Minimal and effective population size of conserved Lithuanian farm animals

Violeta Razmaitė,
Rūta Šveistienė

Lithuanian Institute of Animal Science,
R. Žebenkos 12,
LT-5125 Baisogala,
Radviliškis distr., Lithuania;
E-mail: lgi@mail.lgi.lt

Conservation *in-situ* activities had prevented the total disappearance of old indigenous farm animal breeds. Adopting special mating schemes for populations subdivided into at least 4 non-related groups allows to minimize the increasing coefficient of inbreeding for a longer time. Nowadays the status of old indigenous breeds could be categorized as critical-maintained breeds.

It is important to counteract the decline processes of other Lithuanian endangered breeds before their size is too small. Genetic improvement is the main option available to stop and reverse the decline process into a self-sustaining status. The effective population size is 70 males to 700 females (1:10), the populations for horses can be considered effective with 55 males and 1000 females, but as regards the population of Lithuanian White pigs, their number should be no less than 2000 females and 200 males if the breed is to remain the main dam pig breed in commercial crossbreeding combinations and be self-sustainable.

Key words: breeds, old indigenous, population, critical-maintained

INTRODUCTION

Some of the indigenous farm animal breeds of Lithuania have become extinct, others, such as native wattle pigs, Žemaitukai horses, ash-grey and white-backed cattle, native coarsewooled sheep, Vištinės geese were on the verge of extinction. Unfavourable conditions have formed for the breeds developed in the 20th century, such as Lithuanian White pigs, Heavy-type Žemaitukai and Heavy-draught horses, Lithuanian Blackface sheep, and they need action plans for conservation to be based upon the sustainable use in active breeding populations. In 1992, the United Nations Conference (2nd) on the Environment in Rio de Janeiro recognized the importance of farm animal genetic resources in Agenda 21 and in the Convention on Biological Diversity (Danel, 1994; FAO, 1999; Oldenbroek, 1999). Lithuania has signed this convention, which resulted in political and social awareness of national animal genetic resources and activities to conserve them. Conservation of Lithuanian farm animal genetic resources was initiated in 1993 and based upon the primary goal to save the old breeds. J. S. Šveistys, the initiator and organizer of conservation of farm animal breeds, was of the opinion that the sequence of conservation and research of the critical breeds should be formation of the herds and maintenance of their genealogical structure, complete investigation of biological and farming qualities, preparation of evaluation principles and systems and search for possibilities of their introduction into the general breeding scheme of corresponding animal species (Razmaitė, 2001). *In situ* conservation was preferred, because it proved to be effective in attaining such objectives as opportunities to meet future demands, insurance against future changes in production circumstances, cultural and historical value, ecological value and opportunities for research. Besides, there is wide consensus on conservation by maintaining populations within their production systems, when the development of the breed can continue, which means selection for economic profit as far as it is possible within the limits of a small population and what facilitates adaptation to changing circumstances (Oldenbroek, 1999). Therefore, the purpose of the present study was to work out the conservation strategy, determine the minimal and effective population size.

MATERIALS AND METHODS

In-situ conservation principles of old Lithuanian critical farm animal breeds were developed on the basis of the material collected during the expeditions for the search of indigenous animal and data records of animal herds kept and studied at the Li-

thuanian Institute of Animal Science. These principles are also based on the experience in breeding small herds and on the criteria and global strategy of FAO for the management of farm animal genetic resources (Bodo, 1999; Danel, 1997; FAO, 1999; Šveistys, 1982). The status of other Lithuanian animal breeds was evaluated by their monitoring. The effective population size was expressed as

$$Ne = 4NmNf / (Nm + Nf),$$

where Nm is the number of breeding males, Nf is the number of breeding females (Maijala, 1999).

The minimal size of the population was determined according to the possibility for isolated breeding of animals without considerable increase of inbreeding and according to the evaluation standards for breeding animals.

RESULTS AND DISCUSSION

During the expeditions to the remote parts of our country the remaining individuals of critical breeds were found and collected with the aim to establish herds of the corresponding breeds. Due to their low present socio-economic value, high needs in guidelines for conservation activities, signaling schemes and continuous monitoring, herds of old critical Lithuanian animal breeds were established at the Lithuanian Institute of Animal Science. The first decision in setting up a conservation scheme was to carry forward the existing variability in the breeds. This is mainly concerned with the size of available resources, which could be adjusted by choosing individuals for conservation from different lines and by carrying out planned mating between the chosen animals. This could be most efficiently achieved if the pedigree information were available in the population. In the case of old Lithuanian animal breeds, except Žemaitukai horses, there were no pedigree records available, and we had to use other possible information, such as geographical accounts, to avoid redundant use of individuals, unnecessarily increasing the average kinship. To meet these requirements, we divided founders into at least four disconnected pedigree animal groups and developed mating plans on the basis of experience in the pig breeding system, prepared by J. Šveistys (1982). The progeny of the founder generation in one group are mated with the progeny of the founder generation in another non-related group. After the progeny of the generation is available, their mating with the progeny of the first generation in the third group is carried out in order to obtain the second generation, etc. (Table 1). Application of such circular mating schemes with four disconnected pedigree animal groups allows to minimize inbreeding. The coefficient of inbreeding (by Wright) amounted to only 6.2% after four generations. On application of similar mating schemes with eight disconnected pedigree animal groups, the coefficient of inbreeding should amount to only 3.12% after eight generations (Šveistys, 1982). It was a great achievement to form four non-related groups (genealogical lines and families) of Lithuanian old critical indigenous breeds.

The minimal number is an important parameter for planning the conservation of isolated populations for possible use in the long-term future, but there are no possibilities to increase significantly the size of old breeds. According to the prepared testing standards for breeding animals, the boars may be evaluated for the quality of the progeny out of 4 sows, stallions out of 3–6 mares, rams out of 3–5 ewes. Circular mating schemes are based on crossing four disconnected groups and need 1–2 males for each group. Application of these rules and schemes allows to minimize the size of herds (mini populations) to 20–40 breeding animals. Therefore,

Table 1. **Circular breeding scheme for small populations**

Generation	Disconnected pedigree animal groups							
	1		2		3		4	
	Female	Male	Female	Male	Female	Male	Female	Male
Founder generation, parents	A × B		C × D		E × F		G × H	
Daughters, sons	A_1	B_1	C_1	D_1	E_1	F_1	G_1	H_1
1st generation, parents	$A_1 \times H_1$		$C_1 \times B_1$		$E_1 \times D_1$		$G_1 \times F_1$	
Daughters, sons	A_2	H_2	C_2	B_2	E_2	D_2	G_2	F_2
2nd generation, parents	$A_2 \times F_2$		$C_2 \times H_2$		$E_2 \times B_2$		$G_2 \times D_2$	
Daughters, sons	A_3	F_3	C_3	H_3	E_3	B_3	G_3	D_3
3rd generation, parents	$A_3 \times D_3$		$C_3 \times F_3$		$E_3 \times H_3$		$G_3 \times B_3$	
Daughters, sons	A_4	D_4	C_4	F_4	E_4	H_4	G_4	B_4
4th generation, parents	$A_4 \times B_4$		$C_4 \times D_4$		$E_4 \times F_4$		$G_4 \times H_4$	
Daughters, sons	A_5	B_5	C_5	D_5	E_5	F_5	G_5	H_5

conservation of old breeds should be based on at least this number of animals.

The number of animals in these conserved small herds is very low (Table 2). The conservated herd of Lithuanian wattle pigs had 19 founders, of which five were non-related boars and fourteen sows from five non-related groups. The population of Lithuanian Vištinės geese was restored from 100 eggs. The population of Žemaitukai horses in 1994 totalled 30 purebred horses with recorded pedigree. There is only one isolated herd of Lithuanian indigenous wattle pigs and one flock of Vištinės geese, and when animals are located only in one herd, there is a risk that accidents, disease outbreaks, disposal of the herd for economic, health, age or other unforeseen reasons and circumstances will increase the danger of breed disappearance. In Germany, less than 10 herds is considered to place the breed in a threatened status, because the risk of herd dispersion has increased due to over-production and economic depression, which may also affect all the population (DGL, 1991). Therefore, the goal of the Lithuanian programme for conservation of critical breeds is maintenance of at least two isolated herds of corresponding breeds (Šveistys et al., 1997). The herd of Lithuanian native coarsewooled sheep had 6 founders. Though 493 white-backed and 1737 ash-grey cows are registered and 45.000 semen doses are collected and stored from 9 ash-grey and 7 white-backed heterogeneous bulls, two herds were established for pure breeding and selection with the aim of both production of purebred progeny and raising of purebred bulls for deep-freezing of semen. Currently the main conclusion from theoretical and experimental research is that the reduction in genetic variance is small and negligible for the first ten generations (population size >50) and much smaller than was predicted earlier (Bodo, 1999; Danel, 1994).

Another measure of the genetic status of a population-inbreeding can be minimized by having a large enough effective population (>50) and by using within family selection to as large an extent as possible. In extreme cases of very small populations, Yamada and Kimura (1984) consider that a founder stock with less than 5 individuals cannot survive when such parameters as fecundity, viability, sex ratio and their correlation to inbreeding depression are taken into consideration.

One of the methods to express a population size and determine the vulnerability of a given population is to calculate the effective population size Ne. Ne is also important for understanding the effects of varying numbers of males and females on genetic drift variance and inbreeding. The calculated risk status, based upon the effective population size Ne, of old Lithuanian animal breeds is 32 for wattle pigs, 24 for ash-grey and white-backed cattle, 26 for local coarsewooled sheep, 55 for old-type Žemaitukai and 107 for Vištinės geese. Thus, all Lithuanian old indigenous animals breeds, except Vištinės geese, can be given the risk status category according to the effective population size. From the theoretical statements and estimations, a Ne between 50 and 200 seems generally to indicate the threatened status. above at Ne above 200 there is generally no danger of genetic drift and at Ne below 50, the driftless reproduction and even the survival of the population is uncertain (Bodo, 1999; Maijala, 1999). Wu (1999) calculated that if the inbreeding coefficient is to increase by no more than 0.1 per 100 years, then a minimum Ne of 100 is needed for horses and cows having a generation interval of five years, whereas for sheep and pigs with a generation interval of two and a half years the Ne would be 200. For our old Lithuanian breeds to change their risk status category into a less vulnerable one, the number of animals by sex ratio should be 60 males and 300 females (1:5) for pigs and sheep, 32 males and 128 (1:4) or 192 females (1:6) for horses and cattle.

Currently, unfavourable conditions have formed for other breeds, such as Lithuanian White pigs, Lithuanian Heavy-draught and Heavy-type Žemaitukai horses, Lithuanian Blackface sheep. It is important to counteract the decline processes of these Lithuanian endangered breeds before their size is too small. Genetic improvement and optimisation

Table 2. **The number of animals of old Lithuanian breeds**

Breed	Total number of individuals of a breed alive	Number of animals of breeding age	Number of animals in conservation herds
Lithuanian indigenous wattle pigs	unknown	40	200
Žemaitukai horses	124	70	103
Ash-grey cattle	2960	1737	29
White-backed cattle	850	493	22
Indigenous coarsewooled sheep	80	21	38
Vištinės geese	140	120	120

of the production system are the main options available to stop and reverse the decline process into a self-sustaining status. Calculation of the population risk status, expressed as effective population size (Ne) for breeds that were developed in the 20th century, indicated that effective population size for the large-type Žemaitukai horses is 42, Lithuanian Heavy-Draught 115, Lithuanian Blackface sheep 114, Lithuanian White pigs 270. The effective population size for large-type Žemaitukai is also driftless reproduction, and therefore the survival of the population in uncertain. The Lithuanian Heavy-Draught horses and Lithuanian Blackface sheep have an effective population size of vulnerable risk status. In Lithuania, only 74 purebred boars are left and used for mating of only 700–800 (40%) Lithuanian White sows, thus the effective population size for Lithuanian White pigs would be a rare risk status in a developed country, but in a developing country it may be categorized as vulnerable or even as endangered and needs been observation due changes in the economic, political and commercial life. Earlier the Lithuanian White was the main pig breed in Lithuania, and their number should be no less than 200 males and 2000 females out of the total 65,000 sows in the pyramid pig production system, if the breed is to remain the main dam pig breed in commercial crossbreeding combinations and be self-sustainable.

Conservation *in-situ* activities had prevented the total disappearance of Lithuanian old indigenous farm animal breeds. Nowadays, their status could be categorized as critical-maintained breeds. Due to the genealogical structure and special mating schemes, according to prepared rules of breed evaluation and direct observation of these populations by the Institute of Animal Science, the minimal size of critical-maintained animal breeds can be only 20–40 breeding animals. Other Lithuanian animal breeds that were developed in the 20th century need to be watched closely and improved genetically, as it is the main option available to stop and reverse the decline process into a self-sustaining status. Though the effective population size is 70 males to 700 females (1:10), populations with lower numbers of males, for example, horses, can be considered effective with 55 males and 1000 females.

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Violeta Razmaitė, Rūta Šveistienė

MINIMALUS IR EFEKTYVUS SAUGOMŲ LIETUVOS ŽEMĖS ŪKIO GYVŪNŲ POPULIACIJŲ DYDIS

S a n t r a u k a

Saugojimu *in situ* sustabdytas visiškas Lietuvos senųjų žemės ūkio gyvūnų veislių išnykimas. Suskaidžius populiacijas į keturias negimininges grupes ir pritaikius uždaro veisimo schemą, galima ilgesniam laikui sumažinti inbrydingo koeficiento didėjimą. Genealoginės struktūros, specialiai pritaikytų porų parinkimo schemų, parengtų vertinimo taisyklių ir tiesioginės Lietuvos gyvulininkystės instituto priežiūros dėka minimalus kritinių-palaikomųjų veislių dydis gali būti 20–40 veisimui naudojamų gyvūnų.

Svarbu laiku sustabdyti kitų lietuviškų veislių nykimą, kol jis nepasiekė kritinės ribos. Genetinis gerinimas yra pagrindinis būdas sulaikant veislių nykimą ir išlaikant jų, kaip savaime išsilaikančių veislių, būklę. Nors efektyvus populiacijos dydis yra 70 reproduktorių ir 700 patelių (1:10), tačiau populiacijose, turinčiose mažiau reproduktorių, pavyzdžiui, arklių populiacijoje, turinčioje 55 eržilus, turėtų būti 1000 kumelių. Šitiek arklių populiacija galėtų tvirtai egzistuoti. Tačiau Lietuvos baltųjų kiaulių veislė, kad galėtų išlikti pagrindine mūsų šalies motinine kiaulių veisle, pramoninio veislių kryžminimo deriniuose turėtų turėti ne mažiau kaip 2000 paršavedžių ir 200 kuilių.

Raktažodžiai: veislės, senosios vietinės, populiacija, kritinė-palaikomoji