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Performance and Fitness Traits versus Phenotypic Appearance: A Novel Approach to Identify Selection Criteria for Indigenous Breeds

Deo Ndumu[1;3;4] , Roswitha Baumung[1] , Maria Wurzinger[1] , Adam Drucker[2] , Mwai Okeyo[3] , Dan Semambo[4] , Johann Sölkner [1]

[1] BOKU - University of Natural Resources and Applied Life Sciences, Department of Sustainable Agricultural Systems, Division of Livestock Sciences, Austria
[2] School of Environmental Research, Charles Darwin University, Darwin NT 0909, Australia
[3] International Livestock Research Institute, Nairobi, Kenya
[4] National Animal Genetic Resources Centre and Databank, Uganda

Abstract

Ankole cattle are well known for their massive white horns and red coat colour. These characteristics are attributed to centuries of cultural breeding practices. Two experiments with traditional cattle keepers were carried out at a governmental Ankole nucleus farm in South-Western Uganda to identify other phenotypic characteristics as well as production and fitness traits which are important indigenous selection criteria. Forty one body measurements, per animal, were taken from 15 bulls and 35 cows and phenotypic characteristics were described in detail. In the first experiment 12 groups of 6 to 8 cattle keepers were invited to rank animals according to their preference for a breeding bull or cow based on phenotype alone. While in the second experiment the ranking was done on the basis of phenotype in addition to a hypothetical history that was randomly assigned to each animal on each day of experiment. The latter history included milk yield (on own performance for cows and that of the dam for bulls), fertility of the animal and its sire as well as resistance to East Coast Fever. For analysis, Generalized Logit Models for Multinomial Logistic Models were fitted. To compare different models the likelihood-based pseudo R-square measure was used. The results indicate that, in the selection of cows, performance and fitness traits are emphasised by the cattle keepers. While in the selection of bulls, the phenotypic appearance of the animal itself plays an important role. In cows the animals' fertility followed by milk performance turned out to be the main criteria for higher ranking, while in bulls resistance to East Coast Fever was of highest importance. In both sexes a dark red coat colour was highly appreciated. The study portrays the potential usefulness of the methodology in capturing information which can be gainfully employed for an insight into indigenous selection criteria of stock owners else where.

1. Introduction

The African Ankole longhorn cattle breed is an intermediate bos taurus / bos indicus type belonging to the Sanga cattle group of East Africa (Rege and Tawah, 1999). It is characterised by a medium to large body frame with a small cervico-thoracic hump. It has, conspicuously, large, long and lyre shaped horns. The coat colour is mainly red and often variegated. The cattle serve as a source of food, mainly milk, wealth storage and income to meet recurrent needs. They are also important in risk aversion. Scientists now recognize that the indigenous breeds of the tropics are a treasured genetic resource, skilfully bred over the centuries by the communities that manage them (Köhler-Rollefson, 1997; Amer et al., 1998; Rege, 2001; LPPS and Köhler-Rollefson, 2005;

Mathias et al., 2005). Therefore, any sustainable use, development, and conservation of these breeds should take into account the knowledge associated with the resource, including indigenous selection criteria used by the communities that manage it. A number of approaches to develop indigenous AnGR have been proposed. These include; socio-economic considerations (Köhler-Rollefson, 1997) and proper evaluation of the breeds' attributes (Drucker, 2001). The aim of this study was to elicit and document the south-western Ugandan African Ankole cattle keepers' trait preferences for breeding animals, using new approaches in the evaluation of selection criteria in indigenous stocks.

2. Material and methods

2.1 Experiment 1

35 cows and 15 bulls were randomly selected from a herd of 1,000 heads at the Government-NAGRC&DB owned Nshaara ranch in south-western Uganda (Figure 1). On each day of experiment, 4 sub-groups of 4 cows each and 2 sub-groups of 5 bulls each were randomly picked from the pre-selected group of 50. Each sub-group was then restricted in a pen for ranking by cattle keepers from the 2 study regions of Mbarara North and Mbarara South. In total 84 cattle keepers took part in the experiment. Each cattle keeper was asked by an enumerator, to rank the animals within each pen according to his or her own judgement on the aggregate value as a breeding stock on the basis of the animal's phenotype alone. The most preferred animal was assigned rank 1 while the least preferred was assigned rank 4 for a cow and 5 for a bull, giving the major reasons as to why a particular animals were ranked first. The socio-economic background of the cattle keepers were also recorded.

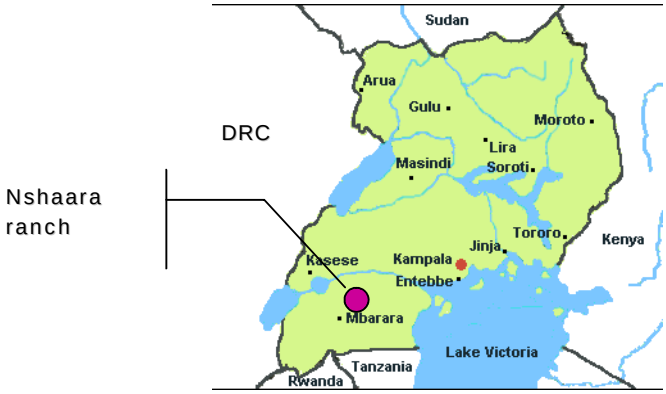

Fig. 1 Map of Uganda showing the location of the site of experiment

2.2 Experiment 2

From the same selected 50 animals used in experiment 1, 5 sub-groups of 3 cows and 3 sub-groups of 3 bulls were selected randomly on each day of experiment and put in separate pens. A total of 70 cattle keepers took part in this experiment and were again from Mbarara South and North. Unlike the first experiment, cattle keepers were provided with additional information on each animal in the form of a hypothetical history. The history included performance and fitness traits, namely, milk yield (on own performance in cows and that of the dam in bulls), own fertility, sire fertility as well as level of resistance to East Coast Fever (ECF). The history was derived from the responses to questionnaires administered in experiment 1 on the additional information that farmers wished to have had in order to make better ranking during experiment 1.

Each trait given in the history had 2 levels: For milk yield either 2 or 4 litres of milk per day were assigned to the cow or the bull's dam, while fertility levels were one calf versus 4 calves born by cows (with a mean age of 7 years). The fertility of bulls was described either as 5 calves born out

of 10 cows or 10 calves born from 10 cows. In both bulls and cows, disease resistance was described at 1 bout of East Coast Fever (ECF) versus 5 bouts of ECF in the animal's lifetime. The fertility of the sire of the test bull or cow was either 5 calves born out of 10 cows or 10 calves born from 10 cows. One level of each trait was randomly assigned to an experimental animal on each day of experiment.

2.3 Morphometric measurements

On each animal, 41 measurements were taken from the head, forequarter, barrel and hindquarter to portray traits sought by the farmers in breeding cows and bulls. The dimensions included weight, distances, circumferences, angles and horn colour as well as a description of the coat colour and pattern.

2.4 Data analysis

The most appropriate statistical models for analysing data with categorical dependent variables, as was the case in this study, are logistic regression models (Agresti, 2002). Multinomial Logit models are used to relate ordered or unordered responses to a set of regressor variables. Multinomial cumulative logit model is suitable for responses of individual units restricted to one of a finite number of ordered values (Ying So and Kuhfeld, 2003). In this study, the proportional odds assumption as a prerequisite for such models was not fulfilled. Therefore, the recommendations of Agresti (2002) were adopted and a baseline-category logit model using the ordinality of the response variables in an informal way in interpreting the associations was fitted. In all models, ranks given by the farmers were considered as the categorical response. The baseline-category logit models pair each response category (rank) with a base line category, in this case, defined as, rank 4 or 5 for cows and bulls in the first experiment or rank 3 in the second experiment. Rank was defined, as the dependent variables (Y) while the independent variables (x) comprised some measured traits, the descriptions of coat colour and pattern as well as additional information traits regarding performance and fitness. The following logit model was used:

$$\log \frac{\pi_j(x)}{\pi_J(x)} = \alpha_j + \beta_j' x$$

With; $\pi_j(x)=P(Y=j|\ x)$ as probabilities with J categories of Y (j =1,…,J-1) at a fixed setting x for explanatory variables.

Regarding explanatory variables seven baseline category logit models were fitted:

Model 1: Horn length, angle of horn orientation and the class variable of colour and pattern were considered as "beauty traits". For coat colour and patterns, 6 classes were built. Class 1 consisted of the dark red animals, while classes 2, 3, 4, 5 and 6 were, dark red with a pattern, red, red with a pattern, black and other colours (including white), respectively.

Model 2: Rump length, body weight and pins width were simultaneously considered as "size" traits and as continuous variables.

Model 3: All explanatory variables from models 1 and 2 were considered simultaneously.

Model 4: The 4 traits describing the hypothetical history of each animal (milk yield, fertility, sire's fertility and disease resistance) were used as class variables with 2 two levels each (see section 2.2).

Model 5: Combined model 4 traits with the average phenotypic rank of each animal based on Experiment 1 and were considered as a continuous variable.

Model 6: the 4 hypothetical history traits were combined with the 3 beauty traits from model 1

Model 7: the 4 hypothetical history traits were combined with the 3 size traits from model 2

All baseline-category logits were fitted with the SAS procedure LOGISTIC using the LINK = GLOGIT option (SAS, 1999).

2.5 Background of the cattle keepers

Three age groups of participants were distinguished, namely; 39 years or younger (comprising 34% and 58% in experiments one and two respectively), 40 to 49 years (i.e. 37% and 31% in experiments 1 & 2, respectively) and the 3rd age group consisted for those aged 50 years and above (they were 29% and 11% of the participants in the two respective experiments). In terms of levels of formal education, the farmers fell in 3 categories:, i) those who had no formal education or had at least completed primary 4 (33% and 30% in experiments 1 and 2, respectively), ii) those who attained between primary five and senior secondary schools level 3 (37% in first experiment and 40% in second one) and iii) those who had, gone beyond senior secondary level 3 (these were 29% and 30% in the two respective experiments).

3. Results

3.1 Experiment one

The traits that significantly influenced the ranking of cows, on the basis of first (best) rank category included rump length, body weight, horn length, angle of horn orientation as well as colour and pattern (Table 1). In bulls, pins width, horn length, angle of horn orientation, as well as colour a pattern were significant. These traits explained 32% and 53% of the variation in ranking results for cows and bulls respectively.

Table 1: Odds ratios for size and beauty traits influencing the rank of cows and bulls

Trait	Rank	Odds ratio	
		Cows	Bulls
Size traits			
Rump length	1	2.386*** (1.722-3.315)	2.927 (0.916-9.347)
	2	1.993*** (1.497-2.654)	1.813 (0.581-5.656)
Body weight	1	1.562** (1.168-2.087)	1.672 (0.447-6.255)
	2	1.129 (0.861-1.480)	1.445 (0.395-5.282)
Pins width	1	0.862 (0.667-1.112)	3.389** (1.426-8.058)
	2	0.980 (0.782-1.229)	1.544 (0.733-3.250)
Beauty traits			
Horn length	1	3.093*** (2.152-4.445)	12.220*** (2.905-51-404)
	2	1.591** (1.172-2.162)	4.899** (1.740-13.794)
Horn orientation angle	1	2.055*** (1.592-2.652)	3.376*** (1.740-6.550)
	2	1.604*** (1.295-1.986)	4.575*** (2.365-8.851)
Colour pattern[1)] (1 vs 6 in cows and 1 vs 2 in bulls)	1	14.093*** (6.662-29.814)	12.145* (1.620-91.032)
	2	2.398*** (1.299-4.427)	6.405 (0.905-45.335)

***; **; * indicate α at 0.001, 0.01 and 0.05 levels of significance

Max-rescaled R-Square: 0.32 (cows); and 0.53 (bulls). The figures in parentheses show a 95% CI

[1]) only significant results are shown with respect to cows

3.2 Experiment two

The estimates of model 4 (results not shown) indicate that all traits in the hypothetical history (additional information) were significant in the ranking of both cows and bulls. The combination of additional information traits with the average rank of each test animal obtained in experiment one (results not shown) indicate that the inclusion of the average rank of phenotype from experiment one in model 5, improves the R square only slightly in cows but highly in bulls (by 28%). All traits were highly significant in the ranking of both cows and bulls. The odds ratio estimates for the average rank of phenotype are in the expected direction.

Table 2 shows that performance and fitness traits in model 6 remain highly significant in both sexes. Odds ratios of ranking highly fertile, disease resistant and better milk producing cows are quite high compared to odds ratios for the corresponding ranks in beauty traits. Again fertility, disease resistance and milk yield traits are emphasized in cows. Beauty traits, on the first rank basis, are again scored in the right direction. The only significant beauty trait for ranking in bulls was the angle of horn orientation.

Table 2: Ranking in cows bulls based on additional information and beauty traits

Trait	Rank	Odds ratio	
Additional information		Cows	Bulls
Milk yield (of cow / dam of bull)	1	9.659*** (6.098-15.302)	2.452*** (1.411-4.258)
	2	1.860** (1.281-2.709)	1.649 (0.953-2.854)
Fertility	1	26.487*** (16.001-43.844)	2.219** (1.323-3.723)
	2	1.979** (1.276-3.070)	2.487*** (1.535-4.029)
Disease resistance	1	9.989*** (6.126-16.287)	6.061*** (3.503-10.486)
	2	3.516*** (2.345-5.271)	2.868*** (1.666-4.940)
Sire fertility	1	5.326*** (3.283-8.641)	5.098*** (2.940-8.840)
	2	4.821*** (3.282-7.082)	1.595 (0.917-2.773)
Beauty traits			
Horn length	1	1.694* (1.031-2.784)	1.250 (0.831-1.882)
	2	1.389 (0.908-2.126)	0.969 (0.684-1.371)
Horn orientation angle	1	1.279 (0.959-1.705)	1.892*** (1.429-2.504)
	2	1.1031 (0.799-1.332)	1.674*** (1.289-2.174)
Color pattern (1 vs 6 in cows and 1 vs 2 in bulls)	1	5.072** (2.166-11.877)	1.452 (0.844-2.496)
	2	3.259** (1.616-6.571)	0.625 (0.380-1.029)

***; **; * indicate α at 0.001, 0.01 and 0.05 levels of significance

Max-rescaled R-Square: 0.50 (cows); and 0.30 (bulls)

The figures in parentheses show a 95% CI

The results in table 3 show the odds ratio estimates for model 7 where size traits are considered along with performance and fitness history in cows and bulls. Only one size trait was significant in the ranking of each sex (i.e. rump length in cows and weight in bulls). In both sexes, performance and fitness traits remain significant. The odds ratios show that disease resistance was the most important trait in the ranking of bulls followed by fertility of the sire and milk yield of the dam. The traits in this model, respectively, explain 50% and 30% of the variation in ranking results in cows and bulls.

Table 3. Ranking cows and bulls on the basis of additional information and size traits

Trait	Rank	Odds ratio	
Additional information		Cows	Bulls
Milk yield	1	10.405***	2.380***
		(6.632-16.325)	(1.407-4.027)
	2	1.911***	1.612
		(1.328-2.751)	(0.971-2.676)
Fertility	1	26.128***	1.876**
		(16.005-42.653)	(1.162-3.002)
	2	1.887**	2.336***
		(1.240-2.871)	(1.520-3.590)
Disease resistance	1	11.476***	6.347***
		(7.023-18.752)	(3.748-10.748)
	2	3.714***	3.284***
		(2.510-5.496)	(1.985-5.434)
Sire fertility	1	4.621***	4.346***
		(2.894-7.381)	(2.551-7.404)
	2	4.139***	1.600
		(2.898-5.911)	(0.954-2.684)
Size traits			
Rump length	1	1.341*	0.998
		(1.004-1.792)	(0.744-1.339)
	2	1.126	1.195
		(0.867-1.464)	(0.896-1.593)
Body weight	1	1.263	2.848***
		(0.961-1.660)	(1.796-4.515)
	2	1.160	1.009
		(0.899-1.497)	(0.657-1.549)
Pins width	1	1.161	0.956
		(0.913-1.476)	(0.677-1.351)
	2	0.988	1.311
		(0.811-1.205)	(0.954-1.803)

***; **; * indicate α at 0.001, 0.01 and 0.05 levels of significance

Max-rescaled R-Square: 0.50 (cows) and : 0.30 (bulls)

The figures in parentheses show a 95% CI

4.0 Discussion

Experiment 1 results (Table 1) indicate that all beauty traits significantly influenced the ranks assigned to cows by the cattle keepers. High odds ratios are observed for the trait of coat colour and pattern whereby cows with dark red coats were preferred over cows with white or fawn colour or brindle pattern. The odds ratios for the traits of the angle of horn orientation and horn length indicate that cows with more forward oriented (pointed) or longer horns were highly rated. Rump length and body weight were also significant in the ratings made, indicating that both

beauty and size traits were important selection criteria in cows. It, therefore, means that while cows should be larger in size they should also be beautiful.
The odds ratios for the traits of rump length and body weight in bulls are of comparable magnitude to those in cows, although only the trait of pins width was significant. Like in cows and on the basis of first rank, all beauty traits were significant for the rating of bulls. The estimated odds of ranking dark red bulls first were 12 times the odds for light red ones. Similarly, for the trait of horn length the odds of ranking bulls with longer horns over those with shorter ones with respect to rank one were also 12 fold. While the odds for ranking bulls with more pointed horns over those with a less acute angle were 3 fold. This emphasis on beauty traits, clearly, indicates that the cattle keepers paid more attention to the appearance of the bulls. This probably reflects the relatively high level of pre-potency of beauty traits, as passed on from bull to his progeny in the herds. This is further emphasized by, the relatively higher repeatability estimates for ranking of bulls relative to those of cows—indicating that bulls were more consistently ranked than cows.
Generally, the history of performance was of high significance and importance in the ranking decisions by the cattle keepers. This is confirmed by the estimates for models that respectively, combined additional information with the average rank of phenotype, size traits and beauty traits However, fertility and milk yield traits were more emphasized in cows, as is consistent with the livelihood roles of such animals, while disease resistance and sire fertility traits were instead emphasized in the ranking of bulls (e.g. Tables 2 and 3). High fertility emphasized in cows and bulls on ancestral performance would ensure the desired large herd sizes and higher herd efficiency. On the other hand the criterion of milk yield would assure adequate milk supply for suckling calves and supply for home consumption, given the central role milk plays in the diets of the Ankole cattle keepers, besides fetching ready cash through sale of excess milk..
Additional information was more important in the ranking of cows than in the ranking of bulls as indicated by the relatively higher values for the odds ratios and the pseudo R square. In cows, fertility is the single most important trait followed by milk yield and disease resistance, whereas in bulls, it is disease resistance followed by fertility of the sire and milk yield of the dam (Tables 2 and 3).

5.0 Conclusions

The selection criteria defined in this study indicate that the traits sought by the cattle keepers reflect the multi-functional nature of the Ankole Longhorn breed. While the cattle must possess the attributes that fulfil cultural values (be beautiful as defined culturally), attributes that ensure productivity (fertility, fitness and production) are also emphasized, albeit, with a slight distinction between sexes. In cows, the traits emphasized include fertility and milk yield on own performance and in bulls ancestral performance for the same traits is important. Resistance to East Coast Fever is of vital importance in the selection of bulls. Although phenotypic appearance plays a crucial role in selection decisions for both sexes, more emphasis is laid on the appearance of the bull .
From the perspective of ‘beauty’, cattle keepers are more likely to select a candidate cow or bull for breeding purposes, if it has a dark red coat and long horns that tend to be more pointed (forward oriented). In this way the cattle maintain the cultural identity to which the Ankole pastoralists seem to relate quite strongly. This has significant implications for ‘AnGR use development and conservation’ that makes these cattle keepers the natural custodians of the Ankole longhorn cattle breed.
This study abundantly demonstrates the potential usefulness of the novelty of methodology in capturing information which can be gainfully employed for insight into indigenous selection criteria of stock owners elsewhere; however, due attention to the experimental design is crucial.

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