FAO Guidelines for the *In Vivo* conservation of Animal Genetic Resources

Chapter 2

Identification of Breeds at Risk of Endangerment

Workshop "*in vivo*" conservation of European livestock

"Challenges applying guidelines into practice"

ERFP, FAO, CGN

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FAO Guidelines – Identification of Breeds at Risk of Endangerment -

- **Update: Guidelines 1988 → 2011, maintaining simplicity**
- **Easy worldwide application**
- **Promote homogeneity across possible additional national/regional systems**

PREFACE

To discuss the methodology to identify breeds that are at risk, where conservation attention might be addressed:

- **parameters of endangerment** (rationale, main and additional parameters, modifications with respect to 1998 Guidelines)
- **parameters' thresholds for endangerment categories** (modifications with respect to 1998 Guidelines)
- **assign breeds to categories of endangerment**

Note: breeds at risk may not all have a strong conservation value, and funds could be insufficient to conserve all breeds at risk. The aspect of determining the conservation value and prioritizing breeds for conservation will be dealt in Chapter 3.

Importance of monitoring

The *Convention on Biological Diversity* specifies the need for monitoring biological diversity, with attention to that requiring urgent conservation measures. Each country is responsible.

The *Global Plan of Action* specifies: "*Complete national inventories, supported by periodic monitoring of trends and associated risks, are the basic requirements for the effective management of animal genetic resources*".

A definition of endangerment

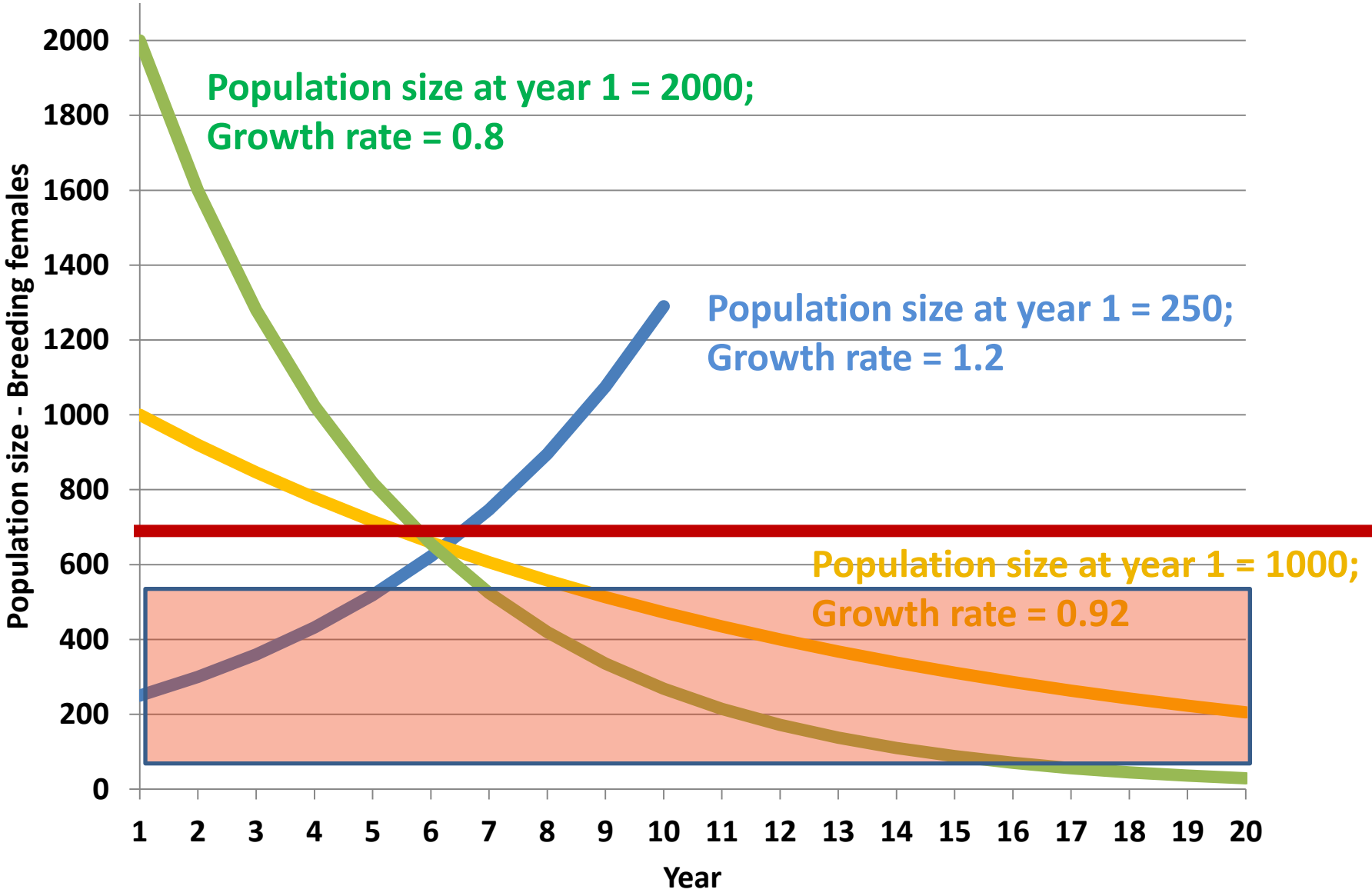
Degree of endangerment = a measure of the likelihood that, under current circumstances and expectations, the breed:

- **will become extinct in a specified period of time,**

and/or that

- **will lose through time its genetic variation at a non sustainable rate**

RATIONALE – Growth and extinction dynamics



RATIONALE – Dynamics of inbreeding and effective population size (Ne)

Inbreeding occurs at a rate per generation that is inversely proportional to the effective size of the population,

$$\Delta F = 1/(2*Ne)$$

How to compute Ne ?

$$Ne = (4*M*F)/(M+F)$$

(S. Wright, 1931) **Overestimation for livestock breeds !**

$$Ne = [(4*M*F)/(M+F)] * 0.7$$

(assuming mass selection, following Santiago and Caballero, 1995)

Note: if relatives' information is used for the estimation of breeding values, unless inbreeding control is implemented, adjustment factors <0.7 should be used !

Computing Ne - Examples

Population	N. Breeding Females (F)	N. Breeding Males (M)	N = M + F	Ne = (4MF)/(M+F)	ΔF = ½*Ne	ΔF = (½*Ne)*0.7
A	995	5	1000	19.9	0.025	0.018
B	980	20	1000	78.4	0.006	0.0045
C	500	500	1000	1000	0.0005	0.00035

ΔF per generation.

Methodology to analyse breed endangerment

Task 1 - Determine the population size, structure, trend, geographical distribution, crossbreeding activities

Task 2 - Identify breeds eligible for conservation activities

Task 3 - Update of endangerment status

Methodology to analyse breed endangerment

Task 1 - Determine the population size, structure, trend, geographical distribution, crossbreeding activities

- **Actions:**
  - **Form a task force to conduct breed surveys**
  - **Gather information about each breed**
  - **Analyse and interpret data**

Parameters required to compute population endangerment

BASE FAO SET:

- **total n. of breeding females (registered + not registered),**
- **total n. of breeding males (registered + registered),**
- **percentage of females bred to males of the same breed,**
- **trend of population size, classified as stable, decreasing, increasing, or measured by an estimate of growth rate**
- **presence of conservation programmes, and/or of populations maintained by commercial companies or research institutions, kept under strict control,**
- **population distribution, as: i.) length (km) of the maximum radius of the area within which approximately 75% of the population lies, ii.) n. of herds and trend.**

Parameters required to compute population endangerment

BASE:

Total n. of breeding females (registered + not registered)

ADDITIONAL:

N. of registered breeding females (or at least estimated % of breeding females). Registered females constitute the part of the population that we can monitor in term of age structure, reproduction capacity, accumulated inbreeding, mating structure, gene introgression from other breeds, and that can actively participate to selection programmes, if these are available;

N. of females registered each year. The annual n. of registered female replacements has been suggested as a more accurate measure of population dynamics, mainly because it reflects the current interest of breeders for farming the breed *(Sponenberg and Cristman, 1995; Alderson,2009)*;

Parameters required to compute population endangerment

BASE:

Total n. of breeding males (registered + not registered)

ADDITIONAL:

n. of males used in artificial insemination. In case of artificial insemination, contribution of males to the next generation can be highly heterogeneous, accelerating inbreeding rate

presence/type of selection practiced in the breeding programme (mass selection, BLUP index selection, optimum contribution selection, etc.)

presence of recent or less recent bottlenecks (severe restrictions in the n. of males or females in a past generation)

Parameters required to compute population endangerment

BASE:

percentage of females bred to males of the same breed, considering that females used for crossing do not contribute to population renewal

ADDITIONAL:

% of introgression per generation through crossing with other breeds;

Parameters required to compute population endangerment

BASE:

expected trend of population size, classified as stable, decreasing, increasing, or, whenever possible, measured by an estimate of growth rate during the last years ,

ADDITIONAL:

average age of farmers, as indication of generational transfer of herds and as such an early indicator of breed dynamics

$$N_{t1} = N_{t0} * r$$

How to estimate growth rate (r)?

We need at least two censuses at a time interval of at least a number of years of about one generation interval (species dependent).

$$r = \text{anti-log}\left((\log N_2 - \log N_1) / t \right)$$

where N_1 and N_2 are respectively the first and the second census of each breed and t the time interval in years among the two censuses.

How to estimate growth rate (r): EXAMPLE

Data:

year 2000 = 1000 mares

year 2008 = 800 mares

(Note: we refer to the horse species, then the period analysed encompasses about one generation interval (if we refer to the poultry species, 8 generation intervals)).

Computation:

$$r = \text{anti-log}((\log 800 - \log 1000)/8) = .988$$

We can now compute the population size expected after 20 years, in 2028, as

$$N_t = N_0 r^t.$$

N. mares in 2028 = $800*(.988^{20}) = 628.$

Parameters required to compute population endangerment

BASE:

presence of conservation programmes, and/or of populations maintained by commercial companies or research institutions, kept under strict control,

ADDITIONAL:

presence of active breeder associations, that is expected to increase the resilience of the breed;

Parameters required to compute population endangerment

BASE:

population distribution, measured as: i.) length (km) of the maximum radius of the area within which approximately 75% of the population lies, ii.) number of herds and its trend.

ADDITIONAL:

risk of catastrophes such as epidemics, drought, floods.

Additional parameters useful to compute population endangerment

- cultural attachment of farmers to their breed, that is expected to increase the resilience of the breed;
- economic competitiveness of the breed with other breeds and/or economic activities in the area, considering that population decline has been often associated to lack of economic competitiveness;
- national and regional trends in animal production;
- national GP and the contribution of agricultural products to national GP;
- economic and political stability of the country/region;
- etc.

Statistical analysis allows to gain insights in the factors affecting population dynamics !

Herd code	herd size	reproduction	farmer's age
A	8	natural	73
B	10	artificial	70
C	60	artificial	55
D	15	natural	70
E	175	artificial	45
F	70	artificial	40
G	12	natural	66
H	310	artificial	42

Herd size: mean = 82.5; standard deviation = 107.8; range 8-310.
Herd size distribution: herd <50 (50%), herd 50-100 (25%), herd >100 (25%).

Farmer's age: mean = 57.6; standard deviation = 13.8; range = 40-73.
Correlation between herd size and farmer's age = -.76.

Frequency of artificial insemination = 62.5%.
Frequency of artificial insemination as a function of herd size = herd < 50, 25%; herd =>50, 100%.

Methodology to analyse breed endangement

Task 2: Identify breeds eligible for conservation activities

Actions:

- Assign breeds to categories of endangerment
- Refine categories of risks by accounting for other factors

Categories of endangerment

modifications with respect to FAO Guidelines 1998

NOTE: Species differ in reproductive capacity, measured as number of breeding females produced by females during their life, and generation length.

For the sake of simplicity we have not considered the species in the definition of the categories above, and the eighth categories are common to all species.

Nevertheless we propose, whenever possible, to consider at least two species-categories, the first category characterized by low reproductive capacity (horse, cattle, sheep, goat), the second characterized by high reproductive capacity (pig, rabbit, chicken) having different endangerment thresholds in terms of number of breeding females.

Categories of endangerment

modifications with respect to FAO Guidelines 1998

Extinct

It is no longer possible to easily recreate the breed population.

This situation becomes absolute when there are both no breeding males (or stored semen), no breeding females (or oocytes) nor embryos remaining. The presence of sufficient cryopreserved material could allow for the reconstruction of a breed, even if no live animals are available (see *FAO Guidelines for Cryoconservation of Animal Genetic Resources*).

For all practical purposes, extinction may be reached well before the loss of the last animal, gamete or embryo, because a small number of living animals represents a very small amount of genetic information not able to keep the breed viable.

Categories of endangerment

modifications with respect to FAO Guidelines 1998

Critical

the total number of breeding females mated to males of the same breed is <100 (<200 for Low-RC species) ; or the overall population is >100 (>200 for Low-RC species) but the number is decreasing and expected to reach the size of 100 females within 10 years; or the total n. of breeding males is less than or equal to 5 (or expected rate of inbreeding per generation of 3% or greater);

Critical maintained (subcategory)

For breeds Critical, but that have active conservation programmes (including cryoconservation) in place, or populations that are maintained by commercial companies or research institutions.

Categories of endangerment

modifications with respect to FAO Guidelines 1998

Endangered

the total n. of breeding females mated to males of the same breed is between 100 and 1000 (200 and 2000 for Low-RC species) ; or the overall population size is > 1000 (>2000 for Low-RC species) but decreasing in size and expected to be between 100 and 1000 (200 and 2000 for Low-RC species) within ten years; or the total number of breeding males is less than or equal to 5 and 15 (or ΔF expected per generation is between 1% and 3%);

Endangered maintained (Subcategory)

For breedsEndangered, but that have active conservation programmes (including cryoconservation) in place, or populations that are maintained by commercial companies or research institutions.

Categories of endangerment

modifications with respect to FAO Guidelines 1998

Vulnerable

the total n. of breeding females mated to purebred males is between 1000 and 2000 (2000 and 4000 for Low—RC species) or the overall population size is >2000 (>4000 for Low-RC species) but decreasing and expected to reach a size between 1000 and 2000 (2000 and 4000 for Low—RC species) within ten years; or the total n. of breeding males is between 15 and 35 (or ΔF expected per generation is between 0.5% and 1%);

Categories of endangerment

modifications with respect to FAO Guidelines 1998

Not at risk

A breed is categorized as *Not at risk* if the population status is known and the breed does not fall in the categories of Critical or Endangered, (and relative sub-categories) or Vulnerable. In addition, a breed can be considered *Not-at-risk* even if the precise population size is not known, but existing knowledge is sufficient to ensure that the population size exceeds the respective thresholds for the Vulnerable category. Nevertheless, for such breeds, the implementation of a survey to obtain a more precise estimate of population size is strongly recommended.

Unknown

This category is self-explanatory and calls for urgent action. A population survey is needed, the breed could be Critical, Endangered or Vulnerable !

		Demographic criteria N. breeding females * current , or expected in ten years time							Genetic criteria Inbreeding rate / generation (%)		
Species category *	**Category**	<100	<200	=>100 <1000	=>200 <2000	=>1000 <2000	=>2000 <4000	**and or**	> 3	>1 =<3	>.5 =<1
High repr. capacity	Critical										
	Endangered										
	Vulnerable										
Low repr. capacity	Critical										
	Endangered										
	Vulnerable										

Refine categorisation of risks accounting for other factors

(To be done whenever data are available or can be collected)

Breed distribution

RATIONALE: Concentration of a major part of the population in a restricted geographical area or in a few herds would usually place it at greater risk to the consequences of catastrophic events such as disease outbreak, climatic or political upheaval.

When the occurrence of such events is considered to be possible, breeds with a concentrated distribution (approximately 75% of the population lies within a limited area (radius), or as very low n. of herds) should be upgraded to the next category with increased risk:

- **from vulnerable to endangered**
- **from endangered to critical**

Such an analysis has been developed for United Kingdom, mainly considering risk of epidemic diseases but also breed dependence from specific small habitats (thresholds: radius 12,5 km, 25 km, 50 km) (Alderson, 2009).

When more information is available, when categorization of a particular breed is borderline, additional analysis should be undertaken.

For example:

- **the demographical and inbreeding aspects can be more precisely evaluated by considering the number of registered females,**
- **number of males used in artificial insemination,**
- **pedigree data and information about historical bottlenecks will yield information about genetic variability**
- **etc.**

Which relation between categories of endangerment and need for action ?

Populations categorized as **Critical** need urgent active management (**action**) and they might have already lost a major part of their variation. Urgent actions then include to determine the genetic status and to estimate the probability of recovering from the critical status.

Populations categorized as **Endangered** need action to develop and implement a conservation/development programme (**action**), to avoid reaching the critical status, and possibly to upgrade to the vulnerable status.

Populations categorized as **Vulnerable** require the constant monitoring of their dynamics (**warning**) - preventing breeds from reaching severe categories of endangerment risk is preferable to the need for therapeutic actions.

Populations categorized as **Unknown** need **urgent analysis action** to determine their endangerment status.

Disseminate information about risk to stakeholders

It is important to communicate to all relevant stakeholders the results of the analysis of the breeds at risk.

The effective dissemination of information regarding the endangerment of breeds should also raise awareness among the general public and policy makers.

The exchange of information about breeds at risk is also important on the international level. FAO National Coordinators for AnGR should obtain access to all information that may be useful to update the DAD-IS and EFABIS databases.

Methodology to analyse breed endangerment

Task 3: Update of endangerment status

Livestock production systems in many areas of the world are being transformed at a high rate.
It is then advisable to set up within each country a methodology to regularly update the endangerment status of breeds, and early warning and information systems.

Note: changes between one method to newer one needs to be analysed to ensure comparison between older and newer data.

Conclusions

- **FAO has selected some simple parameters that can be known in most situations, to allow most countries to estimate degree of endangerment of their breeds.**

Different parameters and procedures have been proposed and/or are in use to estimate the degree of endangerment *(for reviews see: Boettcher et al., 2010; Alderson, 2009; Gandini et al, 2004).*

- **In those countries where more information are available, <u>additional</u> more accurate estimates can be proposed, but it is strongly suggested to work as much as possible for harmonization among methodologies.**

- **In case of breeds farmed in more than one country, degree of endangerment should be computed at the national level and, in collaboration with the other countries hosting the breed, at the regional or global level**