Criteria for the recognition and prioritisation of breeds of special genetic importance

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Summary

The State of the World survey of animal genetic resources (SoWAnGR) has highlighted the necessity to reconcile the varying systems applied by different organisations for the identification and categorisation of endangered breeds of livestock. Currently, many of these systems are irreconcilable. In particular, there is a need to interpret national breed populations in the context of their international population. Rare Breeds International has developed and applied a system which overcomes these problems, and which coincides with criteria applied by FAO. The system utilises three criteria, namely distinctiveness, local adaptation, and numerical scarcity. Numerical scarcity is measured preferentially by the number of annual female registrations rather than the number of breeding females. The system embodies simplicity, accuracy and effectiveness, based on global data, and will enable more effective interpretation of SoWAnGR reports.

Résumé

L’enquête sur la Situation mondiale des ressources génétiques animales (SoW) a souligné le besoin de standardiser les systèmes appliqués par les différentes organisations pour l’identification et la classification des races domestiques en danger. Souvent, certains de ces systèmes ne peuvent pas être standardisés. En particulier, il existe le besoin d’interpréter les populations de races locales dans leur contexte international. Rare Breeds International a développé et appliqué un système qui surmonte ces problèmes, et qui coïncide avec les critères appliqués par la FAO. Le système utilise trois critères: la distinction, l’adaptation locale, et la scarcité numérique; cette dernière est mesurée de préférence par le nombre de femelles enregistrées chaque année plutôt que par le nombre de femelles croisées. Le système est simple, précis et effectif, et se base sur des données globales, ce qui permet une interprétation plus efficace des rapports SoW.

Keywords: *Endangered breeds, Prioritisation, Characterisation, Adaptation, Distinctiveness, Population.*

Introduction

Procedures for the identification and categorisation of endangered breeds of livestock have developed inconsistently. Different systems are applied by various organisations involved with programmes for the conservation of animal genetic resources. This at least may cause difficulty and confusion when attempting to compare data, and at worst may yield misleading results from analytical studies.

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The difficulties were addressed and analysed in the Rachel Ella Nussbaum Memorial Lecture at the Rare Breeds International (RBI) Congress in 1994 (Alderson, 1995), but only limited subsequent action has been taken. There is a need to implement more fully an agreed system which will permit effective and rapid exchange of information between international and national databases, and which will give an accurate measurement of the endangered status of each breed. The objective of this paper was to establish a framework for an internationally acceptable procedure to evaluate the status of endangered breeds.

Current Situation

First model

The earliest procedure to identify breeds worthy of support as endangered breeds was formulated by the author in 1975 (Alderson 1994). It evaluated breeds initially on an assessment of their status as a distinct and recognisable population, and then categorised them by numerical criteria. This procedure was applied in the United Kingdom and, with some minor modifications and refinements, was used until 2001.

The principles embedded in this procedure were based on genetic integrity, indicated by absence of recent introgression, and degree of vulnerability from either geographical limitations or numerical scarcity. Critical population size was calculated through a formula based on mating ratio, reproductive rate and generation interval, but was modified by trends of population, number of distinct sire lines, number of breeding units and geographical distribution. Four priority categories were recognised namely ‘critical’, ‘endangered’, ‘vulnerable’ and ‘at risk’ (broadly compatible with International Union for Conservation of Nature standards), and a different critical population size applied to each species.

In practice, the modifications proved too complex, and the system was applied mainly on the simple criterion of number of registered purebred breeding females. The other factors (number of breeding units, number of unrelated sire lines, trends of population, distance between major breeding units) exert a significant influence on the degree of endangeredness, but were disregarded in the interests of simplicity.

Other NGO models

Variations of the basic model were adopted by rare breeds NGOs in other countries. For example, American Minor Breeds Conservancy (AMBC, later ALBC) segregated breeds on the basis of their national and international population into four categories of vulnerability – critical, rare, watch and study. Breeds also were categorised into four types, namely landrace, standardised, industrial and feral (Christman *et al*, 1997). Most of the endangered breeds in USA have their origin in the Old World, but the introduction of the term ‘landrace’ was a significant recognition of the importance of native (indigenous, autochthonous) breeds, although it has potential for confusion with the named ‘Landrace’ breeds of sheep and pig.

In Europe, the University of Hannover followed a different line by attempting to estimate the potential loss of genetic variability (Simon 1995). Greater emphasis was placed on estimates of increase in homozygosity (inbreeding), and effective population size (Ne) was the favoured criterion. Ne is a valuable tool, but underestimates genetic erosion where selection intensity is high. Without modifying factors it is accurate only when random breeding is practised. Its value in commercial or farm conditions is limited for this reason.

A proposal from the Genetic Resources Committee of European Association for Animal Production (EAAP, 2001/2) uses the number of breeding females as the basic criterion, but applies modifying factors derived from the percentage of females used for purebreeding, trend in number of breeding females, number of herds, and trend in number of herds, to calculate the corrected number of breeding females.

Governmental bodies

FAO used a standard population size for all species and initially set a limit of 10 000 breeding females. As a result of later changes, the numerical criteria adopted by FAO were a maximum of 1 000 breeding females for endangered status, and 100 breeding females for critical status (Scherf, 2000). In Europe the criteria were determined by population size throughout EU rather than simply in the country of origin. The limits ranged from 4 000 breeding females for cattle and equine breeds with increasing populations to 9 000 breeding females for sheep and goat breeds with declining populations. Current proposals within EU favour a return to a criterion of a regional (European) breed population of breeding females of 7 500 cattle, 10 000 sheep and goats, 5 000 horses and ponies, 15 000 pigs and 25 000 poultry (Regulation 445/2002 Article 14).

Cultural and socio-economic factors in developing countries demand the application of different criteria. There is rarely a system of individual identification or registration of animals and research workers at ILRI have developed a concept of ‘extinction probability’ within systems to determine ‘functional diversity’ (Rege, 2001). This concept incorporates factors for adaptation, production, culturally important traits, and local political and social factors.

Evaluation of existing procedures

1. The major shortcoming with most systems is that data are not current, and in some cases not accurate. In some cases population figures are estimates, as a result of the difficulty of collecting complex information. Comprehensive current information is available only spasmodically.
2. It is clear that many breeds that are genetically important are excluded by the procedures used by some organisations. This is evident from an analysis of breeds of cattle in the United Kingdom (Table 3), and results from the use of population size as the dominant indicator of endangeredness. Numerical scarcity is not the only factor which should determine prioritisation for recognition and support.
3. There are fundamental species differences derived especially from variation in length of breeding life, but also from mating ratios and reproductive rate. These are recognised in the UK procedure and in the proposed EAAP system, but not in many others.
4. In most systems population size is assessed through the number of breeding females. This may not be the best criterion. The purpose of prioritisation is to assess the vulnerability of a breed. The number of breeding females has provided useful guidance but it has shortcomings. For example, not all organisations carry out a census of breeding animals, some females may be used in crossing programmes, not all females are registered, not all females may be bred each year, and not all progeny may be registered. The attempt by Hannover to base prioritisation on predictions of genetic loss by-passed these shortcomings, but the use of Ne encompassed some weaknesses.
5. The status of a breed in its country of origin is important, and must be the basic factor of assessment, but it also must be evaluated in the context of its global population (Table 1). Several breeds, which have become scarce in their

Table 1. Comparison of some native UK breeds. Native and foreign population of breeding females (2002).

Species / Breed	Native	Foreign
Sheep: Teeswater	429	0
Sheep: Shropshire	1 050	3 636
Sheep: Lonk	3 500	0
Sheep: Hampshire Down	4 050	19 353
Pigs: Tamworth	171	1 255
Pigs: Large Black	225	119
Pigs: Berkshire	317	11 723
Cattle: Shetland	350	0
Cattle: Red Poll	814	2 293
Cattle: Sussex *	2 000	5 158
Cattle: Galloway **	3 500	1 166
Equine: Dartmoor	330	864
Equine: Clydesdale	500	1 320
Equine: Hackney	750	1 305

*Sussex: the figure for foreign populations does not take account of any recent losses in Zimbabwe.
**Galloway: the figure takes into account significant losses in UK during the FMD outbreak in 2001.

country of origin, have a large and thriving population in other countries. The ALBC procedure, and the EU criteria to some extent on a regional basis, acknowledge this factor. However, it is also necessary to determine that the national populations have reciprocity, otherwise they will exist in isolation and eventually become separate breeds.

Proposed Model

An improved procedure must resolve the shortcomings detailed above. It must be simple and permit easy submission of breed information; it must include criteria in addition to numerical scarcity; it must allow for species differences; it must seek a measure that is superior to the number of breeding females; and it must be able to accommodate an international perspective. The proposed model fulfils these requirements and has been evaluated in UK through the application of programmes of support by RBI during the FMD / 2001 outbreak. It deals with procedures for the recognition of eligible breeds, and the preferred criterion for the measurement of population size.

Recognition of breeds

The procedure formulated for RBI is based on the concept of breeds of special genetic importance within programmes for the conservation of animal genetic resources, and three groups of breeds are recognised:

1. Breeds which possess distinctive characteristics.
2. Breeds which have special adaptation.
3. Breeds which are numerically scarce.

Distinctive characteristics

Distinctiveness can be expressed in several different ways. The increasing application of DNA profiling has enabled calculations of genetic distance for most breeds, and this fits closely with the FAO concept of prioritising resources in support of breeds with a great genetic distance on the basis that they are more distinctive. Among native UK breeds of cattle, Chillingham, Vaynol, White Park, Jersey (Island), Sussex and Lincoln Red are genetically distant from the massed group of other breeds.

Distinctiveness may also be expressed in performance or type. The distinctive size of miniature Dexter cattle is clearly evident. The quality of milk and meat from Shetland cattle and sheep is less obvious, but they are high in conjugated linoleic acid (CLA), which has important implications for human health. Prolificacy in pigs and sheep is a valuable distinctive characteristic. Distinctiveness merits conservation support.

Special adaptation

Local breeds evolved in response to their natural environment, and frequently exhibit strong adaptation to it. Their genotype is designed specifically to function effectively in that environment. The prime example in UK is North Ronaldsay sheep which can exist on an exclusive diet of seaweed, but any breed that is adapted to an extreme or unusual environment is likely to show special adaptation. For example, in Iberic pigs there is interaction between environment (dehesa) and meat quality (jabugo), and this is lost when introgression from Duroc occurs. Currently, genetic conservation of endangered breeds is linked to environmental factors, and locally-adapted breeds are recognised by FAO as a valuable group.

Numerically scarce

Previously this has been the standard criterion for the measurement of endangerment, usually based on the number of breeding females. There is a need to apply refinements to assess founder effect (GCI) and genetic variability (Alderson, 1992). The primary objective of conservation programmes is to maximise the retention of founder alleles, and this objective is confounded by increasing homozygosity and the associated unequal founder effect, as much as by small numbers of breeding animals.

Measurement of population size

The annual registration of female animals, calculated on either a one-year basis or three-year rolling average, is a more accurate indication of the viability of a population in many circumstances. It reflects accurately the confidence and enthusiasm of breeders, records the actual number of young animals qualified to join the breeding herd or flock, and indicates the future trend in population size. It automatically accounts for breeding females that are not registered or do not produce purebred progeny, and for eligible young stock that is not registered. It relies on the principle that only registered animals will contribute to future generations of the breed.

The previous categorisation of endangeredness was based on breeding females in five categories with numerical criteria of <100 (category 1), <300 (category 2), <1 000 (category 3), <3 000 (category 4) and <10 000 (category 5). Only categories 1-4 qualify for endangered status. These categories need to be translated into numerical criteria for annual registrations of female replacements which will require differentiation because of variation between species in length of breeding life, and which must allow for those registered females which fail to join a breeding unit.

Criteria for each species and each category are shown in Table 2.

The basic assessment should take place on the population in the country of origin of the breed, but some recognition must be given to other national breeding populations. It also will be necessary to interpret the numerical criteria in the context of the level of inbreeding and the degree of unequal founder effect in the breed. Significant numbers of breeding females (>10 000) of a breed in other countries would give it a

Table 2. Upper limit of numerical criteria for the categorisation of four species of livestock (expressed as annual registrations of female young stock).

Species	Horses	Cattle	Sheep	Pigs
Category 1	15	25	30	35
Category 2	50	75	100	115
Category 3	150	250	300	350
Category 4	500	750	1 000	11 65

Table 3. Case studies of three British breeds to show procedure for prioritisation.

Breed (spp)	Annual reg of F	Initial priority ranking	Locally dapted	Distinct-veness	Global population	Level of inbreeding	Final priority ranking
Berkshire (p)	87	2	*	*	>10 000	medium	3
White Park (c)	135	3	***	****	671	high	1
Teeswater (s)	126	3		***	429	medium	2

lower global priority. Significant inbreeding and unequal founder effect would give it a higher priority (Table 3).

Although these modifying factors make the system more complex, they would be applied at an organisational level (i.e. RBI, EAAP, FAO or national organisations), and do not compromise the collection of simple information (i.e. annual registrations) from breed societies or other registration authorities.

Effect on breed eligibility

The proposed system continues to place the greatest weighting (by a multiple of three) on the score for numerical scarcity, but the inclusion of scores for distinctiveness and special adaptation widens the parameters for the recognition and acceptance of breeds in programmes of genetic conservation.

The proposed system has the effect of including some breeds which are excluded by other procedures, as illustrated in Table 4 by reference to breeds of cattle in the United Kingdom. In particular, it recognises distinctive breeds (Island Jersey) and specially adapted breeds (Highland and Galloway).

The proposed system lists and prioritises in four categories 22 breeds of special genetic importance as defined by Rare Breeds International. In comparison, 6 breeds are listed by Hannover in four categories (critically endangered, endangered, minimally endangered, potentially endangered) (EAAP, 2001/1), 12 breeds by application of the two categories advised by FAO (critical - <100 breeding cows,

Table 4. Breeds of cattle in UK ranked by RBI priority (D = distinctive; A = specially adapted; R = numerically scarce (rare); NE = not endangered; X= not defined or not listed),

Breed	D/A/R	RBI	UK	FAO	TiHo
Chillingham	DAR	1	5	1	3
Vaynol	DR	1	1	1	X
N.D.S.	R	1	X	1	X
White Park	DAR	1	2	2	NE
Whitebred	R	2	X	2	4
Shetland	DAR	2	1	2	NE
Irish Moiled*	R	2	1	2	4
Belted Galloway	AR	2	7	2	1
Highland	DAR	2	NE	NE	NE
Traditional Hereford**	R	3	3	2	NE
Gloucester	R	3	2	2	X
Red Poll	R	3	3	2	X
Sussex	DR	3	NE	NE	4
Jersey (Island)***	D	3	NE	NE	4
Beef Shorthorn	R	4	3	NE	X
Longhorn	R	4	7	NE	NE
British White	R	4	7	NE	NE
Lincoln Red	R	4	1	NE	X
Galloway	A	4	NE	NE	NE
Devon	AR	4	NE	NE	NE
Dexter****	DR	4	NE	NE	X
Dairy Shorthorn	R	4	NE	NE	X

* Irish Moiled: there is dispute whether this is a native breed of Ireland or UK.

** Traditional Hereford is part of the Hereford breed, but has a separate listing within the Herd Book.

*** Jersey (Island) cattle have a separate Herd Book and have been a closed population for more than 200 years.

**** Dexter is an Irish native breed but is listed provisionally as a UK breed until the breed is re-established effectively in Ireland.

endangered - <1 000 breeding cows) (Scherf, 2000), and 13 breeds by the original UK system in seven categories. Only three breeds (Chillingham, Irish Moiled and Belted Galloway) are prioritised by all organisations. Four breeds (Highland, Dexter, Dairy Shorthorn and Galloway) are listed only by RBI. The standards currently proposed in EU would include all breeds on the RBI list, plus a further 4 breeds including, for example, the Hereford.

Limitations

The proposed system is simple at the point of collection of information (i.e. breeder or breed society), but remains complicated at the point of analysis and interpretation. A pragmatic balance must be maintained between the need for comprehensive data and the effectiveness of collection and collation of detailed information. Factors relating to sex ratio of registered animals, global population, reciprocity, homozygosity, founder effect and species differentiation require sophisticated procedures to be applied for full effect, and can not be supplied by local organisations.

The system assumes that each breed is regulated by a programme for registration of individual animals. This is a valid assumption in many developed countries, but in other regions an approximate head count of the number of breeding females may continue to be a more realistic option than a calculation of breeding stock replacements. The global variation, and even regional variation between northern and southern Europe, in cultural background and registration practices must be recognised.

Distinctiveness and special adaptation require an element of subjective judgement. Factors such as genetic distance studies, and the presence of private alleles or unique aberrations, provide objective data. Measurement of performance characteristics and linear assessment provide objective data. Some other items do not lend themselves to easy mathematical evaluation.

Conclusions

The proposed procedure provides a globally applicable format that is uncomplicated at the source of information (grassroots), and flexible at the analytical stage. The system of data retrieval is as comprehensive as possible within the constraints of a pragmatic evaluation of the ability of owners of livestock and breed organisations to provide the required data. It also permits a degree of flexibility which recognises the differences in information resource and cultural influences between different countries and regions.

The adoption of the concept of breeds of special genetic importance as the basis for recognition of breeds by organisations concerned with the conservation of animal genetic resources provides a better structure than programmes based solely on numerical scarcity. Factors associated with distinctive characteristics and special local adaptation are more relevant to current concepts of utility, disease control and environmental compatibility.

The number of annual female registrations should replace the number of breeding females as the basic numerical criterion applied in procedures to determine the endangered status of a breed. It would provide a better opportunity to evolve a global system to ensure compatibility of national systems and data.

National NGOs concerned with the conservation of animal genetic resources are encouraged to adopt this system

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References

Alderson, L., 1992; A system to maximise the maintenance of genetic variability in small populations. In L. Alderson & I. Bodo (Eds) Genetic Conservation of Domestic Livestock (Volume 2). CABI, Wallingford, 18-29.

Alderson, L., 1994; The Chance to Survive. Pilkington Press Ltd. Yelvertoft.

Alderson, L., 1995; The value of global information for better estimating the vulnerable status of endangered breeds. In R.D. Crawford, E.E. Lister & J.T. Buckley (Eds.) Conservation of Domestic Animal Genetic Resources. RBI, Rome, 66-73.

Christman, C.J., D.P. Sponenberg & D.E. Bixby, 1997; A Rare Breeds Album of American Livestock. ALBC, Pittsboro.

European Association for Animal Production, (Commission of Animal Genetics). 2001/1; Animal Genetic Data Bank. Website www.tiho-hannover.de

European Association for Animal Production (Genetic Resources Committee). 2001/2; A proposal of EAAP for selection criteria in the rural development measures of EC regulation 1257/99 and 1750/99.

Rege, J.E.O., 2001; Personal communication.

Scherf, B.D. (Ed.), 2000; World Watch List for Domestic Animal Diversity. FAO, Rome.

Simon, D.L., 1995; Factors for defining the status of endangeredness of a breed. In R.D. Crawford, E.E. Lister & J.T. Buckley (Eds.) Conservation of Domestic Animal Genetic Resources. RBI, Rome, 66-73.