BACKGROUND STUDY PAPER NO. 21

March 2004

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منظمة الأغذية والزراعة للأمم المتحدة

联合国粮食及农业组织

Food and Agriculture Organization of the United Nations

Organisation des Nations Unies pour l'alimentation et l'agriculture

Organización de las Naciones Unidas para la Agricultura y la Alimentación

COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

THE ECONOMICS OF FARM ANIMAL GENETIC RESOURCE CONSERVATION AND SUSTAINABLE USE: WHY IS IT IMPORTANT AND WHAT HAVE WE LEARNED?

by

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This document was made available to the Commission by the International Livestock Research Institute (ILRI). FAO and ILRI had organised a first workshop on the Economic Valuation of Animal genetic Resources in Rome, 15-17 March 1999. Follow-up work was done by ILRI, leading to the Special Issue: Valuing Animal Genetic Resources, in the July 2003 issue of the Ecological Economics, a multidisciplinary journal of the International Society for Ecological Economics. This background study paper summarises the methodological approaches and knowledge gaps in animal genetic resources valuation. Lack of recognition of the value of animal genetic resources (AnGR) is a major cause of inappropriate management and erosion of genetic resources, hence the discussion on valuation is relevant to the current policy discourse on sustainable management of AnGR and could further could bring some light on how to agree on priorities for conservation activities and sustainable economic exploitation of AnGR.

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Table of Contents

1. Executive Summary

The large number of animal genetic resources (AnGR) at risk in developing countries, together with the limited financial resources available for conservation, means that economic analysis can play an important role in ensuring an appropriate focus for conservation efforts. In this regard, important tasks include, inter alia:

1. determining the economic contribution that AnGR make to various societies;
2. supporting the assessment of priorities through the identification of cost-effective measures that might be taken to conserve domestic animal diversity; and
3. assist in the design of economic incentives and institutional arrangements for the promotion of AnGR conservation by individual farmers or communities.

This paper briefly discusses the theoretical background and potential methodologies that can be used, before analysing the results of a range of economics of AnGR studies recently carried out in Africa, Latin America and Europe.

These studies revealed the existence of a range of methodologies that can be used to value livestock keeper breed/trait preferences, and that can, in fact, be of use in designing policies that counter the present trend towards marginalisation of indigenous breeds. In particular, it becomes possible to, inter alia, recognise the importance livestock keepers place on adaptive traits and non-income functions, and the need to consider these in breeding programme design; identify those breeds that are a priority for participation in cost-efficient diversity-maximising conservation programmes; and contrast the costs involved with the large benefits non-livestock keepers place on breed conservation.

The current challenge is to raise awareness regarding the importance of the economics of AnGR, as well as to strengthen national capacities with regard to the application of related methodologies/decision-support tools and their integration into the wider national livestock development process. In this way, further economics of AnGR work can be applied in contexts where the results can be taken up so as to actively benefit livestock keepers and support the work of national researchers and policymakers.

2. Introduction to the economics of AnGR conservation and sustainable use

AnGR erosion can be understood in terms of the conversion of the existing slate of domestic animals with a selection from a small range of specialised “improved” breeds that are considered to be better able to directly contribute to human welfare. At the same time, economic theory has shown that functioning markets can be a powerful ally in the efficient allocation of resources by reflecting the relative scarcity of a given resource, through the price mechanism, and thus providing the correct incentives for the resources’ use or replacement.

Viewing AnGR loss in these terms leads Mendelsohn (2003) to argue that the primary challenge facing the conservation of AnGR is identifying sound reasons why society should preserve animals that livestock keepers have abandoned. Given that the market will preserve valuable livestock breeds, conservationists must focus on what the market will not do. This includes identifying and quantifying the potential social benefits of AnGR that have been abandoned by the market. So conservationists first must make a case for why society should be willing to pay to protect apparently "unprofitable" AnGR resources and then must design conservation programmes that will effectively protect what society treasures.

Tisdell (2003) also recognizes the importance of market impacts on AnGR, noting the influence of developed country livestock technologies (e.g. artificial insemination, industrialised intensive animal husbandry) on livestock populations in developing countries, together with the fact that

the extension of markets and economic globalisation has accelerated the loss of breeds and encouraged the tendency to specialise.

The ability of such “free” market forces to provide a socially desirable outcome is however questioned by Pearce and Moran (1994) who argue that the activity of biodiversity [and genetic resources] conservation generates economic values (use and non-use) which may not be captured in the market place because of market, intervention and/or global appropriation failures. The result of such "failure(s)" is a distortion where the incentives are against genetic resources conservation and in favour of the economic activities that destroy such resources.

For example, economic rationality suggests that decisions such as the replacement of an indigenous breed of livestock with an imported breed will be determined by the relative rates of return of the two options. However, the relevant rates of return are those that accrue to the livestock keeper rather than to the nation or the world as a whole. To the livestock keeper the loss of the indigenous breed appears to be economically rational because returns may simply be higher than that from activities compatible with genetic resources conservation. This is because the latter may consist of non-market benefits that accrue to people other than the livestock keeper (e.g. existence values, maintenance of a reservoir of diversity) as well as the fact that subsidised inputs and services (e.g. artificial insemination, veterinary treatment, etc.) may be available for the imported breed.

Swanson (1997) goes on to note that such non-market values are likely to be important as biodiversity is not equally distributed among nation states, suggesting that global external values are indeed likely to be significant. The biodiversity problem may thus be conceived of as the set of difficulties that derive from the fact that the conversion process has traditionally been regulated on a globally decentralized basis. Historically, each state or individual has been able to make their own conversion decisions regarding their own lands and resources without regard of the consequences for others. This creates an important regulatory problem because the cost − in terms of the value of lost services − of each successive conversion is not the same. As the conversion process advances, the cost of each successive conversion (in terms of lost diverse resource services lost to all societies on Earth) escalates rapidly. The absence of mechanisms to bring these costs into the decision-making framework of the converting state or individual is a big component of the biodiversity problem.

Economic analysis is therefore needed to both help in understanding the financial incentives that livestock keepers face in making the choice between raising indigenous and/or imported breeds, as well as the interventions necessary in order to ensure that the on-going agricultural development process will be compatible with the conservation and sustainable use of livestock breed diversity.

Nevertheless, despite the importance of the economics of AnGR, the subject has received only limited attention (FAO/ILRI, 1999), even though a conceptual framework exists for the valuation of biodiversity in general. There are a number of reasons for this, which include the fact that (Drucker, 2003): the measurement of the benefits of germplasm diversity to livestock development is difficult; the availability of the data required to carry out an economic analysis is limited; the non-market values of livestock (e.g. traction, manure, socio-cultural values, livestock as an asset for finance and insurance purposes) are important to consider; and obtaining such data frequently requires the modification of economic techniques for use in conjunction with an established body of participatory and rapid rural appraisal methods.

Table 1: AnGR Valuation Methodology Evaluation

Valuation Methodology	Purpose, Objective or Strength	Actor(s) for Whom Valuation Results Will be Most Relevant	Role in Conservation	Type of Data Required	Data Availability	Conceptual Weakness or difficulties
Methodologies for determining the appropriateness of AnGR conservation programme costs						
CVM	Identify society's WTP for the conservation of AnGR, Farmer WTA compensation for raising indigenous AnGR instead of exotics or to determine farmer trait value preferences and net returns by breed	Policy-makers in charge of conservation	Define upper bound to economically justified conservation programme costs	Society preferences expressed in terms of WTP or WTA	Not normally available. Requires survey	Response difficulties when used for "non-charismatic" species and/or chronic genetic erosion
Production Loss Averted	Indicate magnitude of potential production losses in the absence of AnGR conservation	Farmers and policy-makers in charge of conservation	Justify conservation programme costs of at least this magnitude	Estimate of potential production losses (e.g. percentage of herd and market value of animals)	Animal market values available for commercial breeds. Potential herd loss must be estimated.	Not a consumer/producer surplus measure of value. Ignores substitution effects
Opportunity Cost	Identify cost of maintaining AnGR diversity	Farmers, and policy-makers in charge of conservation	Define opportunity cost of AnGR conservation programme	Household costs of production and net income	Not normally available. Requires survey	
Least Cost	Identify cost-efficient programme for the conservation of AnGR	Policy-makers in charge of conservation; farmers and breeders to some extent	Define minimum cost of conservation programme	Household costs of production and profitability	Not normally available. Requires survey	
Safe Minimum Standard	Assess trade-offs involved in maintaining a minimum viable population	Policy-makers in charge of conservation	Define opportunity cost of AnGR conservation programme	Conservation programme costs and benefit differential involved in raising different breeds	Not normally available. Requires survey and modelling.	Requires judgement as to whether breed substitution will in fact generate utility in excess of the unquantifiable benefits of indigenous breed conservation
Methodologies for determining the actual economic importance of the breed						
Aggregate Demand & Supply	Identify value of breed to society	Policy-makers in charge of conservation and livestock policy, as well as breeders	Value potential losses associated with AnGR loss.	Intertemporal or farm-level data	Available for commercial breeds. Not normally available for others – requires survey	Requires shadow pricing of home labour and forage
Cross-sectional Farm and Household	Identify value of breed to society	Policy-makers in charge of conservation and livestock policy; as well as breeders and framers	Value of potential losses associated with AnGR loss	Consumer and producer price differences by location	Not normally available. Requires survey	Requires shadow pricing of home labour and forage
Market Share	Indication of current market value of a given breed	Policy-makers in charge of conservation and livestock policy; as well as breeders and framers	Justify economic importance of given breed	Market value of animal products by breed	Generally available but not always by breed	Not a consumer/producer surplus measure of value. . Ignores substitution effects
IPR & Contracts	Market creation and support for "fair and equitable" sharing of AnGR benefits	Policy-makers in charge of conservation; as well as breeders and framers	Generate funds and incentives for AnGR conservation	Royalty payments or terms of contract	Usually available when such arrangements exist although can be commercial secret.	Limited duration of contracts
Methodologies for priority setting in AnGR breeding programmes						
Evaluation of Breeding Programme	Identify net economic benefits of stock improvements	Farmers and breeders	Maximise economic benefits of conserved AnGR	Yield effects and input costs	Available for commercial breeds. Not normally available for others – requires survey/research	Difficulty in separating the contribution of genetic resources from other costs of programme
Genetic Production Function	Identify net economic benefits of stock improvements	Farmers and breeders	Maximise expected economic benefits of conserved AnGR	Yield effects and input costs	Available for commercial breeds. Not normally available for others – requires survey/research	
Hedonic	Identify trait values	Farmers and breeders, as well as policy-makers in charge of conservation	Value potential losses associated with AnGR loss. Understand breed preferences.	Characteristics of animals and market prices	Available for commercial breeds. Not normally available for others – requires survey/research	Not a consumer/producer surplus measure of value. . Ignores substitution effects
Farm Simulation Model	Model improved animal characteristics on farm economics	Farmers and breeders	Maximise economic benefits of conserved AnGR	Inputs and outputs. Technical coefficients of all main activities	Available for commercial breeds. Not normally available for others – requires survey	Correct definition of farm objective function. Aggregation for estimating consumer surplus can also be problematic

Source: Drucker et al. 2001

Despite such difficulties, there are nonetheless a range of analytical techniques for carrying out such an analysis that could be adopted from other areas of economics. These were reviewed by Drucker *et al*. (2001) and the methodologies were broadly categorised into three groups on the basis of the practical purpose for which they may be conducted. As can be seen in Table 1, these are:

i) determining the appropriateness of AnGR conservation programme costs;
ii) determining the actual economic importance of the breed at risk; and/or
iii) setting priorities for AnGR breeding programmes.

3. Results and Discussion

Where such methodologies and suitable approaches to attaining the required data have been applied, a number of interesting results have been obtained. These are summarised below.

3.a. Decision-support tool for identifying breed conservation priorities

Recognising the large number of indigenous livestock breeds that are currently threatened and the fact that not all can be saved given limited conservation budgets, Simianer *et al*. (2003) develop a decision-support tool by elaborating a framework for the allocation of a given budget among a set of breeds such that the expected amount of between-breed diversity conserved is maximized. Drawing on Wietzman (1993), it is argued that the optimum criterion for a conservation scheme is to maximize the expected total utility of the set of breeds, which is an economically weighted sum of diversity, of breed characteristics represented in the set, and the value of the conserved breeds. The methodology is illustrated with an example of 23 African zebu and zenga cattle breeds. The results indicate that conservation funds should be spent on only three to nine (depending on the model considered) of the 23 breeds and that these are not necessarily the most endangered ones. In addition, where the models are sufficiently specified and essential data on key parameters are available, the framework can be used for rational decision-making on a global scale.

3.b. Stated preference (contingent valuation) techniques for non-market valuation

a) Obtaining the data for use in such decision-support tools and elsewhere frequently requires the development of a number of techniques capable of attributing values to the many unpriced inputs and outputs of household production functions. Tano *et al*. (2003), Scarpa *et al*. (2003a) and Scarpa *et al*. (2003b) use stated preference choice experiments (CE) to value the phenotypic traits expressed in indigenous breeds of livestock. Adaptive traits and non-income functions are shown to form important components of the total value of the animals to livestock keepers. In W. Africa, for example, the most important traits for incorporation into breed improvement programme goals were found to be disease resistance, fitness for traction and reproductive performance. Beef and milk production were less important. The studies also show that not only do these techniques (adapted from other areas of environmental economic analysis) function for AnGR research but can be used to investigate values of genetically-determined traits currently not widely recognised in livestock populations, but desirable candidates for breeding or conservation programmes (e.g. disease resistance).

Furthermore, the papers examined how household characteristics determined differences in breed preferences. This additional information can be used in designing policies that counter the present trend towards marginalisation of indigenous breeds. For example, they can be used to target incentives for breed conservation. In the Mexican case, the CE reveals that since the net value that backyard producers place on the creole pig is very similar to that of the other breeds, minimal incentives and interventions would in fact be needed to ensure its continued sustainable use (more on this below).

b) Cicia *et al*. (2003), in a developed country case study, show that a dichotomous choice stated preference approach can be used to estimate the benefits of establishing a conservation programme for the threatened Italian "Pentro" horse. A bio-economic model is used to estimate the costs associated with conservation and a cost-benefit analysis is subsequently realised. The results not only show a large positive net present value associated with the proposed conservation activity but also show that this approach is a useful decision-support tool for policy makers allocating scarce funds to a growing number of animal breeds facing extinction.

3.c. Revealed preference techniques for market valuation

By contrast to the above stated preference approaches, Jabbar and Diedhiou (2003) show that a revealed preference hedonic approach can also successfully be used to determine livestock keepers' breeding practices and breed preferences. Analysing such factors in southwest Nigeria, they confirm a strong trend away from trypanotolerant breeds, especially Muturu, and identify the traits livestock keepers find least desirable in these breeds relative to other zebu breeds. The results suggest that the best hopes for implementing a conservation/sustainable use strategy for breeds at risk such as Muturu is likely to be in other areas of West Africa; for example in southeast Nigeria where trypanosomosis remains a constraint, where the Muturu is better suited to the farming systems and where a large market for this breed continues to exist.

3.d. Aggregated productivity model for comparative (indigenous vs. crossbreed) performance evaluation

The secondary importance of meat and milk production traits in many production systems leads Ayalew *et al.* (2003) to argue that conventional productivity evaluation criteria are inadequate to evaluate subsistence livestock production, because: 1) they fail to capture non-marketable benefits of the livestock; and 2) the core concept of a single limiting input is inappropriate to subsistence production, as multiple limiting inputs (livestock, labour, land) are involved in the production process. As many of the livestock functions as possible (physical and socio-economic) should thus be aggregated into monetary values and related to the resources used, irrespective of whether these "products" are marketed, home-consumed or maintained for later use. A broad evaluation model involving three complementary flock-level productivity indices was developed and applied to evaluate subsistence goat production in the eastern Ethiopian highlands. The results show that indigenous goat flocks generated significantly higher net benefits under improved than under traditional management, which challenges the prevailing notion that indigenous livestock do not adequately respond to improvements in the level of management. Furthermore, it is shown that under the subsistence mode of production considered, the premise that crossbred goats are more productive and beneficial than the indigenous goats is wrong. The model thus provides a more realistic platform upon which to propose sound improvement interventions.

3.e. Conservation costs and benefits (various techniques)

a) Even where the value of indigenous breeds has been recognised and support mechanisms implemented, significant shortcomings can be identified. Signorello and Pappalardo (2003), in an examination of farm animal biodiversity conservation measures and their potential costs in the European Union (EU), report that many breeds at risk of extinction according the FAO World Watch List are not covered by support payments as they do not appear in countries' Rural Development Plans. Furthermore, where payments are made these do not take into account the different degrees of extinction risk that exist between breeds and payment levels are in any case inadequate, meaning that it can still remain unprofitable to rear indigenous breeds. EU AnGR conservation support measures thus urgently need to be reviewed if they are to meet their goals.

b) The lack of adequate incentives for the conservation of indigenous breeds is what draws on the safe minimum standards (SMS) literature and adapts Crowards' (1998) minimax payoff matrix to consider breeds rather than species, despite the fact that conservation costs are shown to be relatively small by Drucker (*submitted)*. The basic framework considers that the uncertain benefits of indigenous livestock breed conservation can be maintained, as long as a minimum

viable population (the SMS – in this case the FAO measure of "not at risk", which is equivalent to approximately 1,000 animals) of the breed is also maintained. The costs of implementing a SMS are made up of the opportunity cost differential (if any exists) of maintaining the indigenous breed rather than an exotic or crossbreed. In addition, the administrative and technical support costs of the conservation programme also need to be accounted for. Empirical cost estimates are then obtained using data from the three economics of AnGR case studies already mentioned above (i.e. EU, Italy and Mexico). The findings support the hypothesis that the costs of implementing a SMS are low (as shown in Table 2, depending on the breed, costs range from between approximately Euro 3,000 – 425,000 p.a.), both when compared with the size of subsidies currently being provided to the livestock sector (<1% of the total subsidy) and with regard to the benefits of conservation (benefit-cost ratio of > 2.9). Encouragingly, costs are lowest in developing countries; about 70% of the existing livestock breeds are presently found in developing countries, where the risk of loss is highest (Rege and Gibson, 2003).

Table 2: Annual costs (in Euro) of achieving a safe minimum standard for selected livestock breeds

Case study	PB_{exotic}	EB_{ind}	Opportunity cost differential for 1,000 animals[&]	C_{ind}	Annual cost of SMS[#]
Creole pigs, Mexico[a]	24.1	21.5	2,600	200-1,100	<2,800 - 3,700
Various, Sicily, Italy[b]	29 (Comisana sheep)	-12 (Barbaresca sheep)	41,000	Administrative & technical support costs not detailed. Assumed to be 5% of total and thus ranges from €2,000 - 20,000 p.a.	43,000
	15 (Maltese goat)	-27 (Girgentana goat)	42,000		44,000
	201 (Aveglinese horse)	-58 (Ragusana horse)	259,000		272,000
	306 (Bruna cattle)	-53 (Modicana & Cinisara cattle)	359,000		377,000
	224 (Landrace pig)	-182 (Nera Siciliana pig)	406,000		426,000
Pentro horse, Molise, Italy[c]	20.8*	<-158.4**	<179,200	Unknown percentage of administrative & technical support costs included as production costs in EB_{ind} column	179,200

Source: In Drucker (submitted) and adapted from: [a] Scarpa *et al*. (2003); [b] Signorello and Pappalardo (2003); and [c] Cicia *et al*. (2003)
PB_{exotic} = Private benefits of livestock breed substitution based on the use of exotics
EB_{ind} = Expected benefits of continuing to use the indigenous breed
C_{ind} = the cost of conservation of the indigenous breed under the SMS (includes administrative and technical support costs)
* Data not strictly comparable with the other studies. Refers to forgone income
** Data not strictly comparable with the other studies. Refers to "new sales" minus "production costs"
& Opportunity cost differential for 1,000 animals = $1000*(PB_{exotic} - EB_{ind})$
# Annual cost of SMS = $1,000*(PB_{exotic} - EB_{ind}) + C_{ind}$

The SMS approach is thus shown to have a role to play in AnGR conservation but more extensive quantification of the components required to determine SMS costs needs to be undertaken before it can be applied in practice. Such economic valuation needs to cover both the full range of breeds/species being considered, as well as ensure that as many as possible of the elements making up their total economic value are accounted for.

c) Drucker and Anderson (submitted) provide additional data supporting the hypothesis that AnGR conservation costs are likely to be small compared to the benefits. In a paper that shows how data obtained through the use of rural appraisal methods can be applied to some of the

valuation methodologies reviewed in Drucker et al. (2001), they show that the conservation costs are in fact several orders of magnitude smaller[1] (see Table 3).

Furthermore, the low estimated annual costs for the indigenous breed pig conservation and sustainable use programme suggests that the least cost approach (Brush and Meng, 1996) does indeed provide a useful framework within which households/villages where conservation costs would be minimal can be budgeted into a conservation programme. A very strong economic argument for implementing a conservation and sustainable use programme can therefore be made and needs to be undertaken urgently if the breed, currently classifiable as critical on the FAO scale of risk, is not to become extinct.

Table 3: Summary of results of valuation techniques using rural appraisal data related to the Yucatec (Mexico) creole pig (Euro*)

	Conservation & Sustainable Use Benefits	Conservation Costs
Market Share	0.54 million	
Production Loss Averted (Yucatan state only)	1.21 million	
Contingent Valuation (Urban Consumer Taste Test)	1.43 million	
Contingent Valuation (Producer Choice Experiment) and Least Cost approach.		<2,800 - 3,700

Source: Drucker and Anderson, submitted.

- Original US$ values converted to Euros at a rate of Euro 1 = US$ 1.1

The size of the net benefits identified also raises the question of whether the indigenous breed is, as predicted by theory, in fact being lost because they are from the livestock keeper's private perspective less profitable than other breeds. While certain types of household (e.g. larger better-off ones) did express trait value preferences that support this theory, most households did not[2]. Yet backyard indigenous pig production has declined across all households. It would therefore appear that the purebred population has fallen to such a low level that such factors as the lack of availability of indigenous breeding stock, rather than livestock keeper net returns *per se* are determining breed choice.

At the level of society, the large size of the net benefits of a conservation and sustainable use plan suggest that there are also a number of very significant market failures that need to be addressed if the benefit values (e.g. indigenous breed pigs as a reservoir of disease resistance or in terms of their existence value to urban consumers) are to be harnessed for conservation purposes. In addition, the market distortions introduced by subsidising exotic breed production in the commercial sector are considerable and the levels of subsidy are of several orders of magnitude greater than the costs of indigenous breed conservation. A genetic resource of importance to the maintenance of subsistence farmer livelihoods is thus being lost for the lack of minimal funds, while vast and AnGR diversity threatening subsidies are provided to commercial farmers.

4. Conclusions and Future perspectives

The above findings (based on a variety of species, breeds, production systems, locations and analytical approaches) point out that these methodologies of economic analysis are essential for the conservation and sustainable use of AnGR. When used particularly in conjunction with rural

[1] Similarly large net benefits to conservation were identified by Signorello *et al*. (2003), in the case of the Italian Pentro horse, suggesting that this is not an isolated finding.

[2] Furthermore, even in these larger better-off households, the crossbred is preferred over the exotic. Thus, there still remains the issue of how to maintain a purebred line that can be used in crossbreeding activities.

appraisal methodologies, they can reveal useful estimates of the values that are placed on market, non-market and potential breed attributes.

Such information on livestock keeper knowledge about breed characteristics and management needs, as well as livestock keeper preferences for different traits, are critical inputs for designing breeding and conservation strategies. In addition, information regarding indigenous breed performance and potential under improved management, as well as breed conservation priorities and the relative size of the costs and benefits resulting from conservation/sustainable use programmes can be obtained. Such data is crucial for understanding the type and net costs of the interventions necessary to promote the conservation and sustainable use of AnGR.

The challenge is to now raise awareness regarding the importance of the economics of AnGR, and to strengthen national capacities with regard to the application of related methodologies and decision-support tools and their integration into the wider national livestock development process. Further work on the economics of AnGR can be applied in contexts where the results can be taken up so as to actively benefit livestock keepers and support the work of national researchers and policy-makers.

Bibliography

Ayalew, W., King, J., Bruns, E. and Rischkowsky, B., 2003. Economic evaluation of smallholder subsistence livestock production: lessons from an Ethiopian goat development program. *Ecological Economics,* **45** (3): 331-339.

Brush, S. and Meng, E., 1996. Farmers´ valuation and conservation of crop genetic resources. Paper prepared for the Symposium on the Economics of Valuation and Conservation of Genetic Resources for Agriculture, Centre for International Studies on Economic Growth, Tor Vergata University, Rome, 13-15 May.

Cicia, G., D'Ercole, E. and Marino, D., 2003. Valuing farm animal genetic resources by means of contingent valuation and a bio-economic model: the case of the Pentro horse. *Ecological Economics,* **45** (3): 445-459.

Crowards, T., 1998. 'Safe minimum standards: costs and opportunities', *Ecological Economics,* 25: 303-314.

Drucker, A, Gomez, V. and Anderson, S., 2001. The Economic Valuation of Farm Animal Genetic Resources: A Survey of Available Methods. *Ecological Economics,* **36** (1): 1-18

Drucker, A. G., 2003. Economics of AnGR Conservation and Sustainable Use: Importance and Application. Paper presented at Deutscher Tropentag, University of Goettingen, Germany.

Drucker, A.G. and Anderson, S., 2003 Putting the economic analysis of animal genetic resources into practice through the use of rural appraisal methods: Lessons from work on a local breed of pig in Southeast Mexico. *International Journal of Agricultural Sustainability,* (*Submitted*).

Drucker, A.G., 2003. The role of safe minimum standards in the conservation of livestock biodiversity. *Environment and Development Economics*. (*Submitted*).

FAO/ILRI 1999. Economic valuation of animal genetic resources: Proceedings of an FAO/ILRI workshop. Rome 15-17 March.

Jabbar, M. and Diedhiou, M., 2003. Does breed matter to cattle farmers and buyers? Evidence from West Africa. *Ecological Economics*, **45** (3): 461-472.

Mendelsohn, R., 2003. The Challenge of Conserving Indigenous Domesticated Animals. *Ecological Economics*, **45** (3): 501-510.

Pearce, D. and Moran D., 1994. The economic value of biodiversity. Earthscan, London.

Rege, J.E.O. and Gibson, J.P., 2003. Animal genetic resources and economic development: issues in relation to economic valuation. *Ecological Economics*, **45** (3): 319-330.

Scarpa, R., Drucker, A., Anderson, S., Ferraes-Ehuan, N., Gomez, V., Risopatron, C. and Rubio-Leonel, O., 2003[a]. 'Valuing animal genetic resources in peasant economies: the case of the Box Keken creole pig in Yucatan'. *Ecological Economics*, **45** (3):427-443.

Scarpa, R., Kristjanson, P., Ruto, E., Radeny, M., Drucker, A. and Rege, J.E.O., 2003[b]. Valuing indigenous farm animal genetic resources in Africa: A comparison of stated and revealed preference estimates. *Ecological Economics*, **45** (3): 409-426.

Signorello, G. and Pappalardo, G., 2003. Domestic animal biodiversity conservation: a case study of rural development plans in the European Union. *Ecological Economics*, **45** (3): 487-499.

Simianer, H., Marti, S., Gibson, J., Hanotte, O. and Rege, J.E.O., 2003. An approach to the optimal allocation of conservation funds to minimize loss of genetic diversity between livestock breeds. *Ecological Economics*, **45** (3): 377-392.

Swanson., T., 1997. Global Action for Biodiversity. Earthscan, London.

Tano, K., Faminow, M., Kamuanga, M and Swallow, B., 2003. Using conjoint analysis to estimate farmers' preferences for cattle traits in West Africa. *Ecological Economics*, **45** (3): 393-407.

Tisdell, C., 2003. Socioeconomic causes of loss of animal diversity genetic: analysis and assessment. *Ecological Economics,* **45** (3): 365-376.

Weitzman, M., 1993. What to preserve? An application of diversity theory to crane conservation. *Quarterly Journal of Economics* pp. 157-183.

Wollny, C., 2003. The need to conserve farm animal genetic resources through community-based management in Africa: Should policy makers be concerned? *Ecological Economics,* **45** (3): 341-351