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Valuing Animal Genetic Resources in Peasant Economies: The Case of the Box Keken Creole Pig in Yucatan

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SUMMARY

We report the results of a choice-experiment study to model preferences over a selection of breed traits of Creole pigs. The study was conducted amongst households of backyard producers and small farmers rearing indigenous Creole pigs in Yucatan, Mexico.

Hypothetical choice data were collected to estimate the preference of households over alternative weaners profiles whose attributes distinguish Creole pigs from the potentially more productive, yet less adapted (e.g. with regard to disease resistance, foraging capability, heat tolerance, etc.) exotic breeds currently threatening to severely displace this indigenous animal genetic resource.

The observed choices are employed to estimate a series of random utility models whose results are tested for preference equality between households and small farmers. Producers estimates for economic values of traits are validated with cost data and deemed plausible as stated-preference based estimates are found to be of the same magnitude as revealed-preference producers costs. As a consequence the method is deemed to be appropriate for the valuation of non-market functions in production. Estimates conditional on household characteristics are then presented and discussed.

Keywords: Biodiversity values, genetic resources, stated preference, choice experiments, livestock values, non-market values, Creole Pig

NON TECHNICAL SUMMARY

A choice experiment (CE) is used to value the phenotypic traits expressed in Creole pigs in Yucatan, Mexico. Validation is achieved by comparison with a rapid cross-sectional survey. Results indicate that CE can indeed be used to estimate trait values. The data also permits an analysis of how household characteristics determine differences in preferences which can be of use in designing policies that counter the present trend towards marginalisation of indigenous breeds. Since the net value placed on the Creole pig is similar to other breeds, minimal incentives and interventions are in fact needed to ensure its continued sustainable use.

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Abstract

We report the results of a choice-experiment study to model preferences over a selection of breed traits of 'creole' pigs. The study was conducted amongst households of backyard producers and small farmers rearing this local breed in Yucatan, Mexico. Hypothetical choice data were collected to estimate the preference of households over alternative pigs profiles whose attributes distinguish creole pigs from the potentially more productive, yet less adapted exotic breeds currently threatening to severely displace this locally adapted animal genetic resource. The observed choices are employed to estimate a series of random utility models whose results are tested for preference equality between households and small farmers. Stated-preference based estimates are found to be of the same magnitude as revealed-preference producers costs. As a consequence the method is deemed to be appropriate for the valuation of non-market functions in production. Estimates conditional on household characteristics are then presented and discussed.

1 Introduction

Most of the benefits produced by local livestock in marginal production systems are captured by producers, rather then consumers. [1] As a consequence the genetic resources of these breeds have mostly been shaped by producers' preferences. It is therefore to the identification and characterisation of these preferences that research must turn to identify the implicit value of genetically determined traits as a first approximation to local Animal Genetic Resources (AnGRs). These breeds are often characterised by a bundle of genetically and phenotypically stable traits which are often expressed in a complementary fashion. For example, foraging ability (selectivity of intake), tolerance of harsh ambient conditions, digestive capacity for fibrous diets etc.

In marginal production systems the breeding pressure on livestock is directed to creating animals capable of performing satisfactorily on marginal resources. Livestock performance is valued by producers, but assessed mostly in non-market terms. It is therefore this category of economic agents and non-market

[1] The term 'local' refers to livestock that have become adapted to the specific environments of low external input rearing systems. These livestock may be indigenous to the region, or more often those that were brought there many generations before - termed 'criollo' (creole) in Latin America.

functions that one needs to be able to study in order to derive economic values.

In this study we use choice modeling to estimate producers' preferences for genetically determined pig attributes in the backyard economy of Yucatan. The empirical study allows us to derive economic estimates of each attribute and compare these with analogue production costs to assess how choice modelling performs in this task. We also characterise value attributes on the basis of household (HH) composition, showing how multi-attribute valuation can vary according to the HH socio-economic characteristics.

Backyard production systems play a major role in livelihood maintainance of subsistence economies (Anderson, Drucker and Clark, 2000), particularly in marginalised rural systems. For example, the purpose of backyard livestock production for most peasant HHs is to smooth consumption patterns, provide a means of savings, insurance and cyclical buffering, as well as providing a crucial source of high quality protein food.

A species of special importance to subsistence farming in Latin America are pigs. Some well documented historical evidence is now in place to support the claim that the livelihood of many subsistence economies depends on backyard production systems, and in turns, a significant component of the latter depends on backyard pig production. Across Latin America this type of production has a long history, dating back to the Conquistadores who introduced the first population of pig livestock, from which the local ('indigenous', or 'creole' or 'criollo') breeds have been developed, possibly with some inclusion from more prolific Chinese breeds.

The purity of these local pigs is now under threat by the indiscriminate adoption of exotic pig breeds. As a background to this study, and to provide the reader with some appreciation of the relevance of local pig breeds in these types of economies, we briefly present some issues resulting from the relatively recent eradication and repopulation of the creole pig in Haiti. This case is worth mentioning here as a negative example in a context which is in many respects similar to the one under study.

In 1978 an eradication programme destroyed the local population of the creole Pig. This was deemed to be necessary (although contested by many observers) to protect the pork industry and subsistence economy of both Haiti and the rest of the region from African Swine Fever. The eradication affected 80% of the population of Haiti for whom pigs represented an important source of animal protein and food security as well as a means of wealth storage, thereby bringing widespread hardship to Haitians. The following exerpt from the Guardian is descriptive:

> 'The creole pig was our whole life,' a Haitian man told us. 'It was the pig that birthed us, the pig that raised us, the pig that buried us.' Pigs were the

island's honking bank accounts. Pigs paid to put kids through school (six out of 10 of the island's children still cannot read), paid for your wedding, and paid for the scrap of land you wanted to buy.

The Guardian - London October 24, 1997

Shortly after the eradication took place a repopulation program began. The process with which this was implemented — especially with respect to the compensation mechanism used — generated much controversy. However, the issue of interest to this study is the replacement of the local creole pig herd population with a prevalently exotic herd which has provoked the massive substitution of locally developed breeds and therefore well-adapted AnGRs, with an exotic pool of genes, mainly drawn from breeds such as Yorkshire, Durocs, Hamphsires, and some Landrace.

The improved exotic breeds are claimed to be *potentially* superior in many respects. For example, they are more efficient in terms of highly digestible feed-meat conversion and more prolific, as they produce larger litters[2]. However, for this potential to be fully delivered the traditionally extensive management systems must be intensified. Such intensification may often be beyond the scope of existing human and capital resources available to most of the livestock production systems supporting subsistence economies in rural Latin America.

Similarly, some genetically determined traits of the creole pig, such as higher tolerance to environmental extremes and parasite resistance, seem to ensure a higher rate of survival in the traditional management system, which relies on very low input and technology. Furthermore, given these characteristics, this type of production system requires animals with wide dietary tolerance, and enhanced stress-resistance.

In many of these systems, however, local breeds are suffering a strong dilution of their genetic material because of the influx of exotic breeds. The backyard production system of rural Yucatan (Mexico) is one of these and hence it was chosen as the setting for the present AnGRs valuation study.

[2] Under extensive systems it often takes a local swine 2 and 1/2 years to achieve market weight of 200 lbs., while the creole pig's weight rarely exceeded 150 lbs. Instead, with proper nutrition, the improved breeds achieve 200 lbs. in six months, but their genotype has poorer interaction with the local environment. Reports of studies of the creole pig, claim a litter size at weaning not exceeding four piglets, compared to the 8-9 per litter of the introduced breeds.

1.1 The Creole Pig in Yucatan: the current situation.

Pig keeping by 'peasant-farmer' (campesino) families in the Yucatan, as in many other parts of Mexico, is a traditional livelihood activity. Pigs are kept under low input rearing conditions in the homegardens, or backyards, and provide a means for the family to reproduce and/or accumulate natural resource assets that can be easily sold at critical moments of financial need. It has been estimated that this system of pig rearing provides 30 per cent of national pigmeat production in Mexico (SAGAR, 1998).

The recent trend of importation and promotion of pigs of 'improved' breeds and the availability of concentrate feed at subsidised prices have however contributed to a severe genetic erosion of the creole pig population over the last few decades in two ways. These are:

(1) a drastic reduction in the number of creole pigs (breed substitution),
(2) the loss of of the creole pig characteristics through cross-breeding (genetic erosion).

Anderson *et al.*, (1999) estimated Yucatan creole pig population to be between 500 and 1,000 breeding females. The threatened situation of the creole pig in this Mexican state is worsened by the stringent animal health regulations that have been implemented to safeguard the region from endemic diseases and which have effectively isolated the state from any other source of creole pigs.

The decrease in numeric importance of the creole pig breed is despite certain favourable characteristics of the breed. The creoles are considered to be of a 'rustic' nature. They are tolerant of high temperatures, able to walk well in difficult terrain, do not suffer problems of skin photosensitivity nor are they easily affected by ecto-parasites such as mange. Added to which recent evidence from comparative digestive ability trials has shown the creole pigs to have higher voluntary feed intake than 'improved' breeds when fed poor quality diets - maize and maize plus forage (Anderson *et al.*, 2001).

These qualities, and the relatively low cost per head, had enabled the creole pig population to maintain a relatively important presence in the homegarden/backyard system across most rural parts of Mexico. Among these traits are adaptive characteristics which may make the creole pig an important genetic resource for the development of alternative production systems that are less environmentally damaging, and require lower levels of external inputs (Anderson *et al.*, 1999).

1.2 Purpose and objectives.

Valuation studies for AnGRs are of particular interest in those contexts in which AnGRs are an input into the production process. Especially when this production can improve the livelihoods of poor rural HHs.

Given the above, the present study set out to investigate whether some important breed-determined livestock attributes could be valued by employing choice experiments (CE) amongst rural HHs. This is a direct means by which HH preferences over breed traits can be systematically investigated to cast some light on the implicit value assigned in the production process to these traits. CE also allows one to explore how these preferences vary across HH composition and how the variation can be characterised in terms of value attribute estimates conditional on HH covariates such as its size, its income availability and respondent's (head of the HH) age and education level.

Since the attributes investigated are quite distinct between exotic and local pig breeds, the estimated values obtained can be taken as an indication of the differential value that HHs assign to different inputs in the sameproduction processe, and ultimately to the two animal types. CE methods could be particularly valuable in this context in which many production costs cannot be identified as they are directly associated with unpriced activities carried out by the various members of the HH.

The reminder of the paper is organised as follows. Much of the theory and methodological framework employed in the study is presented in section 2 of [OMITTING AUTHOR NAMES] (this issue). The next section describes the sampling framework in the area of study, along with some HH sample statistics and the experimental design of the choice modeling exercise. Section 3 deals with some model estimation issues, while the results of the econometric analysis are reported and discussed in section 4. Some conclusions and directions for further research in this challenging area of work are presented in the last section.

2 Survey approach

The sampling framework was designed on the basis of previous work (Anderson *et al.*, 1999) that had established the size of the creole pig population in the state of Yucatan through a random sampling of villages. Other work by the same authors (Drucker *et al.*, 1999) explored the influence of such factors as: the proportion of backyard pig producers, village size, village distance from main roads, the presence of imported breed pig farms, the percentage of population that still speak Maya (a proxy for the maintenance of traditional cultural practices), etc. on indigenous breed pig populations.

It was finally determined that a group of 18 Yucatecan villages, representative of traditional pig rearing practices, were to be included in the sample for the CE survey. The HHs to be surveyed within each village were randomly chosen based on an 'X' transect of the village layout. The survey was carried out during the months of June to October 2000. This period normally corresponds to the months of low maize availability at the HH level. This cyclical scarcity induces HHs to sell pigs to obtain cash needed to purchase maize for subsistence. Because some HHs spoke no Spanish, but only Maya, an interpreter was occasionally used.

2.1 Household sample description.

The sampling procedure described above produced a sample of size 270 HHs, 4 of which were discarded in model estimation because of missing socio-economic data. Some selected HH characteristics of the remaining 266 HHs are presented in table 1.

15.4% of the respondents had had no formal education, while 71.4% had some primary school education, 9.4% some secondary, and the remainder high school or higher schooling. The main source of income in the HHs was described as 'maize agriculture' or horticulture (40%), followed by employment of some kind (26.7%), construction workers (9%), commerce (11%) and pensions (7%).

Although all the interviewed HHs had raised pigs sometime in the past, only 85.1% of them had pigs in the backyard at the time of the interview. The declared reasons for pig-rearing were: 'as a business' (11.5%); as 'a way of saving' (64.8%); and to 'provide cash for various HH necessities' (10%). Savings and cash for necessities were also jointly indicated by another ten percent, while a small fraction (3%) stated that pig-rearing was carried out for 'socio-cultural' purposes.

It is interesting to notice that only in 12.4% of the HHs was pig-rearing attended to by the male head of the HH, while in a sizeable 56.7% of them it was the female head of the HH[3]. In 3.3% of the cases respondents stated that tasks were shared between the partners, while children attended the rearing

[3] Frequencies of task-sharing in attending to pig-rearing are to be contrasted with those of HH member in charge of buying decisions. The fraction of HHs in which the buying of pigs was declared to be a decision made by males head of the HH was 42% and only in 34% of the cases by the female head, with 9.6% of cases of joint decisions.

tasks in 4.8% of the cases and in 5.2% of them in conjunction with the female head of the HH.

Only 2.5% of the HHs raising pigs never sold them. In more than half of the HHs pigs were sold at least once per year or more frequently, 36% once per year and 9% once every two years.

Finally, of interest for this study are the frequencies of pig breeds across HHs. Exotic 'Americanos' were raised by 29.8% of the sample, 'Criollo' (mainly indigenous genotype) pigs were raised by 39%, and mixed breed (mainly exotic genotype) pigs by 25%. A further 2.2% had both mixed-exotic and other inter-bred, and 1.5% both creole and exotics.

2.2 The choice experiment.

For the CE a total of 300 interviewees were approached and surveyed. These included the 270 HHs engaged in backyard production, and were supplemented with an additional group of 30 randomly selected small-scale farmers (SF) involved in traditional pig-rearing. This extension of the sample was deemed interesting because the creole breed is also important in this type of farming.

The administration of the CE was conducted as follows. Each respondent was first introduced to the type of choice task required by them and then presented with 6 sets of pair-wise choices drawn from the experimental design. Each choice task required the respondent to hypothetically buy for rearing one of two available animal profiles, each described by means of 5 relevant pig rearing attributes. If neither of the animal profiles was found satisfactory, the respondent could choose the 'zero option' and state that s/he preferred neither.

As mentioned above the attributes were chosen so as to reflect a set of relevant breed-related pig-rearing traits. These included:

(1) *Weight at 6-month of age.* As many pigs that are not destined for consumption within the HH are sold at this age this was taken to be a good indicator of the food-conversion performance. This trait is known to differ between creole and exotic breeds, being higher in the latter in absence of dietary constraints. The levels used for this first animal attribute were: 35, 65 and 90 kgs.
(2) *Frequency of bathing.* Heat tolerance is an important factor in pig rearing. Heat exhaustion is often avoided by securing periodical bathing of the animals. Since creole pigs are better adapted to hot climates, they require no bathing at all, or only very occasionally. The frequency of required bathing was therefore taken as a proxy for heat tolerance and investigated

at three levels of expression: never, once a week and at least twice a week.

(3) *Feed purchase requirement.* Ability to rely on a wide spectrum of feed sources is an important attribute in backyard rearing. Versatility in taking advantage of various food sources is a way to avoid HH dependence on external inputs. This was taken as a proxy for foraging capability which is an important aspect of pig-rearing in this production system. Only 12% of the interviewed HHs declared themselves to be self-sufficient in maize production, which is one of the main sources of pig feed for exotic breeds. This implies that scarce cash assets would need to be destined to maize purchase in many HHs. Feed purchase requirement was a 0-1 dummy attribute, i.e. the animal either did or did not require purchased feed.

(4) *Disease resistance.* As the indigenous creole breed is reputed to be more resistant than the exotic breed, a 'low' and a 'high' level of resistance were employed.

(5) *Purchase cost of piglets.* The major layout in pig rearing is the purchase of weaned piglets. For example, in our sample, only 20% of the HHs did not buy piglets. The majority raised piglets purchased outside (68.4%) and 8.7% raised piglets that had been in part born in the HH and in part bought.[4] Since exotic breeds piglets are more expensive, we took this as a proxy for the differential of the initial input cost between breeds. Four levels of cost were employed: 170, 190, 215 and 275 Mexican Pesos (Mex$).[5]

Holding a-priori an assumption of independence across attributes, the experimental design was aimed at investigating only the main effects, and was obtained with the orthogonalization procedure in SPSS software. This gave rise to a set of 16 profiles that were pair-wise combined and selected according to dominance criteria. The final set included 240 pair-wise comparisons which were randomised in groups of 6 for each HH in the sample. A total of 1,800 choices were obtained from 300 interviews.

3 Econometric issues and model specifications

3.1 Econometric issues.

In a study of producers' preferences the AnGRs determining animal phenotype are to be considered as inputs into the household production process. There is

[4] The difference to 100% is made up of piglets acquired by gifts.

[5] The current symbol for Mexican pesos is $, but to avoid confusion with the US$ we employ the abbreviation Mex$. US$ 1=Mex$ 9.5, approximately.

no market that reveals the values of factor inputs of this kind. These unpriced inputs must be valued with shadow pricing techniques from revealed preference data. Alternatively, multi-attribute stated preference data can be employed to assess the importance of individual animal traits associated with breed. This is the approach employed here. The econometric analyses of the CE data followed the well-known random utility (RU) theoretical framework (McFadden 1974) adapted to the animal attribute case as explained in section 2 of AUTHOR NAME. (this issue).

The main aim of the econometric analysis was to estimate the economic value of pig attributes, followed by an assessment of the estimates validity with known production costs from revealed preference data. This is considered an important component of reliability of the stated preference method proposed here, as stated elsewhere (Bishop *et al.* 1995).

A secondary aim was that of investigating whether these preferences varied across and within producer types (i.e. village HHs and SFs), and if so, what changes these variations implied for the economic value of breed-determined attributes. In other words, a characterisation of preference heterogeneity conditional on producers' characteristics.

In order to achieve these two goals, the set of observed discrete choices produced with the CE were employed to estimate a series of RU models, a selection of which are presented here. Although the recent development in computational power allows the researcher to use estimators based on likelihood simulation, such as random parameter multinomial logit (McFadden and Train 2000), we present here only the more conventional results employing fixed parameter logit. [6]

3.2 The basic model and preference stability

In general, we proceeded following two approaches, one for each of the two aims mentioned above.

For attribute value estimation we estimated a 'basic' indirect utility specification limited to the attributes included in the CE and unconditional on socio-economic characteristics. We then compared the estimates for animal attributes implied by this basic specification with those derived from revealed preference studies.

[6] Mixed parameter logit analyses were also conducted using panel data estimators and other more computationally intensive estimators, but the basic conclusions of the study remain under these alternative specifications. Results of these analyses are available upon request from the corresponding author.

From the HHs and SF pooled sample 1,800 choices are available and these were employed to estimate the parameter values of the RUM model $\hat{\beta}_{pool}$. These estimates are reported in table 2. Under the assumption of our sample being representative of the target population, these are preference estimates of Yucatan HH and SF traditional pig producers over the selected set of genetically determined attributes.

Different groups of producers may face different trade-offs in production activities, and this may have relevant repercussion in policy design. It is therefore interesting to test whether the set of parameter estimates are shared across the two sets of respondents: village HHs and SFs. So, separate estimates $\hat{\beta}_{HH}$ and $\hat{\beta}_{SF}$ were obtained from the two distinct samples, with the attendant unrestricted log-likelihood values $\mathcal{L}^{U}_{HH}$ and to formally investigate the difference in implied value estimates for the pig attributes and test the hypotheses of equality of preference.

To test preference stability across type of producers we conducted four separate likelihood ratio tests. These were:

(1) Pooled preferences are shared by HHs:

$$H^1_o : \beta_{pool} = \beta_{HH} \text{ versus the alternative } H^1_o : \beta_{pool} \neq \beta_{HH}.$$

(2) Pooled preferences are shared by SFs:

$$H^2_o : \beta_{pool} = \beta_{SF} \text{ versus the alternative } H_a : \beta_{pool} \neq \beta_{SF}.$$

(3) HHs' preferences are shared by SFs:

$$H^3_o : \beta_{HH} = \beta_{SF} \text{ versus the alternative } H_a : \beta_{HH} \neq \beta_{SF}.$$

(4) SFs' preferences are shared by HHs:

$$H^4_o : \beta_{SF} = \beta_{HH} \text{ versus the alternative } H_a : \beta_{SF} \neq \beta_{HH}.$$

These were conducted by imposing the appropriate restrictions to the two sub-sample likelihood functions. For example, to test H^3_o we obtain estimates of the preference parameters $\hat{\beta}_{HH}$ from the 1,620 choices made by the 270 HHs. We then impose these values to the SF sample likelihood to obtain a restricted SF sample likelihood value $\mathcal{L}^{R}_{SF}$ which was then employed to obtain a $\chi^2_{k=5} = -2(\mathcal{L}^{R}_{SF} - \mathcal{L}^{U}_{SF})$ statistic under the null.

3.3 Specification and value estimates conditional on HH covariates.

In view of the role played by the creole pig in terms of HHs livelihood, it is of interest to examine whether the basic RU specification can be improved by accounting for HH differences that are also relevant in terms of model validation and policy design.

Six HH characteristics where employed to characterise heterogeneity, collectively indicated here by the vector **q**:

- The age of the respondent (as well as the head of the HH) (A);
- The number of years the respondent spent in school (E);
- The number of members in the HH (N);
- The number of income earners in the HH (Y);
- The number of pigs currently raised by the HH (P);
- The average selling age of pigs raised by the HH (SA);

In a random utility specification these effects cannot be examined in isolation, but by means interaction terms (sometimes including quadratic effects, e.g. for Age) which were added to the basic model obtaining an initial specification with over 35 variables.[7] This specification was estimated in the sample of 266 complete sets of responses for a total of 1,596 observed discrete choices. Sample values of **q** are reported in table 1.

This was then 'tested down' to the model whose estimates are reported in table 4, and does not include P and SA as they were not found to be significant. For this specification with covariates, the attendant value attribute estimates are now not only a function of the parameter estimates, but also of the particular values chosen for the conditioning socio-economic HH characteristics **q**, thereby enriching the information content for policy design and for the assessment of the stated preference approach to AnGRs valuation. Selected estimates of attribute values conditional on **q** are reported in table 5.

[7] Notice also that in this specification the frequency of baths was included as two dummies (weekly = BATH1, bath at least twice a week = BATH2), rather than as an ordinal variable as in the 'basic' model in table 2.

4 Discussion of the results

4.1 Pooled model for pig producers and estimate validation.

A total of 1,800 choices were collected, 180 of which from SF. As it can be seen from the values reported in table 2, the purchase price of the piglets to fatten (PIG_COST) is strongly significant and has the expected negative sign. The weight gained at six months of age (6M_WEIGHT) is also strongly significant and with the expected positive sign. The need to purchase food (BUY_FEED) has a high negative value, indicating an intense reluctance by the interviewed HHs to commit themselves to such an expenditure. The frequency of necessary weekly baths (BATH_FR) is also negative as expected, but the estimate is somewhat less significant than for the other breed attributes. Finally, the resistance to disease (DIS_RESIST) also shows an estimate with a high positive value and strong significance, indicating that this breed attribute is strongly valued in the sample of producers. The overall explanatory power of the model is good as far as conditional logit models go, with a McFadden R-square of 23.64%, no doubt thanks to the orthogonal design of the CE.

In order to derive estimates of value from the obtained parameter estimates of the random utility function we employed the analogue of equation (9) in AUTHOR NAME (this issue), and — since these are highly non-linear functions of parameter estimates — the confidence intervals where approximated by means of the delta method (Goldberger, 1993). The reported value estimates in Mex$ are given in the bottom part of table 2.

Each kg of weight increase at six months is valued at Mex$ 4.5 (± 0.19) and the estimate is significantly different from zero. The strong reluctance to buy special feed for pig rearing translates itself in a high negative value of Mex$ 120.4 (± 12.48). This figure is to be interpreted for the entire rearing period and per pig head. The frequency of weekly baths to avoid heat exhaustion also has a negative value of Mex$ 17.9 (± 5.8) per number of baths per week over the entire production period. This estimate is somewhat less significant than the others with an asymptotic p-value of 0.4.[8] Finally, resistance to disease is highly appreciated and highly valued with an estimate of Mex$ 86.9 (± 8.7), also to be interpreted per head and per rearing cycle.

In addition to obtaining a good overall fit, the resulting maximum likelihood (ML) estimates all show the correct expected signs and are statistically sig-

[8] Interestingly, when plugging in dummies for 'one bath' and 'at least two baths' only the latter is significant, implying that one bath per week may well not be perceived as costly, while additional ones are. For this reason in the next RU model we employ two separate dummies for the two bathing frequencies.

nificant. The value estimates for the pig attributes can be validated from the survey and monitoring data obtained through the application of a series of participatory rural appraisal techniques, in addition to more conventional farmer, consumer and market surveys (Anderson *et al.*, 1999 and Drucker *et al.*, 1999). Each of the CE estimates discussed above are considered in turn in the light of these alternative data sources.

Weight increase: According to the survey data, the average butcher purchase price per kilogram of liveweight varied between $8 and $11.2 across 8 villages, depending on breed and the existence (or not) of small commercial pig farms in these villages. However, the butcher purchase price represents the gross income per kilogram of liveweight accruing to the farmer from the sale of a pig. The net income (and hence the value to the farmer) from the sale will be lower as this takes into account various production costs. Survey data suggests that net income per kilogram of liveweight ranges from between Mex$ 0.8 to Mex$ 9.6. Based on the above, Mex$ 4.5/kg would seem to be a plausible estimate.

Feed purchase (proxy for foraging versatility): Data from the monitoring exercise suggests that although commercial farms wean their piglets between 3 weeks and one month after birth, backyard producers tend to do so much later. Under backyard production, this can vary between 2 and 4 months, with the shorter period being associated with the exotic breed and the longer period with the crossbreed. Given the fact that interviewees in the CE were told that the weight characteristic they were considering would be achieved at the end of a six month period following birth, a 2-4 month fattening period can be assumed. Survey and monitoring data also showed that the average cost of purchased feed varied between Mex$ 2.1 - Mex$ 2.5 per day.

Hence the total cost of purchased feed during the production cycle would fall within the range of:

- Maximum: 120 days (4 months) × Mex$ 2.5 per day = Mex$ 300 (more closely associated with exotic breed)
- Minimum: 60 days (2 months) × Mex$ 2.1 per day = Mex$ 126 (more closely associated with the crossbreed)

This would suggest that the CE result is credible although tends to underestimate the cost of purchased feed for animals that are weaned relatively earlier (i.e. the exotic breed). The latter could, however, be related to the fact, identified in previous surveys (Anderson *et al.*, 2001), that many backyard producers taking part in participatory rural appraisal of their pig production systems showed genuine surprise at finding out exactly how much maize (purchased or otherwise) their pigs have eaten over a given period.

Bathing frequency (heat tolerance proxy): According to the monitoring data, total HH water costs per month varied between Mex$ 5 and Mex$ 14. This represents the water bill for the entire HH use and not just for the pigs. Taking into account that on average 40 minutes per day are spent taking care of the pigs (at a shadow wage rate of Mex$ 14 per day) and assuming that 5 minutes of this is associated with bathing the pigs and that this consumes 1% of total water usage, the monitoring data suggests that each additional daily bath costs Mex$ 0.15 in labour and between Mex$ 0.0017 and Mex$ 0.0047 in daily water costs. Over a four month period this represents a total cost of Mex$ 17.7 - 18.1. On this basis, the CE result of Mex$ 17.9, again seems plausible.

Disease resistance: According to the survey data the average cost of medicines and veterinary treatment across 6 villages varied between Mex$ 0 and Mex$ 85.7. The survey data suffered from respondents being unable to remember past medicine/veterinary expenses and applied a zero shadow price to the cost of 'home remedies'. It is therefore likely to underestimate the true costs. The CE result of Mex$ 86.9 therefore seems plausible.

All the above CE results appear to be largely validated by the survey and monitoring data which suggests that this stated preference methodology is indeed likely to be a useful and reliable tool in estimating trait values in these contexts.

4.2 Households vs small farmers preference.

Do small farmers and village HHs share the same preference over animal traits? A formal test can be conducted by checking if the sum of the log-likelihoods for the two sub-samples is significantly larger than the pooled sample log-likelihood. We conduct this test using a model specification in which — along with the other attributes defined as before — the frequency of baths is split in 2 dummy variables BATH1 and BATH2.[9] This specification shows that it is the need for additional weekly baths that is most objected to, rather than the first. And produces the following results: $\mathcal{L}^U_{HH} + \mathcal{L}^U_{SF} = -1,338 + (-119) = -1,457$ while $\mathcal{L}^U_{pool} = -1,507$ with a $\chi^2_5 = 98$ which is much larger than the critical value of 11.07 for a conventional one-tailed test with probability of type I error of 5%. We therefore must reject the null of the two sub-samples sharing the same set of preferences.

In the same fashion, hypotheses 2, 3 and 4 for preference stability stated in section 3.2 are rejected with χ^2_5 values of 90.05, 1,370 and 108 respectively, while hypothesis 1 is not, with a $\chi^2_5 = 8.78$ which produces a p-value of 11.81%.

[9] This split significantly improves the pooled model ($\chi^2_1 = 6$ against a critical value of 3.84 for an α of 0.05.

This is not entirely surprising given that the pooled model is estimated from a sample where 90% of the choices are made by HHs. [10]

Because of the different sample sizes, and the fact that this test is only valid asymptotically (i.e. in large samples), it is possibly more meaningful to compare the values of $(1 - \mathcal{L}^R/\mathcal{L}^U)$, which show the percentage increase in the log-likelihood due to the imposed restriction. These are 0.003, 0.51, 0.38 and 0.45, for the hypotheses 1–4, indicating that the worst fitting restriction is that of forcing the taste parameters from SF unto the set of choices observed by the village HHs.

How does the observed difference in preferences affect the estimates of values for the pig attributes? This question can be answered by examining the value estimates for pig attributes derived from the two separate estimations from each of the subsamples, and comparing them to those from the pooled sample. These estimates are reported in table 3.

When estimated on the choices made by the HHs alone, the only value estimate that is significantly different (accounting for the confidence interval around the point estimate) is that for disease resistance. We speculate that this is due to the risk-aversion of HHs to capital loss given that so much of the function of pig-rearing is as a means of insurance, savings, seasonal buffering and asset accumulation.

Larger differences are observed in the value estimates for the SF sample, although — given the much smaller sample size — these conclusions should be confirmed by other results. Bearing this in mind, the value to farmers of an extra kg of pig-meat at 6 months is significantly lower by nearly Mex$ 1. Further, the negative effect of rearing pigs requiring feed purchase is also much less, Mex$ 50 over the entire period. The surprising result here is that the parameter for disease resistance has an unexpected negative sign.

4.3 Preference heterogeneity across households.

Testing down the model with all the covariates showed that the statistical significance was limited to the respondent's age (A) and years of schooling (E), the size of the HH (N), and the number of member economically active (Y). Let's examine the effects that each of these had on the five pig-attributes in turn.

[10] However, other tests based on bootstrap with similar sample sizes supported the same conclusion, and are available from the corresponding author.

Respondent's age. Age in years showed positive significant interactions with BATH1 and with pig's WEIGHT at 6 months. Therefore older respondents seem to value more speed of growth and be less bothered by the need for 1 bath a week than the average. The opposite is true for feed purchase as a negative effect was found in this interaction term. Finally, the effect of age on value is non-linear as it includes a significant interaction effect with squared age. The signs and the magnitudes of estimates imply that respondents have a marginal utility for money which increases with age at a decreasing rate.

Respondent's years of schooling. The years of schooling interact significantly and positively with the need to purchase feed and negatively with the cost of piglets. This suggests that more educated people are less reluctant to buy weaned piglets which require purchased feed in rearing, yet they prefer cheaper piglets.

HH size. A respondent from a larger HH values much more than average piglets with good disease resistance. Again, we tribute this to risk-aversion on capital stored in pig livestock. Larger HHs are less willing to take risks.

Number of economically active members of the HH. HHs with a higher number of economically active members value disease resistance less than the average. They value more speed in weight increase, and are willing to pay less for piglets.

Given this HH characterization, one can use specific HH profiles and predict the value assigned by the HH to pig attributes. For the purpose of illustration these are computed in table 5 for three different cases. The first is simply computed at the average values of the sample variables. The second corresponds to a small HH (N = 4) with one income-earner (Y = 1) and a young (age 25) respondent with only 2 years of formal schooling. Finally, the third is a prediction for a medium size HH (N = 7) with two income-earners (Y = 2) and a middle-age (age 45) respondent with 7 years of schooling.

The set of predicted values describes well the effects of accounting for HH characteristics in value attributes. For example, it shows how much more important it is to be able to rely on animals not requiring feed purchase or frequent baths in small HHs supported by only one member, and how much these HHs value animals with good disease resistance. On the other hand, these needs are attenuated in larger families with greater labour availability.

5 Conclusions and directions for further research.

The premise of this applied study in valuation of animal genetic resources (AnGRs) for livestock production is that producers' preferences guide the breeding process and hence determine the management of AnGRs. Researcher therefore need adequate tools to characterise these preferences, bearing in mind that in peasant economies these are expressed only rarely in properly functioning markets.

The relevance of pig-rearing as a means of food security and capital storage in Latin America, and the current threat of AnGRs erosion faced by the indigenous creole pigs guided our choice of production system to rural Yucatan. A sample of 300 respondents across a set of 18 representative villages was surveyed and interviewed to administer a choice experiment investigating preferences regarding piglet costs, weight at 6 months, bathing frequency for heat relief, and disease resistance. All of these pig attributes are known to be in part genetically determined within the backyard production system and expressed differently in creole pigs and exotic imports.

The results of the choice experiment conducted across this sample of rural households are encouraging. Breed traits of considerable relevance for the household production function were estimated to have values of plausible magnitude which compared well with shadow cost computations available from previous research.

Further, interesting differences have been identified between two important groups of producers: village households and small farmers, who seem to hold a significantly different set of preferences over the same set of pig attributes.

Finally, random utility parameter estimates for a specification conditional on respondents' characteristics have proven to be able to cast some light in explaining how household characteristics determine differences in preferences. This addtional information can be of use in designing policies that counter the present trend towards marginalisation of the indigenous breed. For example, they can be used to target incentives for breed conservation.

Marginal and subsistence food production systems dominate peasant economics. In these analytical contexts unpriced inputs are pervasive obstacles in empirical studies. It seems to be of particular interest to have access to a methodology that can attribute values to unpriced inputs of the household production functions which are disclosed via the systematic investigation of preferences.

5.1 Implications for conservation

Implications for conservation can also be drawn from the choice experiment results. Since the net value that farmers place on the creole pig is very similar to that of the other breeds, this implies that minimal incentives and interventions are needed to ensure its continued sustainable use.

A cost-effective strategy along the lines proposed by Brush and Meng (1996) would seek to minimise the costs of such a programme by recognising the factors influencing animal selection decisions by farmers, thereby identifying those households that most value the local creole breed. Since these are the households most likely to continue to maintain such breeds they will also be the least costly to incorporate into a conservation programme. The basic methodology is thus to link the probability of a households maintaining a certain breed with the households costs of production and net income.

The cost of such an in-situ conservation programme can thus be expressed as the cost necessary to raise the comparative advantage of such breeds above that of competing breeds, animals or off-farm activities. Thus a relatively small investment may suffice to maintain their advantage in a particular farming system.

The Yucatec survey and monitoring data (Anderson *et al.* 1999) provide indications of the type of interventions that an in-situ conservation and breeding programme might adopt. These would need to include, inter alia, interventions related to reproduction (inbreeding and boar rotation) and fattening periods (and hence the closely related issue of total feed and labour costs).

5.2 Directions for further research

As far as we know this is the first stated preference study aiming at valuing AnGRs in this type of peasant economy. We are therefore venturing into uncharted territory and hopefully more resources will be made available for further research in economic valuation methods for this atypical economic good which is germane to the preservation of biodiversity.

Given sufficient resources, more sophisticated and compelling validity tests may be designed for stated preference methods in this budding segment of non-market valuation research. Some issues relevant to AnGRs management and valuation need to be approached at the macro, as well as the micro level. For example, an important area of research is that of the design of cost-effective policy tools which aim to maintain a safe minimum standard of in-situ population density to avoid extinction and loss of related knowledge.

We know that AnGRs have important non-income functions (e.g. insurance, seasonal buffering, savings and accumulation) which are fundamental to the reasons that poor households keep such animals, and indeed that these functions vary in relative importance across well-being strata (Dorward *et al.* 2001.) It is also becoming clear that not all animal breeds have the same capacity to fulfil these functions in the conditions of marginalised agriculture. In the development of valuation methods for AnGRs it is essential to consider how to estimate the livelihood values of these functions between breeds.

We are hopeful that following the encouraging results from these first attempts more interest will be raised and this important area of applied economic research will grow.

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6 Tables

Table 1

Sample statistics for respondents' and HH socio-economic variables.

Variable	Min	Max	Average	St. Dev.
Age of Respondent (A)	13	83	41.74	13.73
HH members (N)	1	15	5.25	2.18
HH Income earners (Y)	1	7	1.78	1.08
Education in years (E)	0	14	3.87	2.97
N. HH pigs	0	70	3.71	6.16
Selling age (months)	0	24	4.67	6.98

Table 2

ML value estimates of pig attributes from 'pooled' model (Mex $).

Variable	$\hat{\beta}$	St.Err.* of $\hat{\beta}$	p-values of z
PIG_COST	-0.0094	0.0006	0.000
6M_WEIGHT	0.0423	0.0020	0.000
BUY_FEED	-1.1279	0.0844	0.000
BATH_FR	-0.1676	0.0515	0.011
DIS_RESIST	0.8134	0.0845	0.000
Attribute	$\hat{\beta}_k/\hat{\beta}_p$	St.Err.* of $\hat{\beta}_k/\hat{\beta}_p$	p-values of z
6M_WEIGHT	4.52	0.19	0.000
BUY_FEED	-120.43	12.48	0.000
BATH_FR	-17.90	5.80	0.002
DIS_RESIST	86.86	8.70	0.000

Pseudo-R^2 23.64%, $\mathcal{L}$ = -1,510, Choices = 1,800, *delta method.

Table 3

ML value estimates of pig attributes from 'Pooled' model (Mex $).

Attribute	$\hat{\beta}$	St.Err.* of $\hat{\beta}$	p-values of z
6M_WEIGHT	4.42	0.19	0.000
BUY_FEED	-116.96	12.22	0.000
BATH1	2.41	9.77	0.805
BATH2	-42.35	11.88	0.000
DIS_RESIST	84.11	8.56	0.000
Pseudo-R^2 23.78%, $\mathcal{L}$ = -1,507, Choices = 1,800.			

ML value estimates of pig attributes from 'HH' model (Mex $).

Attribute	$\hat{\beta}$	St.Err. of $\hat{\beta}$	p-values of z
6M_WEIGHT	4.68	0.23	0.000
BUY_FEED	-134.47	14.77	0.000
BATH1	0.64	11.22	0.954
BATH2	-42.02	13.63	0.002
DIS_RESIST	107.10	10.31	0.000
Pseudo-R^2 23.64%, $\mathcal{L}$ = -1,338, Choices = 1,620, *delta method.			

ML value estimates of pig attributes from 'SF' model (Mex $).

Attribute	$\hat{\beta}_k/\hat{\beta}_p$	St.Err.* of $\hat{\beta}_k/\hat{\beta}_p$	p-values of z
6M_WEIGHT	3.56	0.30	0.000
BUY_FEED	-54.36	21.76	0.012
BATH1	9.45	16.23	0.560
BATH2	-43.04	17.31	0.013
DIS_RESIST	-43.10	21.85	0.049
Pseudo-R^2 39.81%, $\mathcal{L}$ = -119, Choices = 180, *delta method.			

Table 4
ML estimates of taste parameters with HHs covariates.

Variable	$\hat{\beta}$	St.Err. of $\hat{\beta}$	p-values of z
VALUE	0.0085	0.0029	0.003
WEIGHT_G	0.0076	0.0071	0.285
FEED_P	-0.7945	0.3725	0.033
BATH1	-0.5156	0.3104	0.097
BATH2	-0.3684	0.1155	0.001
RESIST	0.6015	0.2370	0.011
A×BATH1	0.0128	0.0071	0.071
A×FEED	-0.0167	0.0073	0.022
A×VALUE	-4.2E-4	8.0E-5	0.000
A×WEIGHT	6.6E-4	1.6E-4	0.000
A^2×VALUE	3.4E-8	9.8E-9	0.001
E×FEED	0.0618	0.0316	0.050
E×VALUE	-3.3E-4	1.3E-4	0.010
N×RESIST	0.1506	0.0411	0.000
Y×RESIST	-0.2611	0.0947	0.006
Y×VALUE	-0.0012	6.3E-4	0.062
Y×WEIGHT	0.0044	0.0020	0.027

Pseudo-R^2 26.46%, $\mathcal{L}$ = -1,289. Choices = 1,596.

Table 5
ML value estimates of pig attribute with HHs covariates (Mex $).

Attribute	$f(\hat{\beta} \mid \mathbf{q})$	St.Err. of $f(\hat{\beta} \mid \mathbf{q})$	p-values of z
$\mathbf{q}$ = { N , Y , E , A at the sample means }			
6M_WEIGHT	3.46	0.29	0.000
BUY_FEED	-101.22	12.26	0.000
BATH1	1.55	8.17	0.849
BATH2	-29.73	9.90	0.003
DIS_RESIST	74.67	9.10	0.000
$\mathbf{q}$ = { N = 4 , Y = 1 , E = 2, 25 of age }			
6M_WEIGHT	7.44	1.64	0.000
BUY_FEED	-284.77	101.30	0.005
BATH1	-51.02	44.76	0.254
BATH2	-96.27	42.45	0.023
DIS_RESIST	246.42	68.95	0.000
$\mathbf{q}$ = { N = 10 , Y = 2 , E = 7, 45 of age }			
6M_WEIGHT	3.06	0.27	0.000
BUY_FEED	-74.24	12.87	0.000
BATH1	4.06	6.93	0.558
BATH2	-24.51	8.16	0.003
DIS_RESIST	62.75	9.37	0.000

From parameter estimates in table 4.
Approximate standard errors obtained with delta method.

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