Breeds at Risk

Criteria and Classification

Report from a seminar held in London
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1. Introduction

1.1 The importance of conservation of farm animal genetic resources (FAnGR) has been accepted widely, not only because of obligations under the Convention on Biological Diversity (CBD) but also to protect valuable native and historic assets. However, the effective and cohesive implementation of programmes for conservation has been impeded for many years by lack of harmonisation on the definition of criteria and the measurement of thresholds for endangerment factors. The topic was addressed first sixteen years ago at the Rare Breeds International (RBI) global congress in Canada in 1994, but still remains a problem. Little progress has been evident since that time, but recently there has been a renewed willingness and desire to explore the options.

1.2 A blend of NGO initiative and governmental intervention, acting in cooperation, gives the best chance of a successful resolution to the problem. NGOs concerned with conservation of FAnGR, particularly RBI as the global umbrella organisation, are interested parties, not only because they work with governmental agencies at global and national level, but also because some of their programmes are compromised by the current situation.

1.3 The primary objective of the seminar convened in London on 16 February 2010 was to develop criteria to define thresholds for endangerment, both nationally (i.e. native breeds in country of origin) and regionally. Invited delegates represented the relevant policy-making bodies (Appendix 2), and were best placed to encourage the application of harmonised criteria and thresholds to programmes for FAnGR conservation. These thresholds potentially may be used in various ways (e.g. to determine eligibility and prioritisation for support in national programmes, to calculate biodiversity indicators, to assess the trend endangerment), but a major anticipated benefit was the removal of the current confusion and contradiction that arises from lack of harmonisation.

1.4 The presence of FAO and RBI gave the seminar an intergovernmental and NGO global dimension and overview, and confirmed that common criteria can be recommended as a basis for definition of thresholds at regional / national level, but global harmonisation is unlikely to be realised at this stage, partly owing to lack of data. Therefore this report deals specifically with European issues where it is possible to harmonise principles which open the opportunity for increasing harmonisation of criteria and thresholds.

1.5 There must be a realistic assessment of the time factor. The significant changes recommended in this report may require radical changes.

2. Four steps for conservation of FAnGR

2.1 Basic definitions which give an agreed working base for native breeds and breeds at risk.

2.2 Definition of indicators of endangerment which enable identification of native breeds at risk.

2.3 Definition of factors of prioritisation which facilitate appropriate allocation of resources to breeds at risk.

2.4 Management of breeds at risk (this item does not form part of this report).

3. Basic definitions (see Appendix 1):

3.1 What is a breed? A necessary precursor to this question is an understanding of the reasons why breeds should be conserved (see Box 1).

Box 1: Value of breeds

Genetic value:

Although breeds might share a large proportion of their genome with other breeds, each possesses distinctive combinations of genes/alleles.
Some breeds have distinctive traits particularly for native/local adaptation.
Identifiable breed populations assist characterisation studies and other scientific research.

Cultural value:

Breeds are "irrevocably linked to the tradition and history of their region" or locality and represent long-term investment of time and intellect.
Some breeds have distinctive traits and native/local adaptation.
Breeds have commercial value through tourism, local crafts/products.
Conservation of breeds is protection against 'mongrelisation'.

3.1.1 'Breed' is a European concept, and the term 'population' may be more applicable in some other regions.

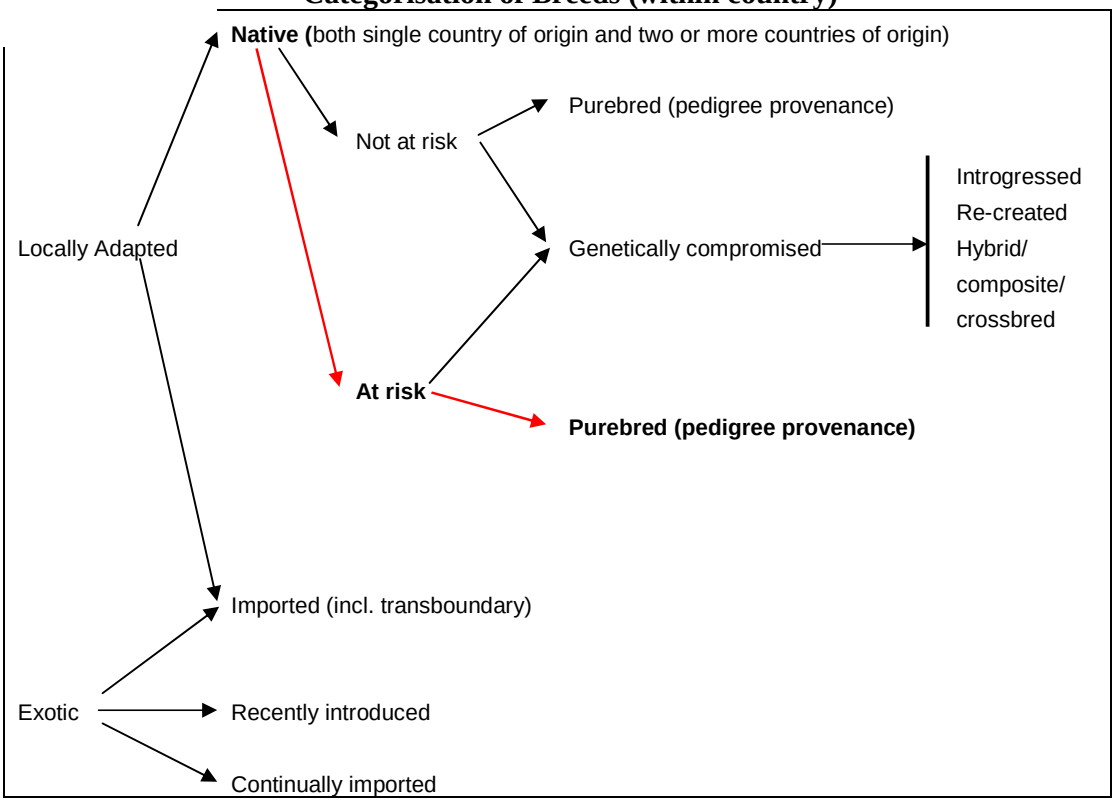
3.1.2 The starting point must be the list of breeds which fulfil the requirements of zootechnical regulations and/or are recognised by the competent authority in each country (usually governmental). In practice this may be dictated by the practical actions of breeders.

3.1.3 These breeds can then be evaluated by biological measures to screen out breeds which do not meet genetic criteria and lack purebred pedigree provenance (e.g. introgressed breeds, recent creations or new breeds, re-creations, composites and hybrids). DNA profiles facilitate the process of assignment to breed.

3.1.4 Some species (e.g. camelids) are not divided by breed, and therefore may be evaluated as species.

3.2 Categorisation of breeds. In each country breeds can be divided into exotic and native, mainstream, minority and 'at risk', purebred and 'genetically compromised' (Figure 1).

Figure 1
Categorisation of Breeds (within country)



3.3 Transboundary origins. No distinctive definition was agreed for breeds that have their origin in more than one country, e.g. Zaupel sheep in Eastern Europe.

3.4 Other definitions:

3.4.1 An extra category of 'semi-feral' was suggested to describe livestock groups with minimal management (e.g. Chillingham cattle) as opposed to those with no management (e.g. Soay sheep on the island of Hirta).

3.4.2 The definitions of native and exotic are exact opposites.

3.4.3 Allowance should be made for the possibility of an exotic breed evolving and being recognised eventually as a native breed subject to the all the following conditions being met [Note: the same conditions also would allow a genetically compromised breed to become a 'purebred']:

3.4.3.1 It has been present in the country as a breeding population for 40 years plus 6 generations (i.e. circa 76 years for bovines, 64 years for ovines, 52 years for porcines, etc)

3.4.3.2 It is effectively a closed population (i.e. minimal genetic exchange)

3.4.3.3 It has developed a type distinctly divergent from the original population, and therefore logically should be treated as a new breed.

Box 2: Exotic to Native - examples of transition:
Devon (UK) to American Milking Devon (USA)
Merino (Spain) to Australian Merino (Aus) and others
Friesian (Dutch) to American Beef Friesian (USA)
Red Poll (UK) to Jamaica Red Poll (Jamaica)
Ongole (India) to Nelore (Brazil)

4. Definition of indicators of endangerment, leading to identification of breeds at risk

4.1 Endangerment is identified by primary indicators.

4.1.1 Primary indicators result from causal factors.

4.1.2 Primary indicators are relevant to definition in this section. Causal factors will be shown under 4.9 below.

4.1.3 Indicators must be reliable, easily measurable, robust and possible to implement.

4.2 Numerical scarcity (rarity) is a primary indicator.

4.2.1 Measured in many programmes by the number of breeding females, but the number of females registered annually may be an easier and more meaningful measure.

4.2.2 Effective population size (N_e) also may offer some advantages over number of breeding females, but it additionally requires data on number of breeding males. It is more difficult to estimate especially where crossbreeding is practised, or where breeding is not random. Molecular methods may be helpful in estimating historical and current N_e.

4.2.3 It was noted that:

4.2.3.1 thresholds currently applied by the EU are not realistic to define 'at risk'.

4.2.3.2 it is necessary for species to have different thresholds because of variations in generation interval, reproductive rate and mating ratio.

4.2.3.3 cryoconserved gametes should be taken into account where appropriate (this probably would apply only where N_e is involved).

4.2.4 Three trigger points are necessary: 1) warning of risk; 2) action threshold; 3) critical risk threshold. FAO already applies a version (i.e. 100/1000 breeding females) which allows for 'critical' and 'action' awareness, but it is recommended that a threshold for 'warning' should be added (see 5.1.2 below), together with variation of thresholds according to species as shown in the example below (Table 1).

Table 1
Numerical thresholds: number of females of breeding age

Category	Cattle	Sheep	Goats	Equines	Pigs	Poultry
Critical	150	300	300	200	100	100
Action	1500	3000	3000	2000	1000	1000
Warning	3000	6000	6000	4000	2000	2000

4.2.5 Animals without provenance (i.e. those not recorded or recognised by either a breed society or a competent national authority) are not included, but should be monitored because they may be the best option to re-construct their breed in the aftermath of a catastrophic event.

4.2.6 Some systems rely entirely on numerical scarcity, but other indicators also are relevant.

4.3 Geographical concentration is a primary indicator.

4.3.1 The distribution of a breed is correlated inversely to its vulnerability in the event of a disease epidemic where death or slaughter is the expected outcome.

4.3.2 GIS provide accurate analyses of geographical concentration and a system offered by University of Worcester is in operation in UK applying an 'action' threshold of 75% of the breed population within a 25 km radius of the weighted mean centre of the breed. It should be tested in countries of varying size to demonstrate whether it is amenable to harmonisation.

4.4 Genetic erosion is an important indicator although it is linked to inbreeding and thus to numerical scarcity through N_e. It could be applied as a modifying indicator under 4.6 below.

4.4.1 Genetic erosion results from rate of inbreeding, genetic drift, introgression (see 4.5.1 below), and other impacts on the gene pool.

4.4.2 Increasingly genetic erosion is likely to be measured by molecular characterisation.

4.4.3 It was noted that rate of inbreeding was more important than level of inbreeding, but the reservations regarding N_e (4.2.2) should be noted. Breeds and populations vary in their tolerance of inbreeding and this reinforces the preference for rate of inbreeding as the factor of endangerment.

4.5 Introgression:

4.5.1 Although introgression is a direct cause of genetic erosion, it merits inclusion as a separate item as it is a direct measure of genetic integrity and has specific mention in EU legislation. This measure would be applied at an initial evaluation (see 3.1.3 above) when introgressed breeds ('genetically compromised') are screened out of 'breeds at risk' lists.

Box 3: Introgression

If introgression had been recognised in UK as an indicator of endangerment when RBST was founded, Dairy Shorthorn cattle would have been monitored closely since 1970 when the Blended Red & White cross-breeding programme commenced, and the current confusion and intermixing of pure and crossbred cattle could have been avoided. Taking a lesson from this omission, the recent use of an unregistered bull on Jersey cattle on their island of origin (previously a closed population since 1789) should trigger an immediate response from organisations concerned with the conservation of FAnGR.

4.5.2 A threshold of 2.5% introgression in any generation should trigger a warning, and 12.5% would be critical.

4.6 Modifying factors:

4.6.1 **A**necdotal evidence could be accepted in the absence of scientific evidence subject to evaluation of its reliability.

4.6.2 Stores of cryoconserved gametes.

4.6.3 Breeding populations in other countries.

4.7 Trends. It was suggested that trends are better tools than thresholds for evaluation of endangerment, especially as they are headline indicators in the CBD.

4.7.1 Trends could facilitate harmonisation by applying percentage decrease/increase rather than a standard threshold.

4.7.2 They could be applied to population size (numbers) and breed distribution, and already are in place for genetic erosion if rate of inbreeding is used rather than level of inbreeding. They are more difficult to apply to introgression because that should have an absolute threshold.

4.7.3 Trends require detailed monitoring over a period of time, and data may be more difficult to obtain.

4.8 Other factors are causal insofar as they contribute to one or more primary indicators.

4.9 Causal factors are more difficult to measure as they include socio-ecological and economic factors such as human demography (age structure of population of owners) and likelihood of a major catastrophe. They are considered below (5.3) under factors of prioritisation. There was general agreement that it was possible to agree principles, but some delegates doubted whether it was possible to agree specific thresholds.

5. Definition of factors of prioritisation to permit allocation of resources to identified breeds at risk:

5.1 Breed approach: Probability of extinction is revealed through categorisation within primary indicators of endangerment.

5.1.1 The criteria used for wild species focus on numerical and geographical indicators, and on trends (1. rate of decline by generation; 2. small declining population; 3. small, concentrated and declining population; 4. very small population; 5. unfavourable quantitative evaluation), and it was advocated that IUCN categories could be used as a guide.

5.1.2 It was noted that:

5.1.2.1 a simpler categorisation could be implemented if 'quantitative evaluation' was carried out earlier (3.1.3)

5.1.2.2 data for trends might be more difficult to obtain (4.7.3).

5.2 Genetic diversity approach:

5.2.1 Currently, there are several different analytical systems which fall into the broad division of molecular genetics and population genetics;

5.2.1.1 Molecular genetics. Tools to understand diversity include measures of between- and within-breed diversity, marginal diversity, genetic distances and

structure of breeds such as bottlenecks, admixture and N_e (current and historical). Various issues remain to be resolved, especially the conflict that breeds with large between-breed diversity values frequently have small within-breed diversity values.

5.2.1.2 Bayesian clustering techniques offer superior ability for assignment to breed. Alternatively, prioritisation could be determined according to the diversity that a breed adds to a core set of safe breeds (i.e. transboundary mainstream breeds).

5.2.1.3 Population genetics. Similar results can be obtained by different routes incorporating average relatedness (kinship), inbreeding levels, rate of inbreeding and morphological traits.

5.2.2 It was agreed that in the near future all these various procedures probably would yield similar answers. Thus harmonisation at some stage was a realistic target, but not at this point.

5.3 Other factors which may be taken into account:

5.3.1 Factors which increase risk:

5.3.1.1 Contemporary socio-ecological factors, including human demography

5.3.1.2 Likelihood of catastrophic events (e.g. FMD 2001 in UK, African horse sickness in Spain)

5.3.2 Factors which increase value:

5.3.2.1 Cultural (historical and heritage)

5.3.2.2 Landscape management

5.3.2.3 Current commercial value

5.3.3 Special traits/alleles (e.g. VRQ scrapie allele)

5.4 'Landscape' issues: Landscape issues should be incorporated into prioritisation, even if it can not be realised in the short-term. Native breeds are efficient tools for grazing management, and the possibility was mentioned of raising numerical thresholds when evaluating eligibility for environmental schemes.

5.4.1 EU acknowledges that "agrobiodiversity is an important element of biodiversity" but focuses attention on the ITPGRFA (International Treaty on Plant Genetic Resources for Food and Agriculture). It is recommended that native FAnGR are part of CBD in their own right and should receive equal attention, including aspects of access and benefit sharing.

5.4.2 In some countries the problem is exacerbated by the lack of communication between departments (e.g. Agriculture and Environment).

5.4.3 A link to the Biodiversity Action Plans implemented for wild species post-CBD was suggested with a protocol which follows broadly clauses specified under Articles 7 and 8 of the CBD for components of biodiversity in national programmes comprising initial data gathering, formulation and implementation of an action plan, evaluation of 'favourable status' through further characterisation to determine requirement for re-planning or progress to a monitoring phase.

6. Management of FAnGR

Management of FAnGR was not part of the remit of the seminar as it is dealt with more properly and effectively through decisions at a national level. Nevertheless, it is relevant to make a preliminary evaluation of the possible impact of harmonised criteria on associated issues and on the policy and programmes of those organisations with responsibility for the conservation of FAnGR. In particular, the following items were noted:

6.1 Zootechnical legislation: there is a need for enhanced knowledge transfer to ensure that breeders and breed societies are involved and that they observe and apply zootechnical legislation (see Shorthorn and Jersey examples in 4.6 above). It was questioned whether there is a case for legislation to protect high priority genetic populations.

6.2 Disease control: clear definitions of breeds and thresholds for endangerment criteria are necessary to identify those native breeds at risk which could be eligible for exemption from slaughter under disease control regulations subject to necessary biosecurity measures.

6.3 Agri-environment:

6.3.1 Conservation grazing: identification of native breeds at risk eligible for incentives.

6.3.2 Climate change: recognition of the value of native breeds with local adaptation in non-intensive grazing systems which are net sequestrators of carbon.

6.4 Biodiversity Indicators:

6.4.1 AnGR now are included in Biodiversity Indicators (e.g. trends in population size for a species, numbers of animals of native breeds as a proportion of the total, etc), and therefore identification of native breeds, and definitions of thresholds for breeds at risk, are necessary.

6.4.2 Lack of attention to AnGR still is evident. The EU Environment Council states "Commission's Communication on the EU post 2010 biodiversity Policy: ACKNOWLEDGES that agrobiodiversity is an important element of biodiversity with significant potential for improving global food security and for climate change mitigation and adaptation, INVITES Member States and the Commission to promote research and capacity development for the sustainable use of agrobiodiversity and ENCOURAGES Member States and the Commission to implement and further strengthen the ITPGRFA2") – see 5.4.1 and 5.3.2.2 above.

7. Next steps

7.1 Delivery of the outcomes from the seminar. Apart from the direct input by FAO delegates to FAO, delivery to the relevant bodies will be the responsibility of a small group of delegates (E Charvolin, N Sæther, A Georgoudis, L Alderson).

7.2 Intergovernmental, Governmental and Quasi-Governmental:

7.2.1 **FAO:** A FAO *in vivo* consultation is about to commence and outcomes from the seminar can be incorporated, and may provide useful guidelines for national systems. They are unlikely to affect existing FAO numerical thresholds, but may extend them (see 4.2.4 above). FAO has been requested by CGRFA to prepare biennial status and trends reports; the first report was prepared in 2009.

7.2.2 **CGRFA** (Commission on Genetic Resources for Food and Agriculture): a report will be made to the IT-WG-AnGR (Intergovernmental Technical Working Group on Animal Genetic Resources for Food and Agriculture) meeting on 13 November 2010

7.2.3 **ERFP**; the clear advice from the seminar to NCs was welcome, especially the definition of breeds (Appendix 1), but EU standards are political and may not be changed easily. A report will be made to the meeting in Crete in August 2010

7.2.4 **Defra:** the definitions of risk indicators were valuable, especially the inclusion of indicators other than numerical. Defra would support efforts to ensure benefits to FAnGR are maximised under CBD.

7.2.5 **EU:** A group of delegates will seek to interact with officials in Brussels, not only to explore the opportunities for harmonisation of criteria and thresholds, but also to urge an equal profile for AnGR vis-à-vis plant GR.

7.3 NGOs

7.3.1 **EAAP**: the topic has not yet been discussed but will be on the agenda of the WG-AGR in Crete in August 2010

7.3.2 **'Breeds at risk' NGOs**:

7.3.2.1 The report will be presented to the next Council meeting of each organisation.

7.3.2.2 Harmonisation is important especially to identify breeds which qualify for 'at risk' incentives, to facilitate genetic exchange between countries, and to enable the provision of consistent guidelines and advice.

7.3.2.3 The outcomes of the seminar, and the wish to adjust to harmonised criteria, are relevant for RBI globally, ELA in Europe and for all national organisations including RBST in UK.

8. Conclusions

8.1 Breed categories. The breeds relevant to programmes for conservation of FAnGR in Europe are 'native', purebred (pedigree provenance), and 'at risk'.

8.2 Native breed (also known as autochthonous and indigenous**)**

8.2.1 Definition: “Originating and initially recognised in a particular country (i.e. country of origin); a breed existing in the country where it was formed.”

8.2.2 Allowance should be made for the possibility of an exotic breed being recognised eventually as native subject to all the following conditions being met:

8.2.2.1 It has been present in the country as a breeding population for 40 years plus 6 generations.

8.2.2.2 It is effectively a closed population (i.e. minimal genetic exchange)

8.2.2.3 It has developed a type distinctly divergent from the original population (i.e. is a new breed).

8.3 Purebred

8.3.1 Breeds which do not meet genetic criteria and lack purebred pedigree provenance (e.g. introgressed breeds, recent creations, re-creations, composites, etc) should be excluded from conservation programmes following evaluation by biological measures.

8.3.2 Breed DNA profiles facilitate assignment to breed.

8.4 Breeds at risk: there are four primary indicators of endangerment which can identify native breeds at risk:

8.4.1 Numerical scarcity. An essential indicator. The FAO thresholds should be expanded to include three trigger points and variation of thresholds by species (e.g. warning threshold 2000-6000 breeding females).

8.4.2 Geographical concentration. An essential indicator. The University of Worcester threshold (75% population within 25 km of WMC) should be tested more widely, with a ‘warning’ threshold extended to a radius of 50 km.

8.4.3 Genetic erosion. Rate of inbreeding is the preferred measure with a threshold of 1% per generation, equivalent to N_e 50.

8.4.4 Introgression should be added as a separate indicator with a warning threshold of 2.5% in any generation, but applied also at the initial evaluation of a breed.

8.4.5 Indicators must be reliable, easily measurable, robust and possible to implement.

8.4.6 Harmonisation is possible for all indicators.

8.5 Factors of prioritisation

8.5.1 Probability of extinction is the primary factor of prioritisation.

8.5.1.1 Categories of prioritisation are achieved by applying degrees of severity to two primary indicators of endangerment (numerical scarcity and geographical concentration) with genetic erosion used as a modifying indicator.

8.5.1.2 Trends should be considered when sufficient data are routinely available.

8.5.1.3 Harmonisation is possible.

8.5.2 Loss of diversity is the secondary factor of prioritisation

8.5.2.1 Molecular genetics and population genetics are not totally in accord in the definition of prioritisation, but it

was agreed that in the near future the various procedures probably would yield the same answer. Both between- and within-breed diversity should be taken into account.

8.5.2.2 Harmonisation at some stage is a realistic target, but not at this point.

8.5.3 Other modifying factors should be considered.

8.6 'Landscape issues'

8.6.1 It is recommended that native FAnGR are part of CBD in their own right and should receive equal attention with plants.

8.6.2 It is recommended that animal and plant genetic resources should be linked, and their evaluation should be linked to Biodiversity Action Plans.

8.7 Management of FAnGR is determined by policy at a national level with **limited opportunity for harmonisation**, although guidelines are appropriate (e.g. FAO Secondary Guidelines for 'Management of small populations at risk')

8.8 Data availability. Lack of comprehensive and up-to-date data is an obstacle to realising several aspects of harmonisation.

8.9 Delivery. The outcomes of the seminar will be delivered to relevant bodies, both policy-makers and users, by a small group of delegates.

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2009; Classification systems and indicators to evaluate breed endangerment level – a critical review; Saether, N.; ppt presentation

2009; Indicators for the management of Animal Genetic Resources; Charvolin, E.; ppt presentation Barcelona

Appendix 1

Basic Definitions

Breed (two definitions)**:**
Legal/political/cultural: A group of domestic livestock for which geographical and/or cultural separation from phenotypically separate groups has led to acceptance of its separate identity. A population regulated by a registration procedure recognised officially by the competent authority.
Genetic: A closed population of animals with common and distinct characteristics. A sub-specific group of domestic livestock with definable characteristics that enable it to be separated by characterisation from similarly defined groups within the same species.

Wild:
Living independently of man; never domesticated nor subjected to artificial selection.

Feral:
Formerly domesticated population existing in a free-living (wild or unmanaged) state under natural selection. Populations living under a regime of minimal management may be described as 'semi-feral'.

Exotic (foreign, non-native):
Originating in a foreign country. Also includes sub-categories: 'Recently Introduced Breeds' and 'Continually Imported Breeds'.

Native (autochthonous, indigenous):
Originating and initially recognised in a particular country (i.e. country of origin); a breed existing in the country where it was formed.
Native breeds are a sub-set of 'Locally Adapted Breeds (i.e. "have been in the country for a sufficient time to be genetically adapted to one or more of the traditional production systems or environments in the country" – FAO).

Transboundary
Breeds that occur in more than one country are referred to as "transboundary" breeds (classification developed for the SoW AnGR for FAO).

Mainstream:
Significant numerical status or significant contribution to the livestock industry.

Introgressed:
Integrity compromised by the infusion of exotic genetic material.
Introgression may occur officially through grading-up programmes (i.e. it is identified and measurable) or illicitly (i.e. it is illegal and not identified).

Re-created:
Development of a population from a mixture of breeds to resemble an extinct breed.
Frequently the name of the extinct breed is adopted even though the new population has no genetic link to it.

Hybrid (composite, crossbred):
The result of a cross between genetically unlike animals; mixed ancestry.
Heterogeneous populations are genetically unpredictable.
A group of hybrid animals may become a breed after the population has been closed and interbred for a period of time.

Appendix 2

Delegates (with affiliations):

Global:

FAO (B Scherf, P Boettcher)
RBI (A Georgoudis, I Soysal, L Alderson)

Regional:

ERFP (A Georgoudis, E Charvolin, D Kompan, M Maguire, M Pontāga)
EAAP (N Sæther, A Georgoudis)
ELA (L Alderson)

Host nation:

Defra (F Radcliffe)
RBST (C Barber, T Brigstocke, L Alderson, S Jones)

Specialists:

M Bruford (University of Cardiff)
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