DISCUSSION ON THE OBLIGATORY POPULATION SIZE OF THE PRESERVED DOMESTIC ANIMAL POPULATIONS

I. Bodó

The problem: *howmany animals are needed for the preservation programmes, what is the limit for endangeredness* has been discussed many times at different meetings. The FAO World Watch List (Loftus, Scherf 1993) used a cathegory system however in the Genetic Diversity of European Livestock Breeds (Simon, Buchenauer 1993) the utilization of the effective number can be found. Thus the discussion of the problem is not yet finished.

Establishing a system for the mimimum number of domestic animal populations to be preserved is important for two main reasons:

- It is necessary to create a World Watch List or Regional, National Lists of domestic animal breeds in order to observe the grade of vulnerability, and also the risk of extinction;
- It is also indispensable to recommend a population size for each population deserving to be involved in preservation programmes in situ.

The contradiction in the problem

There are many uncertainties in the determination of the population size of a given domestic animal breed to be preserved. The number of existing damaging (lethal) factors, the initial gene frequency to be maintained is unknown. Therefore, also calculating with the risk of disasters, for maintaining the whole genetic variation, of the population and to minimise the risk of inbreeding and genetic drift, as many animals as possible must be kept.

On the other hand the domestic animals involved in preservation programmes are not commercial, profitable animals in most of the cases, therefore their maintenance should be based on the subsidies of societis or of the government. This is the reason why the expenses and logically the population size must be as small as possible.

Therefore a balanced compromise should be found.

The scientific approach

The classical calculations and new text books of population genetics use the effective population size Ne, which adjust the actual number of active breeding animals to the 1:1 sex ratio (e.g. Wright 1921, Fisher 1946, Falconer 1964,

Imre Bódo, University of Veterinary Science, Budapest, Hungary

Fewson 1966, Pirchner 1979, Dohy 1989 etc.). The level of inbreeding and the risk of degeneration and extinction is increasing when the population size decreases.

In the latest literature more sophisticated forms are used (e.g.: Latter 1959, Crow, Kimura 1971, Hill 1972, Rochambeau, Chevalet 1991) in order to express the different aspects of the effective population size (e.g. overalapping generations, non random matings etc.).

The conclusion of scientists is, that the recommended effective population size for the maintenance of a given breed should be between 50 and 200. Over Ne 200 the inbreeding effect decreases very slowly however under Ne 50 the risk of genetic drift is too high.

There are some considerations because of which we can not use to effective population size in itself alone in preservation programmes. The following problems arise first of all in slow reproducing species.

- The calculation of Ne is sometimes unceratin because of the changing number and secret use of males the percentage of the offspring of different sires in the next breeding generation will be decided and known only later.
- Effective population size is based on the actual number or breeding males and females however sires may be changed year by year influencing positively the variety of replacement animals.
- The relationship between males can be a misleading factor.
- In the effective population size the initial situation (founder effect, bottle neck syndrome) is disregarded, therefore not the actual inbreeding rate, only its development can be estimated.
- The existence or lack of recessive, damaging factors is unknown and can not be included in Ne.
- Nearly all the geneticists using estimations based upon Ne suppose random mating, in the practice, however, also sophisticated mating systems are used.
- Practical breeders, in general, are not familiar with N_e.

For a good pedigree breeder from preservation aspect the most important moment is the decision for replacement. The mating with a given effective number is an indispensable preparation for producing an appropriately selected new stock to replace culled breeding females and males. Without a correctly high Ne to get an appropriate replacement is not possible.

Some aspects for a replacement system:

- Each breeding animals must be substituted by his/her offspring;
- The males lines and female families should be maintained;
- The frequency of all possible traits (morphology and production) must not be changed;
- The permanent frequency of immunogenetic traits (inc. DNA) should be taken into consideration, if it is possible;
- Generation interval should be kept as long as adequate to the given breed;
- Priorities must not be given to favourite progeny groups in replacement;

- In order to breed correctly according these rules reserve animals should be kept.
- The most important precondition for the replacement in preserved herds is the high variety of young animals produced by many males (narrow sex ratio, i.e. high Ne in the matings of precedent years).

Practical approach

There are other not scientific, simple practical approaches as well, using only the necessary number of males and females. The differences between the opinions are enormous e.g.: for ewes the smallest recommendation is 60 (Smith 1984) and the highest 1500 heads (Alderson 1981). Therefore the global use can not be recommended although the local use of such figures is very effective.

Historical examples

The theoretical considerations and artificially made systems can be completed by some examples taken from the practice of animal breeding,

Emperor Napoleon got a flock of merino sheep from Spain as a gift about 190 years ago. This flock is the famous Rambouillet Merino and it was kept without immigration with not more than 100-120 ewes in the flock from the beginning (Perret 1985).

As a consequence of the activity of Rare Breeds Survival Trust in Great Britain the number of Portland females grew out of 85 to 341 and the number of cows and heifers of White Park cattle out of 65 to 138 between 1974 and 1986 (Alderson 1989).

The stock of Soay sheep was left in an uninhabited island and its population consisted of 20 rams 44 ewes, 22 male lambs and 21 female lambs (Alderson 1989).

The most interesting population of the world from preservation aspect is that of the Chilingham cattle. It has been an inbred population of some dozen heads since 1270. It is a speciality of Great Britain the most traditionalist country of the world. After the severe winter of 1974 the herd consisted of 8 cows and 5 bulls without young animals. During the subsequent ten years the population increased to 8 bulls 29 cows and 7 calves. After all, one can understand the extreme homogeneity of this herd concerning the biochemical polymorphisms as well (Wallis 1986).

In Switzerland a small swine population (Wollhaarige Weideschwein), having however some problems of reproduction, is registered, they have six ancestors, two of which were boars and four sows (Marx 1990).

In the former USSR according to the book of Dmitriev and Ernst (1989) 5 cattle breeds, 6 chicken breeds, 8 goose breeds, 7 turkey breeds and 1 guinea fowl breed did not exceed 1000 heads in population size.

The Murnau-Werdenfelser cattle are preserved in Bavaria with 17 bulls and 250 cows. These figures concerning the European Braunvieh (without American Brown Swiss) are 11 and 500 respectively, 7000 doses of semen of 23 bulls are also available. An effective population size of 51 can be calculated, but the situation will become less

favourable because of the old age of the cows (H i r s c h et al. 1990).

C r a w f o r d (1989) reported, that he could maintain poultry populations with yearly replacement of 18 males and 50 females since many decades.

The number of Hungarian Grey cows was less than 200 before the preservation programme began in the 1960s (B o d o 1985). The Hungarian Cikta breeds has been kept in a flock of 250 ewes for 25 years without any problem. The population size of the different Lippizan studs in the neighbouring Danubian countries has not been more than some dozens each and the use of the males from the other countries began only some years ago (B o d o - P a t a k i 1984).

R y d e r (1985) wrote that all the captive Przewalski horses trace their ancestry to 13 founder animals. The average of their inbreeding coefficients is about 0,23 (max.: 0,597).

It would not be suitable to recommend the smallest numbers from the practice, althought it is true that the mentioned populations survived, but the effect of genetic drift is in most cases not registered. One can not be sure that a lucky case repeats.

The grade of the risk, category systems

Realising that the more accurate solution can not everywhere be used many categorisations were also elaborated. Such systems are elaborated for wild animals by the IUCN in order to prepare the RED DATA BOOK and also for domestic animals in Italy (R o g n o n y 1980), etc.

Only the system of American Livestock Breeds Conservancy (B i x b y et al. 1994). be mentioned here containing the following categories:

Critical - Fewer than 200 North American annual registrations and estimated fewer than 2000 global population

Rare - Fewer than 1000 annual North American registrations and estimated fewer than 5000 global population

Watch - Fewer than 2500 North American registrations and estimated fewer than 10000 global population

Study - Breeds which are of genetic interest but lack documentatiton or definition.

The following table shows a system which was discussed in 1990 at the Edinburgh World Conference (B o d o 1990)

Recently in the WORLD WATCH LIST published by FAO (L o f t u s , S c h e r f 1993) the figures of the table mentioned are used with some adjustment. The EAAP system, developed by S i m o n and B u c h e n a u e r (1993) uses Ne completed by including the expected increase of inbreeding during the next 50 years and the population trend, absence of herdbook, percentage of pure breeding and incrossing as well.

The proposed system

The figures used by FAO and discussed at many conferences seem to be more and more accepted for expressing the status of endangeredness. These categories, give also in the table, are well defined ones and for each consecutive categories the following different activities are suitable:

- *Normal status,* (above 10000 females) seems to pose no genetic problems, therefore no intervention is necessary. However we must taken into consideration that even in this case the effective number owing to the sex ratio can fall below the level needed.

In normal status, it is obvious that population is not in danger of extinction, it can reproduce without genetic loss and there are no visible changes in the population size. In the literature the total number is used for this category, here the females' number is proposed because

- the total number is an easily fluctuating figure owing to the seasonal birth and sale,
- in the other categories the females' number is more suitable.

- *Insecure status* (5000-10000 females) means that some disadvantageous effects can fasten the decreasing tendency and endanger the existence of the population.

The crossbreeding and the use of the semen of exotic males, the pressure of international firms can make quick changes in a short time. That is why some preventive measures must be taken into consideration.

- *Vulnerable status* (1000 - 5000 females). In this case the problem is increasing and the population is threatened with the negative tendencies of extinction.

Then official measures should set up. e.g. the establishment or renewal of breeders' associations, propaganda, the subsidisation or encouraging of the marketing etc.

Risk categories for domestic animals

Status	Number of breeding females	Estimated average effective population size when the sex ratio:				
		5:1	10:1	30:1	50:1	1000:1
Normal	>10 000	>6666	>3636	>1289	>784	>40
Insecure	5 10 000	333 - 6665	1818-3635	645-1288	392-784	20- 39
Vulnerable	1 5 000	667-3332	364-1817	129-644	78-391	4-19
Endangered	100-1000	67-666	36-363	13-128	8-77	-
Critical	<100	<67	<36	<13	<8	-
Extinct	The resuscitation of the population is impossible, even when after a crucial bottle neck syndrome another genetic variance comes into being.					

- *Endangered status* (100-1000 females) implies, that the breed is in danger of extinction, because its effective population size can be inadequate to prevent a genetic loss in future generations. An increase of the degree of inbreeding is unavoidable and threatens the vitality of animals and there is a real danger of loss either spontaneously (e.g. disease) or due to negligence by man. In this case the methods of preservation must be enacted to save the population in question (cryogenic storage, narrow sex ratio, sophisticated mating systems, control of biochemical polymorphisms etc.) The grade of the danger is not the same for a population with 100 and for another with 1000 breeding females. For each population the adequate number of females and males must be elaborated within the framework of this category.

- *Critical status* (below 100 females) is an extension on the former one, and

indicates that the populatin is close to extinction. The first action must be the increase of the population size. In this status the genetic variability is often already reduced so that the population cannot be considered the same as the ancient breed. In spite of the fact that there are some exceptional populations having been bred for many years within this status, the critical status is not suitable for the permanent maintenance of genetic variability of a former populous breed.

- *Extinct status.* It has also some meaning, because sometimes the extinction of a breed must be confessed, if its recreation with the same gene structure is impossible after a bottle neck.

This category system can well be used globally. For each individual population, however, a detailed special minimum number of breeding females and males should be given. The following aspects are useful for the elaboration:

- the bigger the genetic variety is, the more animals should be involved;
- a longer generation interval let reduce the herd size;
- when only few herd (owners) can be involved, more animals should be kept;
- the sensitivity of the given population or the existing damaging genes (if known) should also be taken into consideration;
- the cryogenic storage, where its use is possible, makes easier the correct preservation
- the known immunogenetic factors (inc. DNA) afford an estimation of genetic variety and so an adequate contribution to the calculation of minimum number is possible;
- the possible sex ratio is also important. A higher Ne let keep a smaller herd. For a minimum Ne the sophisticate calculations should be need for slow reproducing animals;
- a reserve herd (for safety and replacement aspects) is indispensable;
- some practical reasons may to be taken into consideration (e.g. an economic herd size can be bigger then genetically required, or the reproduction can be influenced by the environment).

Conclusion

I am convinced that for general use i.e. for World Watch List of for regional endangeredeness registration of domestic animal populations the proposed category system is useful.

It is not too much sophisticated but it is sensible enough to follow the decreasing number of livestock breeds and it makes possible the adequate intervention when necessary. Of coures the number of males (i.e. Ne) must be added correctly, wherever it is possible.

For the individual cases, however, more detailed methods must be elaborated. The most important point is the replacement first of all when breeding low reproducing breeds. The regulation of the replacement must be in order to preserve the gene structure of the parent population as far as possible for many centuries and the number of males, and females (included Ne) must serve this main purpose.

In the framework of the given categories the minimum number of the endangered

population to be preserved may be between 100 and 1000. Using reserve herds it is advisable to fix the population size between 1000 and 5000. Within these figures it is possible and obligatory to create an own special minimum number for each individual case. Within the given category the sensibility of a given species, or breed, the mating system, management, effect of the given environment, the possible generation interval etc. may be taken into consideration.

Thus, this special population size can be protected by the government or other institutions and it is an obligation of all the nations to preserve their natinal native breeds in such an elaborated population size.

REFERENCES

1. Alderson, L. (1981): The conservation of animal genetic resources in UK FAO An. Prod. Health Paper. 24. Rome. 53-76.p.
2. Alderson, L. (1989): The chance to survive. A.H. Jolly Ltd. Yelvertoft Manor. 143. p.
3. Bixby, D.E. Christman, C.J., Ehrman, C.J., Sponenberg, D.P. (1994): Taking Stock (The North American Livestock Census) McDonald and Woodword Blackburg, Virginia 182.p.
4. Bodó I. (1985): Hungarian activites on the conservation of domestic animal genetic resources. FAO. AGRI. 4. 16-22.p.
5. Bodó I., Pataki B. (1984): Special problems in conservation of traditional horse lines in small herds. 35th Ann. Meet. EAAP. den Haag. H. 3b.3.5.p.
6. Bodó I. (1990): Special problems of conservation of domestic livestock. 4th WCGALP Edinburgh Proc. XIV. 427-433.p.
7. Crawford, R. (1989): Experience with in situ preservation in poultry breeds. FAO. Expert consultation. Rome. AGR/GL/89/20. Sept. Manuscript 13.p.
8. Crow.J.F., Kimura, M.(1971): An introduction to population genetics. Theory. Harper and Row Publishers, New York, Evanston and London.
9. Dmitriev, N.G., Ernst, L.K. (1989): Animal genetic resources of USSR. FAO. An. Prod. Health Paper 65. Rome. 517.p.
10. Dohy J. (1989): Az állattenyésztés genetikai alapjai. Budapest. Magveto Kiadó. 303. p.
11. Falconer, D.S. (1964): Introduction to Quantitative Genetics. Oliver and Body. Edinburgh-London.
12. Fewson, D. (1966): Auswahl von Selektionsmerkmahlen. Züchtungskunde 38. Stuttgart. 115.p.
13. Fischer, R.A. (1946): Statistical methods for research workers 10th ed. London Oliver and Body.
14. Hill., W.G. (1972): Effective size of populations with overlapping generations Theor. Pop. Biol. 3. 278-289.p.
15. Hirsch, M., Kustermann, W., Pirchner, F. (1990): Zuchtverbesserung zahlenmässig kleiner Rinderpopulationen in Bayern. EAAP. 41 st Ann. Meeting. Toulouse.
16. Latter, B.D.H. (1959): Aust. J. Biol. Sci. 12. 500-505.p.
17. Loftus, R., Scherf. B. (1993): World Watch List for domestic animal diversity FAO Rome. 376.p.
18. Marx, A. (1990): Das wollhaaringe Weideschwein in der Schweiz. Diplomarbeit. Zollikofen. Manuscript. 38.p.
19. Perret, G. (1985): Races ovines. ITOVIC ed. 287-290.p.
20. Pirchner, F. (1979): Populationgenetick in der Tierzucht. Hamburg - Berlin
21. Rochambeau, Chevalet, G. (1991): Genetic principles of conservation Proc. 4th WCGALP Edinburgh 434-442.p.
22. Rognony, G. (1980): Defence of animal genetic resources. FAO/UNEP Technical consultation. Rome. Manuscript. 7.p.
23. Rydner, O.A. (1985): Genetic analysis of Przewalski horses in captivity The Przewalski horse. FAO. An. Prod. Health Paper 61. 43-66.p.

24. Simon, D., Buchenauer, D. (1993): Genetic diversity of European Livestock Breeds. EAAP. Pub. 66. 581.p.
25. Smith, C. (1984): Genetic aspects of conservation in farm animals. Livestock Production Science 11:37-48.p.
26. Wallis, D. (1986): The rare breeds handbook. Blandford Press Poole. New York-Sidney 157.p.
27. Wrght, S. (1921): Systems of mating. Genetics Princetown Mass. USA. 11-178.p.