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ANALYSIS

Does breed matter to cattle farmers and buyers? Evidence from West Africa

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Abstract

World agriculture is based on a small number of animal species and a decreasing number of breeds within each species. Several breeds of West African shorthorn cattle (*Bos taurus brachyceros)* are now at high risk of extinction due to interbreeding. The West African shorthorn breeds are particularly important resources because of their superior abilities to resist diseases, particularly trypanosomosis, and be productive under high humidity, heat stress, water restriction and with poor quality feed. An analysis of farmers' breeding practices and breed preferences in a sample area in southwest Nigeria confirmed a strong trend away from trypanotolerant breeds, especially Muturu, and identified the traits farmers find least desirable in these breeds relative to zebu (*Bos indicus*) breeds. An analysis of cattle market prices found that buyers have preferences for specific breeds for specific purposes and that though in general price differences due to breed are small, in some cases, buyers pay significantly different prices for certain breeds consistent with their preferences. The best hopes for increased utilization of breeds at risk such as Muturu is likely in other areas of West Africa, for example in southeast Nigeria, where the Muturu is better suited to the farming systems and there is a large market for this breed to provide incentives.

Keywords: Cattle breeds; Market prices; Farmer preferences; Genetic resources; Conservation

1. Introduction

There is an increasing global concern about the potential long-term consequences of loss of plant and animal genetic diversity and the need to conserve genetic resources. The world's animal agriculture is dependent upon about 40 species of mammals and birds, each with a great pool of genetic diversity. With the spread of domesticated animal agriculture across the planet during the last 10,000–12,000 years, different species of animals adapted to a wide range of environmental conditions and developed specialised strains and traits, many of which have become extinct or are now in danger of extinction. It has been suggested that

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globally 618 breeds of domestic animals have already become extinct (Hall and Ruane, 1993) and in Europe one third of the surviving 737 distinct breeds of livestock are in danger of extinction (Cunningham, 1992).

In sub-Saharan Africa, out of 145 cattle breeds identified through a survey, 47 (32%) were considered to be at risk of extinction, and 22 (13%) have already become extinct (Rege, 1999). The sub-humid and humid zones of West and Central Africa, the primary focus of this paper, is the home of some of these extinct breeds and the breeds at risk of extinction. These breeds at risk have developed, over the centuries since their predecessors were introduced into West and Central Africa, the ability to survive and be productive in areas of high humidity, heat stress, water restriction and poor quality feed, and more importantly low to moderate trypanosomosis risk, hence are considered to be trypanotolerant. The *Bos taurus* breeds also reportedly have superior levels of resistance to other diseases e.g. ticks and tick-borne diseases, streptothricosis, helminthosis (Murray et al., 1990; d'Ieteren, 1994; Rege, 1999). These superior adaptive abilities make these breeds valuable for further livestock development in West and Central Africa and other harsh environments around the world. Achieving this goal will require conservation and improvement of the genetic resources carried by these breeds under risk.

The main threat of extinction for these breeds is interbreeding, especially with the humped *Bos indicus* breeds that have moved into the sub-humid and humid regions of West and Central Africa during the last 30 years. High population pressure and periodic droughts in the arid and semi-arid areas have prompted the owners of zebu cattle to extend their seasonal transhumance and relocate their permanent settlements further south. The rate of interbreeding depends upon the breeding strategies and breed preferences of the farmers on the one hand and preferences of consumers on the other.

The primary objectives of this paper are to improve understanding of cattle farmers' breeding practices and breed preferences and determine if buyers have systematic preferences for specific breeds of cattle for specific purposes and whether they pay significantly different prices for different breeds consistent with their preferences. *Ex ante* assessment of farmers' breeding strategies and breed preferences, and market values of different breeds can assist breed conservation and improvement efforts in several ways. First, it can help to assess current stocks of different breeds held by farmers, the geographic distribution of these stocks, and the likely future trends in these stocks. Interbreeding is more likely among animals raised in close proximity and when different breeds are raised in the same herd. Second, farmers' knowledge about specific attributes of different breeds under village conditions can help to focus scientific research on particular traits and identify needs for further farmer education through extension programmes. Third, it can help to determine the incentives that may need to be put in place for farmers to be involved in the conservation of threatened or endangered breeds that may not be supported by market forces. Fourth, information about farmers' breeding practices and breed preferences can help to identify the likely market for existing or improved breeds, as market information reveals buyer preferences for different breeds and attributes, which may be useful in the design of breed improvement schemes.

2. Data source and methodology

2.1. The study area

In West and Central Africa, in the mid-1970s about 7 million *Bos taurus* cattle, including the 4.8 million N'Dama and the 2.2 million West African shorthorns, were most numerous in the more humid southern region; the trypanosusceptible *Bos indicus* breeds were most numerous in the drier northern region covering the Sahel, and most of the 3 million cross-breed populations were found in the boundary area between the two regions (ILCA/FAO/UNEP, 1979). The present study focused on a boundary area because interbreeding and genetic introgression is most likely in those areas and farmers in those areas are more likely to have information about the advantages

and disadvantages of different breeds and the option of bringing different breeds into their herds. The particular boundary area chosen is in the derived savannah ecozone—a transition zone between humid and sub-humid zones—of Oyo State, southwest Nigeria, where most of the cattle in southern Nigeria are located. Cattle breeds commonly found in southern Nigeria are: Muturu—a trypanotolerant *Bos taurus* breed; Keteku—a stabilized cross between Muturu and White Fulani; and N'Dama—a trypanotolerant *Bos taurus* breed introduced into southern Nigeria through breed improvement programmes undertaken since the early 1970s; White Fulani—a trypanosusceptible *Bos indicus* breed.

As of 1959 there were about 65,000 cattle in southern Nigeria, mostly Muturu and Keteku. The cattle population in the area increased to 100,000 in 1974/75, to 140,000 in 1984 and to 234,000 in 1990 as Fulbe pastoralists have moved large numbers of White Fulani cattle into the region. (RIM, 1992; Blench, 1994). At the same time, the number of trypanotolerant cattle in the region, particularly Muturu and Keteku, have decreased. The number of Muturu in all of Nigeria has decreased from about 200,000 in 1938 to between 60,000–115,000 in recent times (Hoste et al., 1992; Akinwumi and Ikpi, 1985RIM, 1992).

Between 1980 and 1983, 5000 N'Dama were imported from The Gambia to five government ranches in southern Nigeria as breeding stock for multiplication and dissemination. Consequently, the total number of N'Dama in the country increased from 14,800 in 1975 to 24,800 in 1984 (ILCA/FAO/UNEP, 1979; Hoste et al., 1992). Although N'Dama are raised as multi-purpose animals in The Gambia, early adopters of the N'Dama in southern Nigeria raised them primarily for beef (Jabbar et al., 1995).

2.2. Household sample and data

A survey of cattle-holding households in the administrative zones of Oyo, Ogbomosho and Shaki in the derived savannah ecozone of Oyo state was conducted between January and June 1994. These zones were known to support a combination of breeds. A zone is divided into blocks, with each block containing 50–80 villages and 5000–10,000 households. Two blocks were selected from each zone in order to represent different agro-climatic conditions. All of the 226 sedentary cattle-farming households in the 377 villages (41,321 households) in these six blocks, who held cattle at the time of the survey, were interviewed.

Data were collected on settlement, breed and sex composition of cattle herds, breeds held in the past and at the time of the survey, and sources of cattle currently in the herd. Respondents were also asked open-ended questions about the main advantages and disadvantages of five breeds with which they might be familiar—White Fulani, Keteku, Muturu, N'Dama, and crosses of White Fulani and N'Dama. Respondents were asked to rate, using a matrix rating approach, the five breeds according to a set of criteria that had emerged as most important from previous studies on cattle farmers' production behavior in the study area (Mohammed, 1990; Jabbar et al., 1995) and through key informant interviews with cattle farmers and traders in the study area conducted prior to the present survey. The criteria were: milk yield, disease resistance, size of animal, ease of handling, market value, marketability (ease of finding buyers), ability to graze diverse species of grasses, need for moving long distances for grazing, and overall desirability. An animal with ability to graze diverse grasses would have less need for moving long distances for grazing but, to avoid disease infected areas, particularly that of trypanosomosis, animals may have to be moved long distances. Animals that need to be moved long distances for grazing may also be sold to a variety of markets along the grazing route to derive possible benefits of inter-market price differences, which benefit may not be derived from sedentary animals.

The meaning of each row, column and cell in the matrix was explained to each respondent during the household interview. Each breed could be rated between one (poorest or lowest or least preferred) and 10 (best or highest or most preferred) for each criterion, so the respondent was asked to consider the first criteria and put between one and 10 bean seeds in the cell corresponding to each breed. The respondent was then asked to

consider the remaining eight criteria in the same way. Of the 226 sample households, 204 (90%) produced complete data regarding breeding practices and breed preferences.

2.3. Logit analysis of breed preference rating

Preference rating is a response variable that can be considered as measured on an ordinal scale showing the strength of preference for an item. In this study, the response on breed preference has 10 possible outcomes: 1 = strongly dislike, ..., 10 = strongly like. The LOGISTIC procedure in SAS (SAS, 1995, 1999) fits a parallel lines regression model that is based on the cumulative distribution probabilities of the response categories. Accordingly, we define:

$$P_i = \text{prob}(Y = i|X), \quad \text{for } i = 1, \ldots, 10;$$

where Y is the response variable and X is a continuous predictor variable. PROC LOGISTIC in SAS fits the following model:

$$\text{logit}(p_1) = \log(p_1/(1-p_1)) = \alpha_1 + \beta^* X$$

$$\text{logit}(p_1 + p_2) = \log((p_1 + p_2) /(1 - p_1 - p_2)) = \alpha_2 + \beta^* X$$

and so on.

PROC LOGISTIC models the cumulative probabilities assuming a common slope parameter associated with the predictor variable, hence called the proportional-odds model as the ratio of the odds of the event Y inferior or equal to j is independent of the category, j. This means that the odds ratio is constant for all categories. In this analysis, the response levels are sorted in ascending order. The score χ^2 is used to test the appropriateness of the proportional odds model. High P-value suggest adequacy of the model in fitting the data.

2.4. Market data

Based on a rapid appraisal of cattle markets in southwest Nigeria to characterize patterns of trade and breeds of animals transacted at each market, the Shaki market, located in the northwest of Oyo state, about 10 km from the border between Nigeria and the Republic of Benin, was chosen for in depth study since the greatest variety of breeds were exchanged there. Data were collected for 2688 cattle transactions conducted on 49 market days between November 1993 and June 1994. Data were generally collected on Mondays, Wednesdays and Fridays, and more frequently before festivals, when more animals were exchanged. The rapid appraisal had indicated that relatively few trypanotolerant cattle were exchanged compared to the trypanosuceptible breeds. In order to ensure adequate samples of all breeds, data were collected for all transactions involving N'Dama, Keteku and Muturu, and a random sample of transactions involving White Fulani and Sokoto Gudali.

For each transaction, data were collected on price (Nigerian Naira per head) and various factors hypothesized to affect price: attributes of the animal (breed, sex, use type, colour, size), attributes of the seller (origin, travel distance, mode of travel, seller type, purpose of selling), and the buyer (origin, destination, distance, mode of travel, purpose of buying). Weight was used as a proxy for size. Since animals are not weighed at the Shaki market, following Buvanendran et al. (1980), a Bovine Weighing Tape (manufactured by WASCO, Fort Atkinson, Wisconsin, USA) was used to measure height at the withers, length and girth circumference. The tape gives an estimated weight of the animal corresponding to its girth circumference and weight was also estimated by using the following formula: live weight = (length $\times$ girth^2)/300 (Payne, 1990, pp. 412–413). The two weight estimates were found to be highly correlated ($r = 0.97$).

An attempt was made initially to assess the total number of different breeds and types of animals on offer on a market day and the proportion of supply actually exchanged. The supply volume could have some influence on prices on the day. However, having found the procedure difficult to accurately account for the supply, the exercise was not pursued.

2.5. Implicit price analysis

The maintained hypothesis of implicit price analysis is that products have attributes that confer utility and that the values of those attributes contribute to the price of the product. The observed product price is therefore a composite of the implicit prices of the product's attributes (Rosen, 1974; Lucas, 1975). In a competitive market an implicit price will be a function of the product attributes alone, and not of individual consumer or supplier attributes (Rosen, 1974; Oczkowski, 1994). This implies that only products are differentiated, while their markets, buyers and sellers are not. However, most empirical studies found that price was also related to attributes of the buyers and sellers, implying some non-competitiveness in the market (Brorsen et al., 1984; Francis, 1990; Andargachew and Brokken, 1993; Parker, 1993; Parker and Zilberman, 1993; Williams et al., 1993; Oczkowski, 1994; Rodriguez et al., 1995).

So, an implicit or hedonic price function was estimated to relate the price per animal to its various attributes, and the attributes of buyers and sellers mentioned earlier. The general form of the implicit price function may be written as $P = F(Q,C)+e$, where P is the observed price of the product, Q is a set of qualitative (discrete) variables or factors each with more than one category, C is a set of quantitative variables (covariates), and e is an error term. Interaction variables may also be incorporated. The partial derivative of the estimated function with respect to a quantitative variable is the implicit marginal value of the attribute. Qualitative attributes are represented by dummy variables so the estimated parameters measure the impact of the presence or absence of the attribute. Therefore, the predicted price cannot be directly obtained from the partial derivatives, and hence additional manipulation would be required (Gujarati, 1988).

The focus in this study was on the importance of breed relative to other factors likely to affect the price of cattle. The hypothesis that was tested was as follows: everything else equal, there were no differences in price per animal due solely to breed. The SPSS Analysis of Covariance procedure (Norusis, 1993) was used to estimate the model parameters. Bonferroni confidence intervals were used in the hypothesis tests in order to reduce the likelihood of false rejection of null hypotheses.

3. Results and discussion

3.1. Farmers' present and past breeding practices

Among the 204 sample herds, 69% contained only White Fulani, 24% contained White Fulani and Keteku, 4% contained mixtures including White Fulani, Keteku and N'Dama, and 3% contained only Keteku. None of the herds contained Muturu. The 55 households that were caretakers of animals had been settled in their current location longer than other households (average of 40 years compared to 27 years) and were less likely to hold pure White Fulani herds (47% compared to 77%). Herd size and composition were fairly similar among the groups.

Breed composition of the farmers' cattle holdings changed substantially over time as there was a large shift away from the indigenous *Bos taurus* breeds, Muturu and Keteku, to White Fulani (Table 1). Of those who gave up Muturu and/or Keteku, 75% mentioned poor market value, 66% mentioned low milk yield, 43% mentioned small size, and 27% mentioned wild temperament or difficulty in management or handling as reasons. Of those who added Muturu and/or Keteku breeds to their herds, 51% mentioned disease resistance, 26% mentioned ability to graze a variety of grasses therefore less need for mobility, 14% mentioned better quality of milk, and 12% mentioned shorter calving interval as reasons. So it appears that changes in the production environment, especially decrease in trypanosomosis challenge, primarily influenced farmers to give more weight to productivity and market value in deciding to change to trypanosuceptible breeds. Where disease risk remained high, change in the opposite direction took place as trypanotolerant breeds were more suitable there.

As for sources of cattle in the respondents' herds at the time of the survey, care-taking arrangements and interbreeding are the main ways that farmers

Table 1
Distribution of sample households according to past and present (January–June 1994) breeds of cattle in the herds, southwest Nigeria

Past breeds	Present breeds					
	White Fulani (WF)	Keteku	WF+Keteku	WF+Keteku+N'Dama	All herds (*n*)	All herds (%)
White Fulani	51	4	34	2	91	45
Keteku	21	–	–	1	22	11
Muturu	1	–	12	5	18	9
WF+Muturu	–	3	–	–	3	1
Keteku+Muturu	61	–	2	1	64	31
Mixtures[a]	6	–	–	–	6	3
All herds (*n*)	140	7	48	9	204	
All herds (%)	69	3	24	4		100

[a] Mixtures of White Fulani, Keteku, N'Dama, White Fulani × N'Dama crosses. Source: farm survey.

exercise breed choice in their herds (Table 2). Overall, 80% of the cattle held by the respondents were inherited or born to animals that were inherited, 14% originated through care-taking arrangements, and just 5% were purchased. Inheritance was the most important source for all breeds of cattle; care-taking was a much more important source for Keteku than for White Fulani.

3.2. Breed preference rating results

In the logistic regression model, Muturu was used as a reference breed, so all comparisons are made with respect to this breed. Since the strong dislike or least preferred ($Y = 1$) end of the rating scale is associated with lower ordered values in the response profile distribution, the probability of disliking the breeds was modelled (Table 3). The χ^2 score test for testing the proportional odds assumption for milk yield rating was not statistically significant, so the proportional odds model assumption is valid for milk yield rating. For other criteria, the P-values are very small because the probability distributions of ratings are more even rather than skewed as in the case of milk yield rating.

The relative magnitudes of the parameter estimates with respect to each criterion imply the preference ordering as well as the distances between the breeds. Results show that all the parameters are highly significant at P-value = 0.05, except in four cases where the outcome was not significant (ns in Table 3). The results indicate that White Fulani is the most preferred and Keteku the second most preferred breed in terms

Table 2
Sources of cattle by breeds in the sample herds, southwest Nigeria

Breeds in herd	% animals for each breed by source			
	Inherited	Purchased	Share of caretaking	Caretaking
White Fulani (WF)	85.1	4.5	0.2	10.2
Keteku	56.0	6.7	–	37.3
WF+Keteku	84.1	5.1	1.3	9.5
WF	91.2	5.6	0.3	2.8
Keteku	74.0	4.4	2.6	19.0
Mixtures[a]	19.1	5.1	6.4	69.4
WF	56.9	18.5	3.1	21.5
Keteku	15.1	–	7.5	77.4
N'Dama+WFxN'Dama	–	–	7.7	92.3
All herds	80.9	4.8	0.8	13.5

[a] Same as in Table 1. Source: farm survey.

Table 3
Maximum likelihood estimates of breeds rating (standard errors are in brackets)

Parameter	Milk yield	Disease resistance	Size	Handling	Market value	Marketability	Grazing diversity	Mobility need	Overall rating
α_1	−1.8097	−8.8707	−0.5795	−1.0006	−0.7727	−1.6008	−10.8787	−4.513	−1.7217
	(0.1722)	(0.3259)	(0.1404)	(0.1447)	(0.1417)	(0.1565)	(0.4025)	(0.1355)	(0.1548)
α_2	0.1414ns	−7.7246	1.2528	0.6841	1.1205	0.0111	−8.7647	1.1938	−0.3882
	(0.133)	(0.3033)	(0.1556)	(0.1384)	(0.1487)	(0.1314)	(0.3602)	(0.1457)	(0.1310)
α_3	1.3065	−6.4471	2.4983	1.7628	2.4815	1.0904	−7.0967	−2.4503	0.5977
	(0.1453)	(0.2702)	(0.1820)	(0.1622)	(0.1768)	(0.1405)	(0.3086)	(0.1716)	(0.1323)
α_4	2.6285	−4.8602	3.7447	3.1676	3.7574	2.3484	−5.4616	3.5256	1.7004
	(0.1697)	(0.2153)	(0.2053)	(0.1955)	(0.2036)	(0.1668)	(0.2352)	(0.1900)	(0.1473)
α_5	3.8204	−3.5417	5.0715	4.3938	4.8703	3.6387	−4.0184	4.6847	2.5580
	(0.1894)	(0.1924)	(0.2255)	(0.2220)	(0.2251)	(0.2012)	(0.2085)	(0.2134)	(0.1615)
α_6	4.9437	−2.2779	6.0028	5.4624	5.8816	4.6930	−2.7082	5.8832	3.2825
	(0.2140)	(0.1700)	(0.2406)	(0.2450)	(0.2446)	(0.2293)	(0.1870)	(0.2619)	(0.1748)
α_7	6.0502	−1.1820	7.0341	6.0539	6.7877	5.4594	−1.7685	6.4511	3.8815
	(0.2592)	(0.1443)	(0.2668)	(0.2608)	(0.2643)	(0.2447)	(0.1629)	(0.2982)	(0.1873)
α_8	7.5584	0.1754ns	8.9002	7.4841	8.2293	6.6025	−0.4131	7.7510	4.8568
	(0.3334)	(0.1321)	(0.3561)	(0.3133)	(0.3140)	(0.2663)	(0.1345)	(0.3891)	(0.2105)
α_9	8.1187	1.0739	9.4867	8.1019	8.8580	7.3296	0.4674	8.2986	5.2024
	(0.3473)	(0.1423)	(0.3711)	(0.329)	(0.3320)	(0.2798)	(0.1352)	(0.4094)	(0.2184)
White Fulani	−8.8304	7.8907	−10.3379	−8.8464	−9.9122	−7.7889	9.1482	−9.7868	−5.3352
	(0.3641)	(0.3148)	(0.3903)	(0.3495)	(0.3596)	(0.3027)	(0.3710)	(0.4387)	(0.2408)
Keteku	−3.6576	3.1970	−5.3877	−4.6604	−5.7037	−5.2407	3.5490	−3.6064	−2.6979
	(0.2149)	(0.2130)	(0.2524)	(0.2466)	(0.2594)	(0.2560)	(0.2247)	(0.2181)	(0.1962)
Ndama	−0.6345	−0.3454ns	−2.0488	1.4048	−1.3464	0.00729	−0.5056	0.2078ns	0.5377
	(0.1799)	(0.1776)	(0.2021)	(0.1951)	(0.1905)	(0.1771)	(0.1832)	(0.1836)	(0.1770)
Wfulani × N'dama	−2.7930	3.6310	−4.1243	−2.4506	−3.5252	−2.1557	3.9783	−2.6941	−1.6098
	(0.2028)	(0.2197)	(0.2345)	(0.2051)	(0.2229)	(0.1947)	(0.2317)	(0.2047)	(0.1838)
χ^2 test									
Prob. with 32 df	ns	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

of milk yield, size, ease of handling, market value, marketability, mobility needs while White Fulani is the least preferred and Keteku the second least preferred breed in terms of disease resistance and grazing diversity. N'Dama is the most preferred breed in terms of disease resistance and grazing diversity and the least or second least preferred breed in terms of milk yield, size, ease of handling, market value, marketability and mobility. Muturu is the second most preferred breed in terms of disease resistance and grazing diversity but least or second least preferred breed in terms of milk yield, size, ease of handling, market value, marketability and need for mobility. The White Fulani × N'Dama crosses lie somewhere in the middle.

The distances between the breeds in relation to a specific criterion can further qualify these orders of preferences. For example, White Fulani is the most preferred breed in terms of milk yield and its distance from the second best breed, Keteku, is very large. Also White Fulani is the least preferred breed in terms of disease resistance and its distance from the second least preferred breed, Keteku, is also very large. On the other hand, N'Dama is the most preferred breed in terms of disease resistance and its distance from the next best breed, Muturu, is not statistically significant. In the case of marketability, there is an order of preference but the distances between the breeds are less pronounced compared to other criteria. Based on all the criteria, the order of preference is as follows: White Fulani, Keteku, White Fulani × N'Dama, Muturu, and N'Dama.

3.3. Results of market and price analysis

There are significant differences between breeds purchased by different buyer categories. Traders purchased 62% of the Muturu and 56% of the Keteku. Sixty-six percent of all cattle traded were males, 29% were cows and 5% were heifers. Sixty-nine percent of the traded animals were sold by traders and 31% were sold by farmers. Of the traded animals, 51% were purchased by traders for resale mainly in Eastern Nigeria, Lagos, Ibadan and in the local market, 23% were purchased by butchers and catering restaurants; 14% were purchased by consumers for various ceremonies and festivals, and 11% by farmers for rearing. Traders mostly purchased males (86%), while butchers mostly purchased females (77%). Farmer purchases included 7% cows, 32% heifers, 23% young males and 38% bulls, all of these mainly for rearing/breeding.

In the overall implicit price model run with the entire sample of traded animals, buyer type or purpose of buying was used as a factor along with other factors and covariates. In order to test whether differences in breed preferences for specific purposes were also reflected in price differences, interaction terms between purpose of buying and breed and type of animal were introduced. But because not all breeds were purchased for all purposes, or in some cases very few animals were purchased for a specific purpose, several cells in the data matrix were empty. In such cases, the model estimates the coefficients of the interaction terms assuming those empty cells as null or zero values (Norusis, 1993), but the hypothesis being tested in this way was not the hypothesis of interest in this study. Therefore, rather than introducing interaction terms in the overall model, separate models were fitted to animals purchased for specific purposes, using relevant factors and categories.

The results of the two best fit implicit price models, based on overall explanatory power, that were fitted to the entire sample, are shown in Table 4. Some of the factors originally hypothesised to influence price, e.g. colour of the animal, origin and distance of the buyer and the seller, mode of travel, did not appear to be relevant in any of the models, hence they were excluded from the final models. The difference between the two models is the exclusion of weight and weight squared as covariates in model 1, so that the parameters of model 1 are not adjusted for differences in weight (a proxy for size) of the animals. The matrix rating from farm survey revealed that size is an important inherent characteristic of the various breeds—White Fulani and Gudali are larger compared to the other breeds. Therefore, any significant price difference between breeds unadjusted for size may indicate that breed per se is valued by buyers (personal communication, Professor Robert Mendelshon, Yale University, 2000). The results, how-

Table 4
Determinants of cattle prices per head, Shaki market, southwest Nigeria

Factors and covariates	All samples: Model 1 β (st error)	All samples: Model 2 β (st error)
Intercept	1662.33 (603.01)	391.09 (447.13)
Breed		
White Fulani	0.0	0.0
Gudali	138.68 (124.89)	−53.08 (90.71)
Keteku	−1645.14* (90.86)	−508.06* (70.81)
Muturu	−1912.50* (117.51)	−404.41* (92.35)
N'Dama	−869.01* (386.57)	352.17 (281.46)
Type of animal		
Male	0.0	0.0
Cow	−21.85 (96.37)	−1379.31* (79.87)
Heifer	246.10 (186.93)	412.00* (135.48)
Trading month		
November 93	0.0	0.0
December	779.28* (98.08)	887.05* (71.10)
Jan.–Feb. 94	131.92 (115.25)	152.25 (83.51)
March–June	−345.75* (141.39)	271.24* (103.33)
Buyer type		
Farmer	0.0	0.0
Trader	1392.22* (133.94)	416.59* (100.43)
Butcher/caterer/consumer	876.23* (143.22)	56.17 (106.01)
Covariates		
Condition score	−34.75 (153.70)	41.41 (111.99)
Condition score^2	105.98*** (14.48)	46.67*** (10.61)
Weight		20.92***(1.26)
Weight^2		−0.006*** (0.002)
R^2	0.47	0.72
Adj R^2	0.46	0.72
N	2688	2688

For coefficients of covariates ***, ** and * indicate t significant, respectively at $P < 1$, 5 and 10%. For coefficient of the factor categories, * indicate the coefficient is significantly different from 0 i.e. the base category within the factor. Here significance is based on 0.95 Bonferroni confidence interval because when joint confidence intervals are constructed, t values are inadequate to determine whether differences are significant (Norusis, 1993).

ever, indicate that holding everything else equal except size, there is no significant price difference between White Fulani and Gudali, but the prices of all three trypanotolerant breeds are significantly lower than White Fulani and Gudali. When size is adjusted in model 2, no significant price difference exists between White Fulani, Gudali and N'Dama, but the prices of Keteku and Muturu are significantly lower, albeit with a much reduced magnitude. However, model 1 explains only 46% of total variation in prices compared to 72% in model 2 indicating that buyers consider both breed and size in valuing an animal. The significant negative effect of weight squared in model 2 indicates that less premium is paid for heavier animals while the significant positive effect of condition score squared indicates that higher premium is paid for animals in good condition.

Other significant results are that: (a) cows and heifers, respectively fetched significantly lower and higher prices than males (cows are generally culled old cows having poor meat quality, hence the lower price, and heifers are normally for breeding hence the higher price); (b) traders paid significantly higher prices than either farmers or butchers/caterers/consumers (treatment of butchers, caterers and consumers as separate categories showed no significant difference between them hence they were combined); and (c) the highest prices prevailed in December and lowest in January–March period.

Results of the purpose or buyer type specific models show that the explanatory power varies from 68% for animals purchased by farmers, to 79% for animals purchased by traders and 62% for animals purchased by butchers/caterers/consumers (Table 5). Farmers did not pay significantly different prices for different breeds, but they paid significantly higher prices for cows and heifers compared to males, as they purchased animals mainly for rearing/breeding. Condition of animals did not significantly influence price paid by farmers, perhaps because if other desirable characteristics were present, the condition of the animal could be improved through rearing and appropriate management. Traders paid significantly lower prices for Muturu and Keteku compared to the other three breeds perhaps because overall market demand for normal slaughtering for these two breeds was lower than the other breeds. Traders also paid significantly lower prices for cows (perhaps because of poor meat quality), paid premium prices for animals in good condition and

Table 5
Determinants of cattle prices per head by type of buyer, Shaki market, southwest Nigeria

Factors and covariates	Farmer buyers β (st error)	Trader buyers β (st error)	Butcher/caterer/ consumer buyers β (st error)
Intercept	3.65 (1107.98)	593.74(873.57)	1524.40** (680.70)
Breed			
White Fulani	0.0	0.0	0.0
Gudali	−283.40 (192.70)	35.18 (128.16)	−78.80 (137.03)
Keteku	−191.26 (152.74)	−567.62* (100.79)	−395.81* (107.96)
Muturu	−251.14 (191.83)	−465.21* (123.64)	−149.77 (161.19)
N'Dama	595.05 (356.07)	747.95 (621.65)	263.64 (393.32)
Type of animal			
Male	0.0	0.0	0.0
Cow	624.39* (245.56)	−2044.56* (118.29)	−714.46* (117.56)
Heifer	1143.51* (119.42)	386.90 (362.15)	−335.32 (284.69)
Trading month			
November 93	0.0	0.0	0.0
December	771.10* (137.70)	1248.33* (94.14)	105.57 (124.48)
January–February 94	758.38* (164.87)	236.97* (112.47)	−551.43* (143.02)
March–June	472.818 (200.78)	709.47* (142.41)	−607.09* (168.54)
Covariates			
Condition score	656.08 (400.16)	79.94 (160.29)	−452.79** (185.49)
Condition score^2	−27.74 (37.98)	31.55** (13.81)	105.94*** (19.37)
Weight	23.71*** (5.52)	28.17*** (1.62)	11.29*** (2.26)
Weight^2	−0.035** (0.017)	−0.01*** (0.003)	0.001 (0.004)
R^2	0.68	0.79	0.62
Adj R^2	0.66	0.79	0.62
N	270	1137	856

For coefficients of covariates ***, ** and * indicate t significant, respectively at $P < 1$, 5 and 10%. For coefficient of the factor categories, * indicate the coefficient is significantly different from 0 i.e. the base category within the factor. Here significance is based on 0.95 Bonferroni confidence interval because when joint confidence intervals are constructed, t values are inadequate to determine whether differences are significant (Norusis, 1993).

less premium for larger animals. Butchers/caterers/ consumers paid significantly lower prices for Keteku compared to the other breeds, also paid lower prices for cows (for the same reason mentioned above) and paid higher prices for larger animals (as quantity of meat is the prime consideration) as well as animals in good condition.

4. Conclusions and implications of findings

Farmers in the derived savannah zone of Oyo State make deliberate choices about breeds of cattle in their herds based on specific criteria. They acquire breeds of choice principally through inheritance and breeding within own herds as well as through purchase and care-taking of other farmers' cattle. About 75% of the respondents reported that the breed composition of their herd was different at the time of the survey than it was in the past. There is a strong trend away from the *Bos taurus* Muturu and Keteku toward the *Bos indicus* White Fulani. Keteku was developed by interbreeding in the past by farmers as a deliberate choice to combine the disease resistance of Muturu and the larger size and milk yield of White Fulani. However, the decreasing number of Keteku at present indicates that as Muturu have disappeared from farmers' herds, so too may the Keteku. Although farmers acknowledged some clear advantages of the Muturu and Keteku (disease resistance, ability to graze a variety of grasses), those advantages appear to be of relatively little importance compared to the many disadvantages

of the Muturu and Keteku relative to the White Fulani. Moreover, where disease challenge, particularly that of trypanosomosis, is smaller, there is less incentive to choose Muturu and Keteku against White Fulani.

The movement away from Muturu in the derived savannah areas of Oyo State is consistent with the aggregate trend in south-western Nigeria. The national livestock survey conducted in the early 1990s (RIM, 1992) found virtually no Muturu in Ogun State where not long ago many farmers held the breed (Grandin, 1980). The national livestock survey reported 11,623 Muturu among a total of 234,461 cattle in Oyo State (now Oyo and Osun states), but most of those Muturu were located in the forested areas.

The results of market price analysis show that there are some differences in prices that are solely due to breed, but that most variation in prices is due to size and condition of the animals. Generally, other things being equal, trypanotolerant breeds (Keteku, Muturu and N'Dama) commanded significantly lower prices compared to the larger trypanosuceptible breeds (White Fulani and Gudali). Although N'Dama prices generally appeared slightly higher than other breeds, in no case was the difference statistically significant. In an earlier analysis, girth and girth squared rather than weight and weight squared were used as covariates, and N'Dama prices in that case were found significantly higher than other breeds (Jabbar et al., 1998). However, purpose-specific equations run in this paper but not in the earlier case, show that overall, N'Dama has a slight edge, but not a significant one, in the market among all categories of buyers. But the total number of N'Dama in the sample is smaller in relation to the other breeds so this result should be treated with caution. However, this outcome is consistent with farm survey results, which show that farmers rated N'Dama low in terms of milk yield, ease of handling, market value and marketability, though they rated N'Dama high in terms of disease resistance and grazing diversity. This partly explains why N'Dama population in the study area as well as in the rest of Nigeria did not expand as rapidly as would be expected after initial introduction by the government-funded project.

The strong trend among farmers against the trypanotolerant breeds, especially Muturu, implies that there is very little scope for conservation of the Muturu through continued farmer rearing in the derived savannah areas of southern Nigeria. If trends from the study area expand into the forested part of Oyo State, the population of 11,000 Muturu that was recently reported could be lost in a few years through interbreeding or outright exclusion from herds. This would mean the loss of an important resource for Nigeria and all regions of the world where livestock are raised under the stresses of disease, heat and humidity. The ability to be productive under low to moderate levels of trypanosomosis makes these animals more attractive to farmers. Trypanosomosis remains a constraint in southern Nigeria[1] and especially as there is evidence from across Africa of resistance to the drugs available for prophylactic and curative treatment of trypanosomosis (Peregrine, 1994).

Research and development agencies should consider the possibility of selecting Muturu bulls with superior production characteristics and promoting them with farmers who now keep Muturu in the forest zone. Conservation efforts might be better directed at locations, such as southeast Nigeria, where the Muturu is better suited to the farming system and where there is a distinct market for Muturu.

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[1] In 1987, in a sample of 1525 zebu cattle in five states of southwest Nigeria, a mean rate of trypanosome prevalence of 14.4% was found −18% in the wet and 10.8% in the dry season (Ikede et al., 1987). A repeat survey in slightly wetter and more forested locations in three of the same five States showed prevalence rates of between 18.5 and 21% in the wet season and 16% in the dry season (ILRI-Ibadan, unpublished data).

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