GENETICS AND ECONOMICS: PRIORITIZING BREEDS FOR CONSERVATION

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Summary
We consider the choice of breeds for conservation programmes. Based on an analysis of past decisions in EU member countries and the results of an expert survey among breed societies and scientists, we find inconsistencies in the valuation of breed characteristics. Policy makers seem to be less concerned about considering true extinction risk and diversity but more about cultural values and about means to benefit a larger number of farmers for raising rare breeds.

Keywords
Animal genetic resources, conservation, preferences, probit model.

Introduction
Relative to its size, Europe owns a large proportion of worldwide farm animal genetic resources (AnGR) and biodiversity: More than a quarter of the worldwide recorded cattle, sheep, pig and horse breeds are found in Europe [4]. This diversity of animal breeds has played an important role in the history of the European economy. However, during the second half of the 20th century, the populations of some breeds have diminished below a critical size and some breeds have even become extinct. The underlying causes for this development can be found in the industrialization of animal agriculture and in the rising ubiquity of few high-yielding and productive breeds.
The importance of conserving farm AnGR has increasingly been acknowledged over the past 20 years. In 1992, the United Nation's Conference on Environment and Development explicitly mentioned their importance in its agenda 21 and Convention on Biologic Diversity [15]. To face the problem of extinction and eroding farm animal biodiversity, a number of efforts have been undertaken by different institutions, among others the European Union.
Despite the increasing interest in and importance attributed to farm AnGR, research has provided little guidance as to how conservation programmes should select valuable breeds. Weitzman [16, 17, 18] has recognized that biodiversity conservation is an inherently economic question and provides a framework for decision analysis. While his framework is of high generality applicable to many diversity conservation questions, he was primarily interested in the conservation of species diversity, e.g. [9] and [17]. However farm AnGR conservation is not a question of species conservation. Here the breed level is of primary importance.
The Weitzman model has been applied to the question of breed selection into conservation programmes [2, 5, 7, 8, 11, 12, 14]. This transposition of Weitzman's original framework is challenged by two major objections. A first criticism is the reduction of the diversity notion to a single dimension [1]. Livestock diversity regarding breeds cannot be characterized by

between-breed diversity only, i.e. their genetic distinctiveness, but within-breed diversity, i.e. the genetic variation within a breed, is of primary importance. Some would even argue that this dimension is most important as it influences the viability of a breed regarding future breeding success and for example its resistance to altered environmental conditions. In fact, within-breed diversity accounts for 50 to 70% of total genetic variance [6].

Second, basically none of the applications has recognized the necessity to include other dimensions of welfare stemming from the conservation of breeds but their contribution to diversity (the only exception is [11]). This is a major drawback, since society is not blindly conserving diversity for its own sake. Much is known about the different livestock breeds, their specific merits in various or highly specialized production systems, their genetic and phenotypic characteristics, so that utility should be extended to take these contributions into account.

This paper analyses the question of how society does or, possibly should, weigh breed characteristics by taking two distinct approaches. First, past decision making of breed conservation is analysed to inquire into the priorities that EU member countries express when selecting breeds for their currently ongoing conservation efforts within rural development plans (RDPs) that are regulated under EC445/2002. Under the hypothesis that the adopted programmes reveal policy-makers', and hence society's, preferences for conservation, we analyse a large data base linking the decision to establish a breed conservation programme to various attributes of farm animal breeds.

While this evaluation allows assessing policy makers' preferences that may reflect various influences by breeders, scientists and society as a whole, we compare these results with those from an expert survey on the conservation of farm AnGR that was primarily addressed to scientists and animal breeding societies.

The following section presents the data base of breed conservation programmes and the methods used in the analysis. Section 3 discusses the results. We turn to the discussion of the results of the expert survey in section 4 and conclude in section 5.

Data and Methods

In this analysis we want to identify the breed characteristics that determine if a breed is enlisted in a conservation programme or not. We follow [9] who used a similar approach analysing US decision making regarding the Endangered Species Act.

Let the attractiveness of a breed to be considered for an in-situ conservation programme be a function of the various attributes of the breed. We cannot observe the conservation attractiveness, but we can observe, ex-post, if a breed is covered in a RDP or not. Let Y_j be the observed conservation decision where $Y_j = 1$, if breed j exceeds a certain threshold attractiveness and is covered by a conservation programme, and zero otherwise. Assuming the attractiveness to be a linear function of breed characteristics, we obtain a probit regression of enlisting a breed in a RDP or not.

To estimate this model we use data of the European Association of Animal Production-EAAP [3]. The EAAP provides a large amount of information about the characteristics of individual breeds. Data was collected on six species (ass, cattle, goat, horse, pig and sheep) in twelve EU-15 countries that cover breed conservation in their RDPs (Denmark, the Netherlands and the UK did not introduce breed conservation programmes in their RDPs). Applying the population size threshold of the regulation EC445/2002, we construct a sample of 548 eligible breeds. In addition, we us a database that was constructed by Signorello and Pappalardo [10] who examined 60 RDPs adopted in EU-15 countries. It provides us with a list of 265 breeds that do actually receive support co-financed by the EU.

Table 1. Explanatory variables of in-situ conservation decision

Variables	Description	Mean	SD
Breed characteristics			
Autochthonous (X_1)	Binary variable with value 1 if the breed is autochthonous and 0 if not;	0.419	0.493
Herdbook (X_2)	Binary variable with value 1 if the breed has a herdbook and 0 if not;	0.877	0.327
Ln-Pop (X_3)	Continuous variable taking the natural logarithm of the population size of the breed	5.530	1.714
T-Growing (X_4)	Binary variable with value 1 if the breed is growing in its population size and 0 if not	0.390	0.488
T-Decreasing (X_5)	Binary variable with value 1 if the breed is declining in its population size and 0 if not	0.321	0.467
No. of Herds (X_6)	Binary variable with value 1 if the has a number of breeding herds greater than 10 and 0 if not	0.583	0.493
Spec. Char. (X_7)	Binary variable with value 1 if the breed carries specific characteristics and 0 if not	0.458	0.498
Geographic Characteristics			
Geo – Countries (X_8)	Binary variable with value 1 if the breed is present in only one country and 0 if not	0.677	0.468
Geo – Regions (X_9)	Binary variable with value 1 if the breed is present in all regions of a country and zero if not	0.642	0.479
In-situ (X_{10})	Binary variable with value 1 if the breed has already benefiting of an in-situ conservation programme before the RDP and 0 if not	0.268	0.443
Ex-situ (X_{11})	Binary variable with value 1 if the breed is included in an ex-situ conservation programme (semen and /or embryo) and 0 if not	0.198	0.399
Control variables			
Dummy w.r.t. species X_i; i=12, ..., 16	Indicator variable for one of the six species (base line for pig)		
Dummy w.r.t country X_i; i=17, ..., 27	Indicator variables for 11 of the 12 countries (base line for Sweden)		

As explanatory variables we identify four categories of breed attributes that may help to explain why a breed enters into a RDP or not. They are listed in table 1. The first category includes information about the breed: If it is autochthonous; if it has a herdbook; its population size; if the recent trend in its population size is increasing or declining (base line is a stable population size); if the number of breeding herds is smaller than 10; and if the breed carries some specific characteristics. The specific characteristics considered are numerous and varied. They concern aspects of reproduction, production (quantity and quality) and adaptability to specific environments. The variable takes the value 1 if the breed has a (or several) specific characteristics and zero if not.

We chose the variables of the first category following the logic of EU regulation. The EU requires breeds to be autochthonous and to be managed by a herdbook or by some breeding association. Furthermore it asks that selected breeds are an integral part of the environment where they are raised.

We include a second set of variables that refers to the geographic repartition of a given breed within a given country and across countries. These variables measure the specificity and uniqueness of a breed in a national and international context. The third set of variables refers to the question if the breed has benefited before of an in-situ or ex-situ conservation programme. Finally, we use a number of country and species dummies.

Results

The results of the probit estimation are shown in table 2. The first set of variables refers to the eligibility criteria of EU RDPs. The EU requires breeds to be autochthonous and to be managed by a herdbook or by some breeding association. The results of the probit estimation confirm our hypothesis that these characteristics increase the probability for a breed being included in a conservation programme. Having a herdbook does not significantly enter into the estimation. This suggests that the alternative eligibility criterion of being managed by a breeding organization is considered sufficient by member states for a breed to qualify for a conservation programme. Table 2 also presents the estimated marginal effects in the fourth and fifth column. It shows that being autochthonous raises the probability of a breed to be in a conservation programme by 30%.

The next three variables characterize the extinction risk of a breed. It is described by the population size, the recent trend in population size and the number of breeding herds. Contrary to our expectations breeds with a higher population size are more likely to be included in a conservation programme. The variable is significant at the 10% level. Increasing or declining trends of population size are found to be not significant. Finally the variable referring to the number of breeding herds is found to be highly significant. However its sign is negative. The more breeding herds there are, the more likely it is that the breed is covered by a conservation programme. This contradicts our expectations, as breeds with a small number of breeding herds are at higher risk of homozygosity and lower within-breed variation.

The results on this first set of variables lead to the conclusion that the consideration of breeds in RDPs is not driven by considerations of extinction risks. This concurs with conclusions in [10] where it was found that a large number of breeds at risk of extinction have not been integrated in RDPs.

The last variable in this category refers to the specific value characteristics that distinguish breeds from each other. We find a positive coefficient to this variable that is significant at the 5% level. The impact on the probability of being included in a RDP is relatively large (0.138), showing that these breeds have high chances of being included in conservation efforts co-funded by the EU.

The geographic dimension of breeds has been approached using two variables. The first informs about the geographic distribution within a country and the second refers to the geographic distribution across countries. Both variables are highly significant and the signs of their parameters confirm our expectations. If a breed cannot be found in any other country, then it is more likely to be included in a RDP. The dummy variable increases the probability of being included by 22%. At the same time, the fact that a breed is associated to one and only one region of a given country makes it more unique, possibly in a cultural sense, and raises its probability of being included in a conservation programme by 31%.

Table 2. The determinants of in-situ conservation of AnGR in EU countries

		Probit		Marginal Effects	
Explanatory Variables		**Parameter**	**t-statistic**	**Value**	**t-statistic**
Breed characteristics					
Constant	α_0	-3.024***	-5.182	-1.201***	-5.213
Autochthonous	α_1	0.772***	4.773	0.300***	5.01
Herdbook	α_2	0.012	0.051	0.004	0.051
Ln-Pop	α_3	0.092*	1.789	0.036*	1.790
T-Growing	α_4	0.221	1.193	0.088	1.196
T-Declining	α_5	-0.089	-0.450	-0.035	-0.451
No. of herds	α_6	-0.582***	-3.241	-0.229***	-3.328
Specific characteristics	α_7	0.350**	2.234	0.138**	2.254
Geographic characteristics					
Geo – countries	α_8	0.574***	3.130	0.222***	3.292
Geo – region	α_9	0.824***	4.199	0.313***	4.582
Conservation characteristics					
In-situ	α_{10}	0.494**	2.234	0.195**	2.287
Ex-situ	α_{11}	0.224	0.852	0.089	0.854
Dummy w.r.t. species (base species: pig)					
Ass	α_{12}	1.717***	2.602	0.491***	6.306
Cattle	α_{13}	0.754***	2.578	0.292***	2.766
Goat	α_{14}	0.474	1.463	0.186	1.521
Horse	α_{15}	0.758***	2.692	0.294***	2.853
Sheep	α_{16}	0.962***	3.493	0.366***	3.894
Dummy w.r.t. countries (base country: Sweden)					
Austria	α_{17}	2.736***	3.943	0.572***	17.501
Belgium	α_{18}	0.951***	2.101	0.345**	2.645
Finland	α_{19}	-0.111	-0.205	-0.044	-0.207
France	α_{20}	-0.192	-0.549	-0.075	-0.555
Germany	α_{21}	0.477	1.317	0.188	1.343
Greece	α_{22}	0.160	0.323	0.063	0.324
Ireland	α_{23}	-0.400	-0.787	-0.152	-0.839
Italy	α_{24}	0.600*	1.674	0.234*	1.756
Luxembourg	α_{25}	0.799	0.999	0.297	1.189
Portugal	α_{26}	-1.403***	-2.623	-0.402***	-5.160
Spain	α_{27}	1.132***	2.576	0.399***	3.487
Number of observations		548.000			
Log-likelihood		-208.564			
χ^2		341.969***			
Correct predictions (%)		83.029			

***: parameter significant at 1%, **: parameter significant at 5 %, *: parameter significant at 10%

Regarding the third category of variables, ex-situ conservation is not identified as a significant determinant for breeds to be included in RDPs. The second variable concerns the question if a breed has been covered by in-situ conservation programmes before regulation 445/2002. This variable has a highly significant positive effect. Overall 113 out of 265 breeds have been covered before and now been integrated in RDPs. This effect may be explained by member countries now using the possibility of co-financing their original efforts in terms of breed conservation. It also suggests that member countries recognize the importance of posing economic incentives to farmers if they want to develop successful conservation strategies. Finally, we find a large number of significant country and species dummies.

Expert Survey

The purpose of this section is to compare the results of past conservation decision making to the view of experts in the field. A survey among experts was conducted. The contacted experts were the national EAAP- and FAO-coordinators charged to follow the management of AnGR, breeding associations in various EU-countries, and scientists and administrators being concerned with the conservation of AnGR in various ways. The database has been constructed to be representative of different countries, professions and disciplines. The survey instrument was sent to almost 300 experts. Since not everybody identified could be contacted, only 275 experts received the questionnaire. Another six questionnaires were incomplete and excluded from the analysis. In total we received 137 usable responses resulting in an effective response rate of 51%.

The sample consists to 33.6% of geneticists, 44.5% animal scientists, 8% veterinarians, 16% agronomists, 14.5% socio-economists. Most work in research (24.8%) or higher education (24.8%), 3.6% in veterinary medicine, 5.8% in administration, 38% in breeding societies and 7.3% in other organisations (e.g. NGOs, consultants). They have experience with conservation programmes (48.9%), animal breeding programmes (42.3%), and administrative issues (29.9%). Almost half of them (44.5%) have a doctoral degree and 36% a university diploma.

Table 3: Principle reasons for conservation of AnGR

Reason	**Frequency**	**%**
Potential Use (Option value)	94	68.89
Cultural and historical function	68	49.63
Environmental and landscape function	48	35.56
Genetic adaptability	29	21.48
Typical products	24	17.78
Scientific function	24	17.78
Maintenance of diversified production systems	20	14.81
Specific genetic character	17	12.59
Disease resistance	13	9.63
Economic function	11	8.15
Food function	7	5.19
Aesthetic function	4	2.96

A share of 60.6% of our expert sample considers the issue of AnGR erosion as very important and another 35.8 % as important. They find that putting in place conservation programmes for AnGR is important and should be done for the reasons listed in table 3.

When being faced with the statement that the EU requires breeds to be (1) autochthonous, (2) at risk of extinction, (3) important in environmental conservation and (4) managed by a breeding society or herdbook, a share of 12.4% of the queried experts found these criteria very sufficient and another 52.6% found them sufficient. Regarding the separate criteria, most agreed to the idea of extinction risk but fewer (less than 50%) agreed to the role of breeding societies or the criteria of contributing to environmental conservation. However, almost 65%

agreed to the statement that the criterion of being an autochthonous breed is an important selection criterion.

We asked for other criteria that they think important when selecting breeds for conservation programmes. The additional criteria are listed in table 4. Most suggest considering indicators of diversity such as genetic distinctiveness, genetic within-breed variety and phenotypic distinctiveness. Of importance are also the cultural role and typical products of breeds. These are already acknowledged in current conservation programmes as our analysis has shown. Other parameters relate to the management of extinction risks such as the age and number of breeders, the percentage of females purely bred and the tendency in population size.

Table 4. Other eligibility criteria suggested by experts.

Criteria	**Frequency**	**%**
Genetic distinctiveness	73	53.28
Cultural role	46	33.58
Typical products	35	25.55
Genetic within breed diversity	25	18.25
Geographic distribution	25	18.25
Phenotypic distinctiveness	16	11.68
Age and number of breeders	16	11.68
Percentage of females purely bred	14	10.22
Genetic value characteristics	13	9.49
Average herd age	13	9.49
Tendency of population size	11	8.03
Disease resistance	5	3.65
Other reasons	22	16.06

Conclusions

This paper provides an analysis of decision making regarding breed conservation in the EU. We find that current decision making in EU member countries shows a preference for selecting autochthonous breeds that are unique on a regional or EU-basis. According to our results, it seems that the conservation programmes put in place operate independent of extinction risk. Indeed, it is more likely to find a breed with a large population size and many breeding herds in a programme than one with few animals in a small number of herds.

The characteristics that mostly determine the chances for a breed to be considered in a RDP are being autochthonous and carrying specific value traits. This picture can be brought in context to the remarks raised in [13]. Analysing the programmes put in place according to the first agri-environmental regulation EC2078/92, Simon concluded that the conservation objectives are guided by a rationale of future potential and cultural reasoning. These objectives are quite different from those modelled in applications of Weitzman’s approach to breed conservation.

The results contrast starkly with the results of the expert survey. The queried experts put much more emphasis on genetic distinctiveness and within-breed diversity. However, both policy makers and experts agree in their assessment that the specificity of a breed and its future potential should be taken into account when making conservation choices.

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REFERENCE LIST

[1] Bruford, M.W. (2004). Conservation Genetics of UK Livestock: From Molecules to Management. Pp 151-169. In *Farm Animal Genetic Resources*. Eds. G. Simm, B. Villanueva and S. Townsend. Nottingham University Press, Nottingham, UK.

[2] Cañon, J., Alexandrino, P., Bessa, I., Carleos, C., Carretero, Y., Dunner, S., Ferran, N., Garcia, D., Jordana, J., Laloë, D., Pereira, A., Sanchez, A. and Moazami-Goudarzi, K. (2001). Genetic diversity measures of local European beef cattle breeds for conservation purposes. Genetics, Selection and Evolution 33: 311-332.

[3] EAAP (2004). Animal Genetic Data Bank. http://www.tiho-hannover.de/einricht/zucht/eaap/

[4] FAO (2003). DAD-IS Database. Personal Communication. FAO, Rome, Italy.

[5] García, D., Corral, N. and Cañon, J. (2002). Further developments on Weitzman's approach to assess conservation of genetic diversity. Proceedings of the 7th World Congress on Genetics Applied to Livestock Production, Montpellier, France, August 19-23, 2002. Vol. XXXIII, pp 561-564.

[6] Hammond, K. and Leitch, H. (1996). The FAO Global Programme for the Management of Farm Animal Genetic Resources. In: Miller R., V. Pursel, and H. Norman (eds.), Beltsville Symposia in Agricultural Research. XX. Biotechnology’s Role in the Genetic Improvement of Farm Animals. American Society of Animal Science, IL: 24-42.

[7] Laval, G., Iannuccelli, N., Legault, C., Milan, D., Groenen, M.A.M., Giuffra, E., Andersson, L., Nissen, P.H., Jorgensen, C.B., Beeckmann, P., Geldermann, H., Foulley, J.L., Chevalet, C. and Ollivier, L. (2000). Genetic Diversity of Eleven European Pig Breeds. Genetics, Selection and Evolution 32: 187-203.

[8] Marti, S.B. and Simianer, H. (2002). Marginal Diversity: A Decision taking tool for mimizing conservation. Proc. 7th World Congress on Genetics Applied to Livestock Production (WCGALP) CD-Rom Communication No. 26-05.

[9] Metrick, A. and Weitzman, M.L. (1998). Conflicts and Choices in Biodiversity Preservation. Journal of Economic Perspective 12(3): 21-34.

[10] Signorello, G. and Pappalardo, P. (2003). Domestic animal Biodiversity Conservation: A Case Study of Rural Development Plans in the European Union. Ecological Economics 45(3): 377-392.

[11] Simianer, H. (2002). Noah’s Dilemma: Which Breeds to Take Aboard the Arc? 7th World Congress on Genetics Applied to Livestock Production. Montpellier, France, 19-23 August, 2002.

[12] 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: 377-392.

[13] Simon, D.L. (1999). Genetic Resources and Conservation. In: R. Fried and A. Ruvinsky (eds.). The Genetics of Cattle. CAB International.

[14] Thaon d’Arnoldi, C., Foulley, J.L. and Ollivier, L. (1998). An Overview of Weitzman Approach to Diversity. Genetics, Selection and Evolution 30: 149-161.

[15] United Nations (1992). Convention on Biological Diversity. United Nations Conference on Environment and Development (UNCED), Rio de Janeiro, 3-14 June 1992.

[16] Weitzman, M.L. (1992). On Diversity. Quarterly Journal of Economics, 107: 157-183.

[17] Weitzman, M.L. (1993). What to Preserve? An Application of Diversity Theory to Crane Conservation. Quarterly Journal of Economics, 108: 157-183

[18] Weitzman, M.L. (1998). The Noah’s Ark Problem. Econometrica, 66: 1279-1298.