]	130.37±5.86[a]	**	129.58±6.06	129.37±5.59	130.10±5.78	NS

Means with different superscripts within the same row and class are statistically different. Ns = Non significant;*significant at 0.05; **significant at 0.01 and *** significant at 0.001.

Table 6. Maximum likelihood estimates (± s.e) and their level of significance for cows traits.

Parameter	DF	Estimates (± s.e)	
		Midland	Lowland
Size	1	0.14±0.054 **	0.14±0.053 **
Coat color	1	-2.15±0.048***	-2.09±0.047***
Temperament	1	0.12±0.054*	0.18±0.533***
Milk yield	1	0.47±0.058***	0.33±0.055 ***
Calving interval	1	-0.10 ±0.051[NS]	0.21±0.054***
Mothering ability	1	1.51±0.082***	1.22±0.072***
Pseudo-R^2		0.348	0.335

DF=degree of freedom; ***p<0.001; **p<0.01; *p<0.05 NS = p>0.05.

Preferences for Sheko cattle attribute using choice experiments

Cow traits preferences

The results for cow are presented in Table 6. The pseudo-R^2 ranged from 0.335 to 0.348 for cow. The maximum likelihood estimates (MLE) of the parameters for cows were significant (P<0.05 or p<0.01 or p<0.001) in both AEZs except calving interval (CI) in midland AEZ. Attributes with unexpected signs were CI in midland and coat color in both midland and lowland areas. The trait mothering ability was the most preferred trait followed by milk yield in both AEZs.

Bull traits preferences

Results for bull are presented in Table 7. The pseudo-R^2 ranged from 0.247 to 0.288 for bull.

Table 7. Maximum likelihood estimates (± s.e) and their level of significance for bull traits

Parameter	DF	Estimates (± s.e)	
		Midland	Lowland
Size	1	0.29±0.052***	0.21±0.051***
Coat color	1	-1.84±0.046***	-1.44±0.044***
Growth rate	1	0.03±0.049^{NS}	-0.11±0.048*
Milk per of mother	1	0.46±0.054***	0.62±0.056***
Temperament	1	0.71 ±0.058***	0.47±0.054***
Traction	1	0.34±0.053 ***	0.26±0.051***
Pseudo-R^2		0.288	0.247

DF = degree of freedom; ***p<0.001; **p<0.01; *p<0.05; NS=p>0.05.

Attributes with unexpected signs were growth efficiency in lowland and colour in both AEZs. The estimates were significant (p<0.05 or p<0.001) with the exception of growth rate in midland AEZ. Temperament was of high importance in midland and it ranked second in lowland next to milk performance of mother. Milk performance of mother was the most preferred attribute for breeding bull selection in lowland and the second most preferred trait in midland. This indicates that cattle keepers prefer bulls whose dams are high milk yielder. In midland AEZ, bull attributes influencing breeding candidates' selection were temperament, milk performance of dam, traction and body size in that order, whereas in lowland, milk performance of dam, temperament, traction and body size were the preferred traits in choosing breeding bull, respectively.

Cow trait-levels preferences

The results for cow are presented in Table 8. For breeding cow, the odds ratio estimates of the different attribute levels are very similar in both AEZs. Sheko cattle breeders in lowland AEZ, slightly more preferred cows with red–brown, pure red, plain yellow and patchy red and brown colors relative to black, in that order with an odds ratio estimates of 1.08, 1.06, 1.04 and 1.01, respectively. However, the attribute levels red-brown colour relative to black coat colored was only considered and less attention was given for the other attribute levels of pure red, plain yellow and patchy red and brown colors in midland AEZ. The attribute levels one calf a year, red-brown and two litre milk per milking of cows appear to be important for breeding cow selection with nearly comparable preferences in both AEZ. Large-sized and docile tempered cows are slightly more preferred than their counterparts in midland agro ecology. In both areas, it appears that less emphasis was given to cows' mothering ability as indicated by the odds of selecting good mother cows v. bad ones. The odds of choosing 2 L milk vs. 1 litre milk-producing cows remains almost equal in both AEZs.

Bull trait-levels preferences

The results for bull attribute-levels preferences are presented in Table 9. Like in cow, the odds ratio estimates for all attribute-levels of bull were very similar in both AEZs. The odds of choosing big vs. small-sized bulls remains almost equal in both AEZ, and it appears that less emphasis was given to bull body size as indicated by the estimates of odds ratio (Table 9). Farmers in midland area preferred pure red, plain yellow, patchy red and brown and red-brown in that order with an odds ratio estimates of 1.12, 1.11, 1.10 and 1.03, respectively. Whereas farmers in lowland area consider plain yellow, pure red, red–brown and patchy red and brown over black with an odds ratio estimates of 1.25, 1.19, 1.09 and 1.08, respectively. Docile tempered bull and 2lt milk performance of mother were slightly more preferred than their counterparts in lowland AEZ. Concerning traction, a slight more preference values for suitable traction are placed in midland area. Growth efficiency of the animal does not play a key role in the choice made by the cattle keepers in midlands while fast growing bulls are slightly more preferred than their counterparts in lowland AEZ.

The explanatory power of the model is good with a pseudo-R^2 ranging from 0.247 to 0.288 for bull and 0.335 to 0.348 for cow. Well-fitted models occur with likelihood ratio index or pseudo-R^2 greater than 0.2 (Hoyos, 2010). The trait body size, milk performance of mother, temperament and traction is strongly significant (p<0.001) and has the expected positive sign for breeding bull in both AEZs with nearly comparable coefficients which indicates homogeneous preferences implying that Sheko cattle keepers derive a positive utility from the attributes. Results also indicated that growth efficiency in lowland, and coat colour in both AEZs had negative coefficients but is significant (p<0.05 or p<0.001). The results of coat colour are inconsistent with our expectations that red,

Table 8. Odds ratio estimates of the different attribute levels against their reference categories and their confidence intervals for cows traits.

Effects	Point estimates (95% Wald CI)	
	Midland	**Lowland**
Size (1 *v*. 2)	1.01 (0.815 to 1.229)	0.972 (0.793 to 1.190)
Coat color (1 *v*. 5)	0.99 (0.710 to 1.353)	1.06 (0.761 to 1.482)
Coat color (2 *v*. 5)	1.02 (0.709 to 1.455)	1.08 (0.746 to 1.572)
Coat color (3 *v*. 5)	0.95 (0.659 to 1.384)	1.01 (0.696 to 1.476)
Coat color (4 *v*. 5)	0.98 (0.690 to 1.392)	1.04 (0.726 to 1.493)
Calving interval (1 *v*. 2)	1.04 (0.860 to 1.265)	1.07 (0.869 to 1.315)
Milk yield (1 *v*. 2)	1.07 (0.855 to 1.347	1.06 (0.853 to 1.310)
Temperament (1 *v*. 2)	1.00 (0.816 to 1.228)	0.96 (0.785 to 1.184)
Mothering ability (1 *v*. 2)	0.82 (0.578 to 1.148)	0.93 (0.687 to 1.246)

CI=confidence interval. Size (1=big, 2=small); colour (1=red, 2= red-brown, 3=patchy red and brown, 4=yellow 5=black for both midland and lowland); calving interval (1=one calf a year, 2=one calf every two years); milk yield (1=two litre per milking, 2=one litre per milking); temperament (1=docile, 2=aggressive); mothering ability (1=good mother, 2=bad mother).

red-brown, patchy red and brown or yellow coat colour types are preferred to black as usually the latter have higher chances of being bitten by the tsetse flies and as revealed by the production systems study. Attributes showing negative coefficients of MLE are not preferred by livestock keepers as they signify a negative utility from the attribute (that is, growth rate and coat colour). Growth performance in midland is positive but not statistically significant suggesting that respondents choices are not strongly influenced by growth rate. For the cow model, the derived MLE for the attributes mothering ability is one of the most highly valued attributes in both AEZ (Table 6). In the current study, milk production trait is the second most important attribute for breeding cows selection, had positive coefficient and statistically significant in both AEZs, suggesting that Sheko cattle keepers' choices are strongly influenced by milk yield or it likely be that the respondents gave more weight to milk production. The odds of choosing 2 L as opposed to 1 litre per milking were also very similar in both AEZs. With regard to calving interval, the odds of choosing short calving interval as opposed long one was very similar in both AEZs, whereas, temperament was favoured in lowland. Results indicated that body size in both AEZs, remains equal and had the expected positive sign and significant ($p<0.01$) suggesting that respondents choices are strongly influenced by big body size as opposed to small body sized cows. The available reports on cattle other discrete choice experiments conducted elsewhere indicated significant influence of reproductive potential (calving interval) for cows' in south-western Ethiopia and Kenya (Ouma et al., 2004); milk performance of mother and temperament for bulls and milk yield for cows (Wurzinger et al., 2006); body size for cows (Kassie et al., 2009) in central Ethiopia and bull (Zander and Drucker, 2008) in southern Ethiopia and bull and cow in

Table 9. Odds ratio estimates of the different attribute levels against their reference categories and their confidence intervals for bull traits.

Effects	Point estimates (95% Wald CI)	
	Midland	Lowland
Size (1 v. 2)	0.96 (0.79 to 1.18)	0.97 (0.79 to 1.18)
Coat color (1 v. 5)	1.12 (0.84 to 1.49)	1.19 (0.73 to 1.64)
Coat color (2 v. 5)	1.03 (0.75 to 1.41)	1.09 (0.71 to 1.69)
Coat color (3 v. 5)	1.10 (0.80 to 1 .51)	1.08 (0.71 to 1.68)
Coat color (4 v. 5)	1.11 (0.70 to 1.75)	1.25 (0.73 to 2.15)
Growth rate (1 *v*. 2)	0.96 (0.79 to 1.16)	1.02 (0.85 to 1.23)
Temperament (1 *v*. 2)	1.06 (0.84 to 1.33)	1.09 (0.88 to 1.35)
Traction (1 *v*. 2)	1.01 (0.82 to 1.24)	1.00 (0.81 to 1.22)
Milk of mother (1 *v*. 2)	1.02 (0.82 to 1.26)	1.05 (0.84 to 1.31)

CI=confidence interval. Size (1=big, 2=small); colour (1=red, 2= red-brown, 3=patchy red and brown, 4=yellow 5=black for both midland and lowland); growth rate (1=fast, 2=slow); temperament (1=docile, 2=aggressive); traction (1=suitable, 2=unsuitable); milk performance of mother (1=two litre per milking, 2=one litre per milking).

southern Ethiopia and northern Kenya; bull and cow (Ouma et al., 2007) in central Ethiopia and northern Kenya and suitable traction for bull (Zander and Drucker, 2008) on producers' decisions. Application of CE for the valuation of attributes of livestock is very recent and only a few employed it. The significant influence of milk yield and body size for cows on producers' decisions obtained in this study is in agreement with the results reported for milk yield (Tano et al., 2003; Wurzinger et al., 2006; Zander, 2006; Ouma et al., 2007; Kassie et al., 2012) and body size (Ouma et al., 2007; Zander and Drucker, 2008; Kassie et al., 2009). Contrary, Kassie et al. *(*2012) obtained non significant influence of body size on producers' decisions for cows working on indigenous breeds of cattle in Ethiopia. Similarly, for bulls, the significant influence of milk performance of mother, temperament, body size and traction on producers' decisions obtained in this study is in agreement with the results reported for milk performance of mother and temperament (Wurzinger et al., 2006), body size (Ouma et al., 2007; Zander and Drucker, 2008) and traction (Zander and Drucker, 2008; Kassie et al., 2012). In other studies, the significant influence of size and coat colour for bulls, and body size, colour, calving interval and mothering ability for cows on producers' decisions obtained in this study is in agreement with other finding of Duguma et al. (2011) on different sheep breeds of Ethiopia; Omondi et al. (2008a) for bucks in Kenya; and Roessler et al. (2008) for pigs in Vietnam working on body size.

Comparisons of phenotypic ranking and choice experiments

These methods directly measure preferences in the form of ranking as done by each individual respondent. The results of trait preferences of Sheko cattle keepers obtained in the present study using hypothetical choice experiments and phenotypic ranking methods were compared. The results of farmers' preference for traits are not consistent and varied accordingly among the methods. However, comparable result was established for production traits (like milk) regardless of the methods. For example, qualitative traits (like color) were the least preferred trait for both cows and bulls using choice experiments in both AEZs. However, in phenotypic ranking color of cows was ranked 4th in both AEZs whereas for bulls color was ranked 4th in midland and 3rd in lowland area. In Choice Experiments, mothering ability is the most preferred attribute for breeding cow selection followed by milk yield in both AEZs. However, in phenotypic ranking mothering ability ranked 5th in midland and 7th in lowland while milk yield ranked first in both AEZs followed by body size and body conformation for midland and lowland Sheko owners, respectively. Again in choice experiments, the influence of milk performance of mother followed by temperament on respondents' decision making was high for bulls in lowland and the reverse in midland. While using phenotypic ranking method, dairy character of bull was ranked 3rd in midland and 2nd in lowland. Temperament ranked 14th and 7th in midland and lowland, respectively, while body size was the most preferred attribute in both AEZs followed by draught character in midland.

Conclusion

Both phenotypic ranking and choice experiments can serve as tools for identifying indigenous selection criteria of Sheko cattle keepers with differences of emphasis between cows and bulls. Through both methods, the results were heterogeneous. Sheko cattle owners in both AEZs identified a large number of traits including traits of appearance, fitness for traction, production and reproduction with differences of emphasis that they would use for bull and cow selection reflecting the multi-functional nature of the Sheko cattle breed. However, only few producers' priority attributes should be used in designing breeding plans in order to make as simple as possible, easy implementation and to complement with the real life of the different communities. Therefore, the values of tangible attributes (production and reproduction traits) as well as important feature of the animal for herding and handling ease (temperament) considered in this study are particularly relevant, as they can be used in determining breeding programme goals and in selecting appropriate animals for breeding programmes. The methods of both phenotypic ranking and choice experiments approach are useful for identifying selection criteria for designing breeding plans and in selecting appropriate animals for breeding programmes of Sheko breed in their production environment.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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