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Using Conjoint Analysis to Estimate Farmers' Preferences for Cattle Traits in West Africa

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SUMMARY

This paper estimates the preferences of farmers for cattle traits in southern Burkina Faso using Conjoint analysis, a survey-based system for measuring preferences for multiple-attribute goods. Here the technique is used in the context of a West African country where literacy is low, where cattle perform multiple functions, where low-input management is the norm, and where cattle are exposed to a number of tropical diseases and other environmental stresses. The results reflect the production practices of the region, suggesting that important traits in developing breed improvement programs should include disease resistance, fitness for traction and reproductive performance. Beef and milk production are less important traits. The study shows the potential usefulness of conjoint analysis for quantifying preferences in less developed countries for livestock and for the wide variety of other multiple-attribute goods. Distinguishing differences in preferences between groups of respondents in connection with specific locations and production systems can be used to promote conservation-through-use of breeds at risk of extinction.

Keywords: Animal traits, breeds, farmer preferences, Conjoint analysis, West Africa

NON TECHNICAL SUMMARY

A choice experiment study carried out in Burkina Faso identifies the most important traits for incorporation into breed improvement program goals as being disease resistance, fitness for traction and reproductive performance. Beef and milk production are less important. The results, which permit the identification of differences in preferences between groups of respondents in connection with specific locations and production systems, provide important information that can be used to promote the conservation of breeds at risk of extinction.

CONTENTS

1. Introduction

Livestock make several valuable contributions to African agriculture. Most obviously, cattle, sheep and goats produce milk and meat for home consumption and sale. Milk and meat comprise about 25 percent of the value of agricultural products produced in Africa (USDA, 1990 in Winrock International, 1992, p. 11). Livestock, particularly cattle, donkeys, horses and camels, are important sources of draft power for cultivation and transport. Animal traction allows farmers to increase cultivated area, labour productivity and allocative efficiency (Savadogo et al., 1998). Livestock also play important roles in the processes of nutrient cycling and transfer, thus contributing to the sustainability of cropping systems that use little or no inorganic fertilizer (Powell and Williams, 1995). In addition to direct offtake and farming system improvement, livestock are also valued for their roles in the farm economy because they are used to reduce income risk and provide a substitute for missing insurance and credit markets.

The productivity of Africa's livestock is low. The bovine raised in the humid and sub-humid grasslands produces an average of 13.8 kilograms of beef per year in Africa, compared to 34.1 kilograms in Central and South America and 85.5 kilograms per year in the OECD countries (Seré and Steinfeld, 1995). In order to keep pace with expected increases in the demands for meat and milk, Africa's domestic supplies will have to increase by an average of four percent per year at least until the year 2025 (Winrock International, 1992). Achieving this growth will require sustained improvements in the supplies of feed, animal health supplies and services, the genetic capacity of the cattle, sheep and goat populations, and the overall system of incentives faced by farmers.

Winrock International (1992) argues that improvements in genotype are particularly important for the sub-humid zone, the zone with the highest potential for productivity growth despite the many diseases and environmental stresses to which livestock are exposed. Indigenous genotypes, such as the N'Dama and West African shorthorn, need to be multiplied, better exploited, and cross-bred with more productive European breeds. Large programmes of artificial insemination are, at best, only part of the answer. New genotypes must be well-adapted to the environment, capable of performing multiple functions, and must possess traits that are appealing to the smallholder farmers that own the large majority of the cattle.

Various types of consultative processes and farm surveys can be used to better understand the preferences of African farmers for cattle traits. Self-explicative ratings and rankings can shed some light, but usually cannot provide insight into the substitutions and complementarities that farmers consider when they make upstream choices about the breed. Cattle breeds tend to differ in a number of ways, so it is unlikely that farmers would face choice decisions that focus on each animal trait individually. Instead, farmers usually face choices involving tradeoffs between desirable characteristics.

The main systems of cattle production in southern Burkina Faso are mixed-crop farming, beef and milk and subsistence farming systems. Mixed-crop farming, the dominant sytem, integrates cattle and crop production, with cattle mainly providing draught power and manure, while crops provide fodder and residues to cattle and income for the subsistence of the family. The second largest cattle production system, the beef and milk system is primarily a market-oriented and provides the majority of the domestic sale of cattle and milk and exports of live cattle to the neighbouring countries. The subsistence system is more a traditional way of subsistence than a production system designed for optimal offtake. However, cattle play a wide range of functions such as store of wealth, insurance against risks and misfortunes, milk, means of transport, manure and various social needs (funerals, sacrifices and dowry).The two study sites–Pays Lobi and Kourouma–are representative of large areas of sub-humid West Africa. More details on the study sites, breeds and production systems is given in Withheld (1998).

This paper describes a study in which conjoint analysis was used to quantify farmers' preferences for cattle traits in the sub-humid zone of West Africa. It was partly motivated by the desire to provide a better understanding of farmers' preferences for cattle so that specific programme to encourage adoption and use of trypanotolerant cattle could be assesed (Tano et al, 1998). The selected study sites have high potential for expansion of agricultural production, but now support relatively low populations of people and livestock. Tick-borne diseases and trypanosomosis, transmitted by the tsetse fly, are severe constraints on animal health and productivity. Thus the study focuses particular attention on farmers' preferencesfor disease resistance, relative to other important traits, which could be introduced through breeding programs that utilize indigenous genotypes.

2. Using Conjoint Analysis to Value Cattle Traits

The conceptual foundation of conjoint analysis arises from the consumer theory developed by Lancaster (1966, 1991) which assumes that utility is derived from the properties or characteristics of goods (Ratchford, 1975). A major implication is that the overall utility for a good can be decomposed into separate utilities for its constituent characteristics or benefits (Louviere, 1994). In terms of the utility function, this translates into using the characteristics of goods as the arguments of the function. Conjoint analysis and hedonic price analysis are alternative empirical applications to the Lancaster consumer theory (Withheld, 1998; Rosen, 1974; Griliches, 1971).

The hedonic price technique has been widely used to estimate marginal values for animal characteristics (Faminow and Gum, 1986; Lambert et al., 1989; Schroeder et al., 1988). However, using hedonic price analysis to estimate cattle owners' preferences in rural Africa can be very difficult. First, most cattle transactions do not take place in formal markets where transactions are transparent and easily recorded. Rather, transactions usually take the form of private agreements between buyers and sellers using cash, barter or exchange. Second, many cattle are never traded or sold, but stay within the farm household or are passed on to other households through traditional practices such as dowry. Third, breeding cattle and young animals are thinly traded in African markets. Fourth, unfamiliar breeds are very rarely traded. In such circumstances, the collection of price data is likely to be incomplete and can suffer from substantial measurement errors.

Conjoint analysis is an experimental-based tool that can also be used to guide the development of breed improvement programs (Baidu-Forson et al., 1997). Data are generated through a survey in which respondents are asked to rate products with alternative levels of important characteristics. Tradeoffs between characteristics can be studied, including wider variation in relevant variables than might be observed in actual field data. Thus, researchers can guide new breed improvement programs by presenting characteristics of hypothetical cattle. Those data can provide information about the marginal values of the specified levels of traits. The marginal values can be used to generate preferences of producers of existing or hypothetical products that are described in terms of the levels of traits. The overall preference of a specific profile is obtained by adding up the estimated coefficients of the levels of traits that make up the profiles. This is particularly relevant for assessing the potential and overall utility of genetically improved breeds. The results of a conjoint analysis study can complement the offtake-based selection indexes traditionally used by animal breeders and also distinguish differences in preferences between groups of respondents (Amer et al., 1994; Sy et al., 1997). Assessing these differences in connection with locations and production systems can lead to viable programme for *in situ* conservation of breeds at risk of extinction.

Conjoint analysis is best utilized as an alternative to hedonic estimation when transactions data are poor. Because preferences are measured directly, the results are less likely to be adversely affected by traits that are not priced or transactions that do not occur through organized markets (or occur for non-consumptive purposes). In rural regions of Burkina Faso, the majority of livestock transactions still are private agreements, although formal markets are increasing in number and volume.

Sy et al. (1997) propose that the utility an individual will derive from choosing a given cattle breed is a function of the characteristics of the breeds, the individuals' socio-economic background, the interaction between the individuals' background and the characteristics of the breed. Since utility is not directly observable, a choice variable representing ratings or rankings of animals is used in empirical work in place of utility. The choice variable is related to utility as follows:

$$R = 1 \quad \text{if} \;\; 0 \quad U \quad \gamma_1 \qquad (1)$$

$$R = 2 \quad \text{if} \;\; \gamma_1 \quad U \quad \gamma_2$$

$$.$$

$$.$$

$$.$$

$$R = \omega \quad \text{if} \quad U \quad \gamma_{\omega - 2}$$

where U are the unobservable utility levels, R's are preference ratings and γ's are the threshold variables or cut-off points that link the respondents' actual preferences and the ratings. Using the choice variable, the empirical model is written as:

$$R = \alpha + X\ \beta + Y\ \lambda + e \qquad (2)$$

where R is a vector of preference ratings (0, 1 ,2 ,....n), X is a vector of non-stochastic variables capturing the levels of traits, Y is a vector of non- stochastic variables capturing the interaction between the levels of traits and farmers' background, β is a vector of marginal utilities for the levels of traits, λ is a vector of marginal impacts of the interaction between the levels of traits and individuals' background and *e* is a disturbance term. The marginal values β and λ are estimated from observations on R, X and Y. When the dependent variable is discrete (i.e., like ratings, preferred choice), a discrete choice estimator is appropriate (for an application, see Scarpa et al. in this issue) (Greene, 1990; Sy et al., 1997). The λ vector measures the variability in preferences due to the interaction between farmers' background and the levels of traits. Farmers with the same estimated λ have similar preferences, and would make up one segment of the market. Thus, estimates of λ can be used to assess preferences across production systems to determine if a segmentation approach to breed improvement is warranted.

It is common in conjoint analysis to use an effect-coding procedure for categorical independent variables. In an effect-coding the usual (0-1) dummy system is replaced by a (-1, 1) system for two trait levels where -1 is used for the variables that are normally excluded in order to avoid the dummy trap during the estimation. (When there are three trait levels a (-1, 0, 1) system is used.) The use of effect-coding generates estimates that measure the marginal change in the dependent variable as a result of a unit change in the independent variable (Pedhazur, 1982). Effect-coding also implies that the sum of the estimated coefficients of a group of variables (e.g., all the levels of a given trait) is constrained to be equal zero (Jain et al., 1979; Pedhazur, 1982). This, in turn, implies that the estimates of the variables that were not used in the regression can be computed as the negative of the sum of the estimated coefficients of the level of trait that were used in the estimation.

3. Experimental Design and Data Collection MethodologyError! Bookmark not defined.

Conjoint analysis was first developed for, and primarily applied in, marketing studies of consumer goods in developed economies. Adaptation to animal breeding in a traditional livestock system with low literacy and multiple languages poses particular problems which require several modifications to the standard methodology.

3.1 Applying conjoint analysis in developing countries

Researchers must take great care to design a survey that provides clear and unambiguous information about the choices that the respondents are asked to make. The survey should also present respondents with enough choices that their preferences are sufficiently investigated, but must not overload them with too many choices or give them too much information about each choice. When there is information overload, survey respondents tend to simplify the evaluation process by ignoring less important characteristics or by ignoring the levels themselves, especially when they have to evaluate profiles with a large number of levels (Green and Srinivasan, 1990). The potential for information overload is intensified in applications of the technique in developing countries such as Burkina Faso.

In conjoint studies, stimuli can be presented to respondents in one of the following three ways: verbal descriptions, paragraph descriptions, and pictorial representations (Weiner, 1993; Cattin and Wittink, 1982). Verbal descriptions use cards in which each level of traits is described in a brief line item fashion, while paragraph descriptions give a more detailed description of each level (Weiner, 1993). Pictorial representations use some graphical images to present the levels of traits. A survey of the commercial use of conjoint analysis in the United States indicated that verbal and paragraph descriptions of profiles were used by 70% of the surveyed practitioners (Catting and Wittink, 1982). About 19% of them used pictorial representations in combination with verbal descriptions.

Verbal and paragraph descriptions are convenient, straightforward and inexpensive. However, high illiteracy levels and language differences in the Burkina Faso population make data collection more complex and pictorial representations were required to present the differences in levels of traits. Visual materials help respondents to process the information, thereby facilitating the interpretation and rating of the profile (Holbrook and Moore, 1981). The main disadvantage comes from the additional time that is necessary to conduct field interviews in order to ensure that respondents are interpreting the pictures in a similar manner.

Cattle profiles (descriptions of hypothetical cattle presented in a trait-by-trait format) are used to elicit ratings. The number of profiles used in a conjoint study depends on the numbers of traits and levels of each trait that are used. Empirical studies have shown that respondents have difficulty evaluating profiles defined on more than six characteristics (Green and Srinivasan, 1990). For example, Sy et al.(1997) used six traits with either two or three trait levels in their study of breed preferences in Canada.

3.2 *Design of the Conjoint Survey for Farmers' Breed Preferences in Burkina Faso*

Cards with pictorial representations of the differences in the levels of traits were used to demonstrate each cattle profile to survey respondents. Examples of the cards that were used are reproduced in Withheld (1998).

The multiple-product and multiple-stress environment in Burkina Faso increases the number of criteria that farmers consider when making choices about breed. Initially, lists of 14 traits of bulls and 15 traits of cows were developed. It was necessary to reduce these to a more workable number of traits using the participatory consultative procedures described by Withheld (1998). Using the pictorial representations of the traits made it even more important to reduce the number of choices presented to the respondents as much as possible. Seven traits of bulls and seven traits of cows were ultimately defined and used in this study (Table 1).

Two survey designs were developed for both cows and bulls. One design for each was comprised of the four traits which were individually ranked as most important, while the second design (one for each of cows and bulls) included the remaining traits. To assign traits to the first and second designs, a statistical analysis of individual rankings of traits by farmers was performed (see Withheld, 1998). The final assessment of the relative importance of the traits was provided by a statistical analysis using the Wilcoxon nonparametric matched-pair signed-ranks test, a nonparametric equivalent of the paired t-test that is usually needed to see whether or not two dependent samples have equal means (Withheld, 1998). These statistical rankings indicated that the four highest ranked traits of bulls were fitness to traction, weight gain, disease resistance and feeding ease. These were used to construct the profiles of bulls in the first design, while fertility, temperament and size were added to disease resistance to construct the profiles in the second design for bulls. The first design of cows used reproductive performance, milk yield, weight gain and disease resistance while feeding ease, temperament, size and disease resistance were used in the second design. Disease resistence was used as a common trait in the two designs (for each of bulls and cows) for three reasons: (1) it is the key limiting factor in cattle productivity; (2) it was the highest rated trait according to an explicit ranking of traits by farmers and (3) the research team was assessing the potential for a breeding program to introduce disease resistance from indigenous cattle genotypes.

Given that each trait has two levels, there are $2^4 = 16$ possible cattle profiles for each experimental design in a full factorial design, which will make data collection quite impractical. The number of profiles was reduced to a manageable size using an orthogonal or fractional factorial design which treated all attributes as independent and precluded collinearity between them in an empirical model (Mackenzie, 1993). The use of a fractional factorial design resulted in a randomized selection of eight profiles in each individual questionnaire (SPSS, 1994). Each profile is shown in the form of a card representing an hypothetical cattle breed that was described in terms of the levels of traits included in the experimental design. For example, the eight profiles of bulls used in the first experimental design are shown in Table 2.

Data were collected in January and February 1996. The sample size was 299 cattle-owning households, all of whom had participated in an earlier survey conducted by the authors. The survey was specifically targeted at cattle owners since they are the ones who will purchase the animals that might be generated by a breeding scheme. In West Africa many agricultural households that own cattle either employ herders or entrust the herding and day-to-day management of their cattle to pastoralists. Herders and herd managers are often remunerated in terms of milk: we thus expect herders and herd managers to emphasize milk production more than would herd owners (Itty, 1992). During personal interviews cattle owners were asked to consider eight profiles of bulls (cows) and give a rating to each profile using a five-point (1-5) preference scale, where 5 means the most desirable animal for the respondent's cattle operations, 1 the least desirable animal and ratings 2 to 4 represented desirability between the two extremes. Five wooden sticks with increasing lengths were used to represent the preference scale, with the longest stick used for the highest preference (5), the shortest stick for the least desirable profile (1). The sample was split between the two experimental designs.

Response elicitation began with the enumerator explaining the meaning of the levels of traits represented by special drawings. Then the cattle owner was asked to explain his (her) understanding of the levels of traits. This usually took 30 to 45 minutes. These preliminary explanations were provided in order to make sure that the drawings were providing the information that was intended in the survey. After considering all eight profiles, cattle owners evaluated each profile by assigning a stick reflecting his (her) preference. Ratings of profiles were recorded using a pre-prepared questionnaire shown in the appendix, along with an example of drawings showing a profile of bulls used in the first experimental design. Despite the additional time necessary to do the ratings and the cost of making the drawings, the approach made the pictorial profiles more realistic and helped reduce perception differences.

4. Results and DiscussionError! Bookmark not defined.

The analysis was conducted with the iterative maximum likelihood procedure for Ordered Probit in Limdep (Greene, 1995). Four models, including two models of bulls and two models of cows, were estimated. Since all the traits considered in this study have two levels, during the estimation one level was left out. Recall that for each trait, the estimate of the variable that has been left out is the negative of the estimate of the level that was included in the regression. The ratings that farmers gave to the profiles to express their overall preference was the dependent variable and the independent variables were the traits and interactions between the traits and the producers' characteristics.

Three main interaction variables were initially considered: type of production system (subsistence, milk and beef, mixed crop-livestock), location (the districts of Pays Lobi and Kourouma) and farmer's origin (indigenous and migrant). The production systems variable was selected for final estimation because the different production systems are related to both location and farmer origin.

4.1 *Main Effects*

Model 1 for bulls was fit to data collected with the first design (4 highest rated traits) and is used to estimate partworth values for disease resistance, rapid weight gain, poor fitness to traction and selective grazing habit. Model 2 for bulls was fit to data collected for second design (disease resistance and 3 lowest rated traits) and used to estimate partworth values for disease resistance, small size, high fertility and difficult temperament. Model 1 of cows was fit to data collected with the first design (4 highest rated traits) and used to estimate partworth values for disease resistance, rapid weight gain, low reproductive performance and low milk yield. Model 2 for cows was fit to data collected with the second design (disease resistance and 3 lowest rated traits) and used to estimate partworth values for disease resistance, selective grazing habit, difficult temperament and small size.

The estimated results for bulls are indicated in Table 3 and the results for cows are indicated in Table 4. The overall significance of the models is assessed using the likelihood ratio statistic, which is distributed as a χ^2. The critical levels for 12 and 16 degrees of freedom at the 1% level of significance are 39.14 and 45.92, respectively, with the likelihood ratios for all the models much larger than the critical values.

The significance of the individual parameters was assessed using the p-value which is an alternative way to assess individual significance of estimates in Maximum Likelihood Estimation. The p-value is the lowest significance level at which a null hypothesis can be rejected (Mirer, 1988; Gujarati, 1992). Under the null hypothesis, the p-value represents the probability that the computed statistic is larger than it actually is; and a small p-value would mean that the result is quite unlikely and would lead to rejecting the null hypothesis, thereby failing to reject that the estimated coefficient is statistically significant.

Results of the main effects for bulls shown on Table 3 indicate that all four levels of traits considered in both models of bulls were statistically significant and have the expected sign. For example, selective grazing habit has a negative sign, indicating that respondents prefer cattle which are not selective in the type of grass they will eat or the quality of water they will drink. Poor ability in traction of bulls is also negative. In contrast, high fertility, disease resistance and rapid weight gain have positive signs.

Similarly, the model for cows shown in Table 4 indicates that all four levels of traits were statistical significant and with expected signs. Selective grazing habit again has the expected negative sign. Low reproductive performance has a negative impact on herd productivity and herd size, so a negative sign was expected. As small sized animals do not yield high market value, the negative sign is also expected. Disease resistance and rapid weight gain have the expected positive signs, as in the models for bulls.

4.2 *Interaction Effects — Specific Groups*

One important issue is the existence of differences in preferences among producers. Are producers preferences homogeneous or can they be segmented? Interaction variables representing the main farming systems were used to test the impact of the levels of traits and the farming systems (Table 5).

The partworth values for each farming system were computed by adding up partworth values of the average farmer indicated in Tables 3 and 4 and the incremental partworth values due to the interaction variables for the different farming systems. Only the coefficients of the interactions that were statistically significant were used. Non-significance of the interaction variables means that preferences of the given producer group for the specified levels were not different from the preferences of an average farmer.

Table 5 indicates that no segmentation of producers groups can be identified on the basis of disease resistance and rapid weight gain of bulls. For disease resistance, this result confirms its importance as perceived by all cattle owners in the study area (i.e., they do not perceive it differently). Assuming that cattle owners use different disease management strategies, this implies that disease resistance is a general concern. In contrast, rapid weight gain in bulls is equally less preferred by all cattle owners. This general low preference for rapid weight gain may indicate that rapid weight gain in bulls was not perceived as important as traits such as disease resistance, fitness to traction or fertility.

The results also show variable partworth values for selectivity in feed. Mixed crop-livestock farmers have the lowest preference for this trait. They usually are crop producers who feed their animals using some of the crop residues, so selective preferences for grass are less of a problem for them. Some farmers may be less directly concerned by the issue because most of their cattle are managed by hired herders who did not participate in the interviews. Alternatively, milk and beef producers and subsistence farmers usually rely less on crop residues and / or manage their own cattle. They dislike feed selectivity more.

There are also significant differences in preferences for animal traction. Subsistence farmers do not use cattle for traction and have lower preference for fitness to traction than milk and beef producers who use some traction for food production. In fact, most milk and beef producers are pastoralist Fulani who live far from any market and produce their own food. Fulani raise Zebu cattle, which are the most suitable cattle for traction, and may use draught power to grow cereal crops on a limited scale. Mixed crop-livestock farmers produce food crops for home consumption and grow cash crops. The use of traction for cash-crop production has been extensively promoted in most of the cotton-growing zones of West Africa. This is probably why mixed crop-livestock farmers are the group of farmers who preferred fitness-to-traction the most.

The differences in preferences for difficult temperament are related to the use of hired herders. Most mixed crop-livestock farmers and milk and beef producers use specialized herders, while most milk and beef producers use adult family members to herd the animals. Even though they dislike difficult temperament, both types of producers have less concern for this trait than subsistence farmers who use younger members of their family.

The differences in preferences for size of animals can be explained either by the needs for draught purposes (mixed crop-livestock farmers) or the market value of the animals (milk and beef producers). Subsistence farmers who do not use cattle for traction seem less concerned about this trait.

Different preferences for the reproductive performance of cows can be attributed to differences in the role of livestock in farming systems. We hypothesize that mixed crop-livestock farmers are most interested in animal traction, less interested in meat and milk off-take, and thus are less concerned about low reproductive performance. In contrast, we hypothesize that subsistence farmers are most interested in maintaining the size of their herds because they have poor access to markets and because their cattle play such a variety and complexity of roles (meat offtake, dowry, insurance, social events). Low reproductive performance is of great concern because of its impact on herd size and productive capacity. Milk and beef producers are more interested in off-take than mixed crop-livestock farmers, but they are specialized cattle producers who may have alternative management ways of overcoming low reproductive performance.

Low milk yield is less of a problem for mixed crop-livestock farmers than the other groups because most of their milk goes to their herders whose salary usually includes milk off-take. In contrast, subsistence farmers manage their own cattle and use any milk they can get for consumption or sale. The fact that milk and beef producers have a lower preference for milk offtake than subsistance farmers was not expected.

As in the case of bulls, large size in cows was preferred because it has an impact on the market value of the animals. Milk and beef producers, who are more interested in off-take, are more affected by cow size than mixed crop-livestock farmers, who generally own male animals for traction.

4.3 *Relative Importance of Traits***Error! Bookmark not defined.**

Since the partworth values for the traits are measured on a relative basis, traits used in the two models can be compared. In conjoint studies, this comparison is achieved by computing the relative importance score for each trait. The relative importance score for a given trait is the ratio of the partworth range for that particular trait (difference between highest and lowest partworth values) and the sum of all the partworth ranges. This ratio provides an indication of the traits the survey respondents valued most highly. Results about the relative importance of traits are presented in Table 6 for the traits of bulls and Table 7 for the traits of cows.

In model 1 for bulls, fitness to traction and disease resistance were the most important traits. Feeding ease and weight gain were less preferred. In model 2 for bulls, disease resistance and fertility were the most important traits, followed by temperament and size. Fitness to traction has a direct link to crop production, one of the main purposes for raising cattle in the study area. Fitness to traction may also have impacts on income that could be generated by renting out animals for draught power.

Reproductive performance and disease resistance were the most important traits in model 1 for cows, while disease resistance and feeding ease were the most important traits in model 2. Like fertility of bulls, the reproductive performance of cows had a significant impact on the herd size and off-take. Feeding ease in cows (especially in dry season) has a significant impact on the reproductive performance of the herd, which may have further impacts on various income generation activities. Again, disease resistance was an important trait of cows.

Given that both designs of bulls and cows had one trait in common, and all conjoint partworth values are relative measures (Sy et al., 1997), it is possible to combine all partworth values of the levels of traits included in each case (bulls or cows) and compute a unique index that shows the relative importance of each trait. This provides a way to overcome the limitations created by the need to limit choices in the survey to four traits, each at two levels. As noted earlier, estimates of disease resistance in both models of bulls and cows were quite close, which gives support to the construction of a common index reflecting a preference ordering based on the entire set of traits. In constructing the overall index, the average of the two estimates of coefficients in each case (bulls and cows) was used. The overall index of relative importance of the traits is shown in the last columns of Table 6 (bulls) and Table 7 (cows).

On the basis of the overall index, the relative importance of the traits for bulls can be established as follows: fitness to traction, disease resistance, fertility, temperament, feeding ease, size and weight gain. In the same way, the most important traits of cows were found to be: reproductive performance, disease resistance, feeding ease, weight gain, temperament, milk yield and size.

Table 8 was constructed in order to see how these results compare with farmers' explicit ranking of individual traits. This table combines results from the conjoint study with the statistical rankings described in Withheld (1998). The results indicate some differences between the two methods, especially regarding the relative importance of milk yield and feeding ease for cows. Milk yield was individually ranked second by farmers but the conjoint process revealed it to be less important. For bulls, the differences in the two methods concern feeding ease and weight gain. For the other traits, both methods yield fairly similar results.

Kendall's (Kendall, 1970; Daniel, 1990) coefficient of concordance (normally ranges from 0, indicating no agreement or independence, to 1 which indicates perfect agreement among the rankings) was computed at 0.55 for bulls and 0.52 for cows. Both coefficients are only statistically significant at only the 10% level. This suggests that simply asking farmers their preferences for traits of cattle, which would normally be done using consultations, may result in dis-concordant rankings relative to when they are faced with a choice among cattle with different traits.

5. **Conclusions**Error! Bookmark not defined.

The method of conjoint analysis was used to estimate preferences of cattle in southern Burkina Faso for seven important traits of bulls and cows identified from a survey of cattle owners. There are three main results.

First, the estimated models indicate that all of the traits were statistically significant with the expected signs. Fitness to traction and disease resistance, and disease resistance and fertility, were the most preferred traits in the first and second models of bull preferences. The most preferred traits for cows were reproductive performance and disease resistance in the first design and disease resistance and feeding ease in the second design. The technique used to combine the two sets of results for both bulls and cows confirmed these results. Thus, resistance to disease has been revealed in both explicit rankings by livestock owners and through conjoint analysis as a key factor in efforts for genetic improvement. These results suggest that farmers in these tsetse-affected areas do not focus on trypanotolerance per se, but on resistance to a variety of diseases. D'Ieteren et al. (1998) note that the trypanotolerant breeds, particularly the N'Dama, have been shown to be resistant to trypanosomosis and a number of tick-borne infections such as dematophilosis, heartwater, bovine anaplasmosis and bovine babesiosis. In addition, there is also evidence that N'Dama are resistant to ticks and internal parasites. According to D'Ieteren et al. (1998), it appears that the combination of these traits, rather than resistance to individual diseases, is what farmers value and what they tend to associate with the West African *Bos taurus* cattle breeds. Breeding for improved resistance to trypanosomosis should not be at the expense of increased susceptibility to other diseases.

Second, several significant differences in preferences among cattle producers for the levels of traits were found: (a) subsistence farmers have the lowest preference for fitness to traction and small size and the high preference for easy temperament; (b) milk and beef producers have the highest preferences for bulls that are non-selective grazers and large-sized cows; and (c) mixed crop-livestock farmers have the lowest preference for non-selective grazers, high reproductive performance, high milk yield and the highest preference for fitness to traction. The fact that there was no detectable differences among cattle producers based on disease resistance confirms the importance of disease resistance to all cattle owners in the study area.

Third, off-take of beef and milk is often used as the basis for development of a selection index for breed improvement. In the case of smallholders in Burkina Faso (and likely elsewhere in West Africa) reliance on offtake for breed selection is not advised. Traits related to beef and milk off-take were consistently ranked below other factors such as fitness for traction and disease resistance, reflecting the use of cattle as an energy input in farming and substitute for credit and insurance markets.

These results indicate that all types of farmers in southern Burkina Faso value the adaptation traits, especially disease resistance, of the indigenous cattle breeds. To be consistent with those preferences, breed improvement programmes should ensure that improved genotypes maintain disease resistance at the same time as they improve reproductive performance and fitness to traction. Improved milk production, achieved for example by cross-breeding with European dairy breeds, does not appear to be important to most farmers.

Finally, differences in preferences between groups of respondents as distinguished through conjoint analysis can be extended to locations and specific production systems for *in situ* conservation of trypanotolerant breeds at risk of extinction.We believe the best way to achieve this is conservation-through-use. This strategy explicitly recognizes that animal genetic resources are natural-capital assets of farming communities (Brush, 1991; Faminow and Weber, 2001) and that mechanisms can be developed in a participatory manner to manage the resources for sustainable use and conservation.

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Table 1. Traits and levels of traits used in the experiments

Traits	Levels	Bulls/Cows
Feeding ease [1, (2)]**	1. Non selective	Bulls and cows
	2. Selective*	
Weight gain [1]	1. Rapid*	Bulls and cows
	2. Slow	
Disease resistance [1, 2]	1. Resistant*	Bulls and cows
	2. Susceptible	
Reproductive performance [1]	1.High (1 calf/year)	Cows
	2.Low (1 calf/ 3 years)*	
Milk Yield [1]	1. High	Cows
	2. Low*	
Size [2]	1. Large	Bulls and cows
	2. Small*	
Temperament [2]	1. Easy to handle	Bulls and cows
	2. Difficult to handle*	
Fitness to traction [1]	1. Good	Bulls
	2. Poor*	
Fertility [2]	1. High	Bulls
	2. Low*	

Note: (1): Used in the first experiment

(2): Used in the second experiment

* Levels with the asterisk were used in the estimated equation; the other levels were left out to avoid the dummy variable trap

** Feeding ease was used in the first design of bulls and in the second design of cows.

Table 2. Sample of profiles used in the first experiment of bulls

N°1 Diseases: *Resistant* Weight: *Rapid* Feeding ease: *Selective* Fitness for traction: *Good* Rating ………………../ 5	N° 2 Disease: *Resistant* Weight gain: *Rapid* Feeding ease: *Selective* Fitness for traction: *Poor* Rating ………………../ 5
N°3 Diseases: *Susceptible* Weight: *Low* Feeding ease: *Selective* Fitness for traction: *Poor* Rating ………………../ 5	N°4 Diseases: *Susceptible* Weight: *Rapid* Feeding ease: *Non Selective* Fitness for traction: *Good* Rating ………………../ 5
N°5 Diseases: *Resistant* Weight: *Low* Feeding ease: *Non Selective* Fitness for traction: *Poor* Rating ………………../ 5	N°6 Diseases: *Resistant* Weight: *Low* Feeding ease: *Non Selective* Fitness for traction: *Good* Rating ………………../ 5
N°7 Diseases: *Susceptible* Weight: *Low* Feeding ease: *Selective* Fitness for traction: *Good* Rating ………………../ 5	N°8 Diseases: *Susceptible* Weight: *Rapid* Feeding ease: *Non Selective* Fitness for traction: *Poor* Rating ………………../ 5

N. B: Survey respondents were asked to evaluate each profile using a five-point (1-5) preference scale, where 5 means the most desirable animal for the respondent's cattle operations, 1 the least desirable cattle and ratings 2 to 4 represented desirability between the two extremes.

Table 3. Main effects of levels of traits of bulls on ratings, Southern Burkina Faso

Variables	Model 1	Model 2
Constant	1.191(0.1029)***	0.973 (0.119)***
Rapid weight gain	0.306(0.0451)***	
Selective grazing habit	-0.437(0.0452)***	
Poor fitness to traction	-1.115(0.0517)***	
Resistant to disease	0.918(0.0377)***	0.905 (0.0505)***
High fertility		0.831 (0.0515)***
Small size		-0.407 (0.0496)***
Difficult temperament		-0.500 (0.0460)***
Coefficients of threshold variables		
μ^1	0.939 (0.0521)***	0.939 (0.0517)***
μ^2	2.0720 (0.0691)***	1.999 (0.0678)***
μ^3	3.133 (0.0887)***	3.050 (0.1127)***
Log likelihood ($L\omega$)	-1311.763	-1275.581
Restricted (slopes=0) log-likelihood	-1912.752	-1826.218
Likelihood ratio (L_R)	1201.978	1100.873
Significance level	0	0
Degrees of freedom	12	16

*** Statistically significant at 1% level,

The likelihood ratio is computed as: $L_R = -2 (L_\Omega - L\omega)$

The threshold variables represent a link between the utility of cattle profiles to the respondents and the numerical ratings given to the profiles

Table 4. Main effects of levels of traits of cows on ratings, Southern Burkina Faso

Variables	Model 1	Model 2
Constant	1.22 (0.0802)***	0.9092 (0.104)*
Low reproductive performance	-1.185 (0.0468)***	
Rapid weight gain	0.632 (0.0432)***	
Low milk yield	-0.436 (0.0476)***	
Resistant to disease	0.984 (0.0424)***	0.884 (0.04778)***
Selective grazing habit		-0.743 (0.0466)***
Small size		-0.313 (0.0483)***
Difficult temperament		-0.518 (0.0470)***
Coefficients of the thresholds		
μ^1	0.9859 (0.0538)***	0.9580 (0.0533)***
μ^2	2.0308 (0.0710)***	1.9027 (0.0651)***
μ^3	3.3959 (0.1069)***	2.7749 (0.0811)***
Log likelihood (Lω)	-1218.621	-1380.395
Restricted (slopes=0) log-likelihood	-1912.685	-1837.868
Likelihood ratio (L_R)	1388.128	914.647
Significance level	0	0
Degrees of freedom	12	12

*** Statistically significant at 1% level,

The likelihood ratio is computed as: $L_R = -2\ (L_\Omega - L\omega)$

The threshold variables represent a link between the utility of cattle profiles to the respondents and the numerical ratings given to the profiles

Table 5. Impact of interaction between levels of traits and farming systems on ratings of bulls and cows, southern Burkina Faso

Traits of bulls				
Levels of traits	Subsistence system	Milk and beef system	Mixed crop-livestock	Average farmer
Resistance to disease	0.918	0.918	0.918	0.918
Rapid weight gain	0.306	0.306	0.306	0.306
Selective grazing habits	-0.555*	-0.666***	-0.089***	-0.437
Poor fitness to traction	-0.868***	-0.908**	-1.569**	-1.115
High fertility	0.634*	831	1.028**	0.831
Small size	-0.170**	-0.407	-0.644***	-0.407
Difficult temperament	-0.680*	-0.5	-0.320**	-0.5
Traits of cows				
Resistance to disease	1.460*	0.963	0.780**	0.963
Rapid weight gain	0.614	0.614	0.614	0.614
Low milk yield	-0.727***	-0.432	-0.138**	-0.432
Low reproductive	-1.414**	-1.185	-0.956***	-1.185
Selective grazing habit	-0.743	-0.743	-0.743	-0.743
Small size	-0.313	-0.478 **	-0.148***	-0.313
Difficult temperament	-0.518	-0.275 ***	-0.762***	-0.518

***, **, * Statistically significant at the 1, 5 and 10% levels respectively

Table 6. Relative importance of the main traits of bulls, Southern Burkina Faso

Traits	Model 1	Model 2	Overall
Fitness to traction	40.2		24.7
Weight gain	11		6.7
Feeding ease	15.8		9.7
Disease resistance	33	34.2	20.2
Fertility		31.5	18.6
Size		15.4	9
Temperament		18.9	11
Total	100	100	100

Source: Computed from estimates data of Tables 4.6 and 4.7

The overall importance of the traits is obtained by combining estimates of both designs as if they were coming from a single design using then following formula:

$$\psi_a = \frac{[\ max(v_{ga}) - min(v_{ga})]}{\Sigma\,\omega_a}$$

where v_{ga} is the marginal value of the g^{th} level of the a^{th} trait; ψ_a represents the relative importance for the a^{th} trait; $\Sigma\omega_a$ is the sum of the ranges, [max (v_{ga}) - min (v_{ga})], across all traits.

Table 7. Relative importance of the main of cows, Southern Burkina Faso

Traits	Model 1	Model 2	Overall
Reproductive	36.6		24.9
Weight gain	19.5		13.3
Milk yield	13.5		9.2
Disease resistance	30.4	35.9	19.6
Feeding ease		30.3	15.6
Size		12.8	6.6
Temperament		21	10.8
Total	100	100	100

Source: Computed from estimates data of Tables 4.6 and 4.7

The overall importance of the traits is obtained by combining estimates of both designs as if they were coming from a single design using the following formula:.

$$\psi_a = \frac{[\ max(v_{ga}) - min(v_{ga})]}{\Sigma\, \omega_a}$$

where v_{ga} is the marginal value of the g^{th} level of the a^{th} trait; ψ_a represents the relative importance for the a^{th} trait; $\Sigma\omega_a$ is the sum of the ranges, [max (v_{ga}) - min (v_{ga})], across all traits.

Table 8. Comparison of the relative importance of the traits of bulls and cows: conjoint versus ranking, southern Burkina Faso

	Bulls		Cows	
Traits	conjoint	ranking	conjoint	ranking
Fitness to traction	24.7 (1)	1	-	-
Fertility	18.6 (3)	4	-	-
Feeding ease	9.7 (5)	2	15.6 (3)	5
Disease resistance	20.2 (2)	2	19.6 (2)	3
Weight gain	6.8 (7)	4	13.3 (4)	4
Size	9.0 (6)	5	6.6 (7)	7
Temperament	11.0 (4)	3	10.8 (5)	6
Reproductive	-	-	24.9 (1)	1
Milk yield	-	-	9.2 (6)	2

Source: Statistical rankings from Table 4.4

Conjoint index from Tables 4.9 and 4.10

Number in parentheses indicate the rank of the trait based on the index value.

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(xlii) This paper was presented at the International Workshop on "Climate Change and Mediterranean Coastal Systems: Regional Scenarios and Vulnerability Assessment" organised by the Fondazione Eni Enrico Mattei in co-operation with the Istituto Veneto di Scienze, Lettere ed Arti, Venice, December 9-10, 1999.

(xliii)This paper was presented at the International Workshop on "Voluntary Approaches, Competition and Competitiveness" organised by the Fondazione Eni Enrico Mattei within the research activities of the CAVA Network, Milan, May 25-26,2000.

(xliv) This paper was presented at the International Workshop on "Green National Accounting in Europe: Comparison of Methods and Experiences" organised by the Fondazione Eni Enrico Mattei within the Concerted Action of Environmental Valuation in Europe (EVE), Milan, March 4-7, 2000

(xlv) This paper was presented at the International Workshop on "New Ports and Urban and Regional Development. The Dynamics of Sustainability" organised by the Fondazione Eni Enrico Mattei, Venice, May 5-6, 2000.

(xlvi) This paper was presented at the Sixth Meeting of the Coalition Theory Network organised by the Fondazione Eni Enrico Mattei and the CORE, Université Catholique de Louvain, Louvain-la-Neuve, Belgium, January 26-27, 2001

(xlvii) This paper was presented at the RICAMARE Workshop "Socioeconomic Assessments of Climate Change in the Mediterranean: Impact, Adaptation and Mitigation Co-benefits", organised by the Fondazione Eni Enrico Mattei, Milan, February 9-10, 2001

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(xlix) This paper was presented at the International Conference "Knowledge as an Economic Good", organised by Fondazione Eni Enrico Mattei and The Beijer International Institute of Environmental Economics, Palermo, April 20-21, 2001

(l) This paper was presented at the Workshop "Growth, Environmental Policies and + Sustainability" organised by the Fondazione Eni Enrico Mattei, Venice, June 1, 2001

(li) This paper was presented at the Fourth Toulouse Conference on Environment and Resource Economics on "Property Rights, Institutions and Management of Environmental and Natural Resources", organised by Fondazione Eni Enrico Mattei, IDEI and INRA and sponsored by MATE, Toulouse, May 3-4, 2001
(lii) This paper was presented at the International Conference on "Economic Valuation of Environmental Goods", organised by Fondazione Eni Enrico Mattei in cooperation with CORILA, Venice, May 11, 2001
(liii) This paper was circulated at the International Conference on "Climate Policy – Do We Need a New Approach?", jointly organised by Fondazione Eni Enrico Mattei, Stanford University and Venice International University, Isola di San Servolo, Venice, September 6-8, 2001

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