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THE RISK STATUS OF POLISH LOCAL BREEDS UNDER CONSERVATION PROGRAMMES – NEW APPROACH*

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Abstract

Native breeds of farm animals, despite their unique characteristics and adaptability to diverse and often adverse environmental conditions, are at risk due to their lower profitability and corresponding declining use. According to FAO data, there are currently around 8800 livestock breeds in the world (http://www.fao.org/dad-is/en/ update: 09.11.2019), of which 17% have been assessed to be endangered. The objective of the study was to develop a model for estimating the risk status of Polish native breeds. The proposed new model is based on 3 factors: demographic, genetic, and socio-economic. The last factor is composed of 6 elements: geographical concentration, demographic trend over the last 5 years, cultural value of a breed, parentage control, *ex situ* conservation and anthropogenic factors. Using the factors and elements above, among the examined 30 breeds of cattle, horses, pigs, sheep and goats, 1 was assessed as being critically endangered; 24 were determined to be endangered and in need of conservation; 5 were less endangered, but in need of constant monitoring. Out of 35 populations of poultry 29 were assessed as endangered as they were being kept in only single public collections. Six flocks of ducks were given a critical risk status, due to a very low number of females.

Key words: native breeds, risk status factors, effective populations size, conservation indicator

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Farm animal genetic resources are the primary biological capital for livestock production providing both food security and sustainable rural development. Their conservation and sustainable use are essential to conserve future breeding and livestock use and development options as well as assist to keep rural ecosystems in balance (FAO, 2015). Past livestock development has been possible because of the wealth of available animal genetic resources enabling the development of an enormous number of livestock breeds from a relatively small number of species (Groeneveld et al., 2010). Declining animal genetic resources decreases livestock development options, and could jeopardize food security and rural economies.

Assessment of the risk status of livestock breeds has long been studied in many countries. The first biodiversity global assessments aimed to identify endangered species and preserve genetic diversity, and resulted in the establishment of the Red List (IUCN, 2019), as a registration and diagnostic description of endangered wild animal species. In Poland, the Red List was first published in 1992. The result categorized the species risk status into five groups according to size population: E – critically endangered and declining (population between 1 and 100 individuals), V – vulnerable to extinction (between 100 and 10000 individuals), R – rare (less than 10000 individuals), O – out of danger, and I – indeterminate status.

The Red List stimulated FAO to assess the risk status of farm animals and publish three assessments – the World Watch List – Domestic Animal Diversity 1993, 1995 and 2000.

These first assessments determined risk status of livestock accounting to the size of the entire population and the proportion of purebred matings (Loftus and Scherf, 1993; Scherf, 2000). In 2007, during the first International Technical Conference on Animal Genetic Resources in Interlaken (Switzerland), the risk status of breeds was shown not only to depend on the population size, but also to result from many demographic, genetic and socio-economic factors (FAO, 2007 a b).

An approach proposed by Gandini et al. (2005) was to assess the degree of endangerment of livestock breeds taking into account demographic and genetic aspects, as well as the time (number of years) needed to reach a critical population size, which is also the time that may be available to undertake action to save the population from extinction.

In 2010, Alderson (2010) stated that indicators of endangerment must be reliable, easily measurable, robust and possible to implement. Alderson listed four primary indicators: numerical (the number of breeding females and effective population size); geographical (geographical concentration in a country); genetic (e.g. genetic erosion); and introgression (measured by the percentage of animals of a specific breed used for crossing). Apart from the primary factors, Alderson also mentioned other factors affecting the risk status of breeds, such as the occurrence of the same breed in many countries, as well as anthropogenic, climatic and epidemiological factors. In the European Union states, methods used to estimate the risk status and the use of specific factors are country dependent. For instance, in Germany, the status of breeds of cattle, horses, sheep, goats and pigs is estimated with only one factor, the effective population size (N_e) (BLE, 2019). The following 4 thresholds for breed risk status were chosen: $N_e \leq 50$ – no conservation measures possible because the popula-

tion is too small; $50<N_e\leq 200$ – population in need of conservation; $200<N_e\leq 1000$ – population in need of monitoring, $N_e>1000$ – population at no risk. Other criteria proposed in a number of studies include: the demographic trend (stable, downward, upward), inbreeding increment over a specific time frame, percentage of purebred males and females, information about the implementation (or lack) of conservation programmes, projected population growth in a given period of time, breed concentration in a country, number of herds and trends in population growth, and the degree of introgression (crossbreeding) per generation (Alderson, 2003, 2010; FAO, 2004, 2013; Verrier et al., 2015; Wainwright et al., 2019).

FAO prepared guidelines on *in situ* conservation of breeds that contained proposals for estimating the breed risk status based on three parameters: overall population size, the size of the breeding population, and reproductive capacity of a species (FAO, 2013). Using this approach, the numerical data entered by countries into the DAD-IS (Domestic Animal Diversity Information System – www.fao.org/dad-is) became a basis for establishing a risk status assessment method as a comparative platform at global level. FAO stressed, however, the need for individual country solutions that account for situations in each country.

Verrier et al. (2015) developed a method for assessing the risk status of 178 local French breeds that was based on six indicators: the number of breeding females (N_f); the change in the number of breeding females over the last 5 years or generations (T5); the percentage of crossbreeding (C); effective population size (N_e); breeders organization and technical support; and the socio-economic context where the breed occurred. Using this method, around 80% of local French breeds were found to be endangered.

In reviewing the importance of additional and sometimes hard-to-measure factors affecting breed risk status, the European Regional Focal Point (ERFP) initiated a project to analyze the risk status of twelve local breeds from five countries. The results demonstrated that the additional factors, such as the concentration of a population in a country, the existence of markets for products and a trademark, the availability of breeding stock, the implementation of breeding programmes, and the existence of breeders organizations contributed in assigning the risk status and result in assessments of each breed being more reliable (Duchev, 2014; Sturaro, 2017).

The aim of the present study was to elaborate and validate a model for estimating the risk status of native breeds of cattle, horses, pigs, sheep, goats and poultry (chickens, ducks and geese), included within current genetic resources conservation programmes for farm animals (http://www.bioroznorodnosc.izoo.krakow.pl/). The approach took into account, apart from measurable traits, the specific environmental conditions and impacts of anthropogenic factors. The study did not cover breeds of fur animals, lines of bees and fish included within existing conservation programmes. Conserved breeds of fur animals, currently, have little economic significance and their population numbers are small. Fish as a group of aquatic organisms, were not considered as farm animals. Bee populations, the most important of species not included in the present study, will be analyzed in future due to their biological and economic role. It may seem controversial to estimate the risk status of poultry species (chicken, ducks and geese), held in public collections where their numbers are small, and some factors, such as socio-economic factors, e.g. a distribution of

flocks throughout the country; the existence of breeders' associations are making comparisons difficult. Nevertheless, a new model was used to illustrate the actual situation in conserved populations of various poultry breeds.

Material and methods

The data were obtained from the National Research Institute of Animal Production databases on breeds included within genetic resources conservation programmes that are supported from both EU and national funds. Table 1 presents the number of females and breeding herds/flocks from 65 breeds/varieties/strains included in conservation programmes in 2018, and the mean number of animals per herd/flock.

Table 1. Number of breeds/varieties/strains, females and herds per species

Animal species	Number of breeds/varieties/strains	Number of herds/flocks	Number of females	Mean number of females per herd	Standard deviation
Cattle	4	802	8641	10.8	9.2
Horses	7	1459	6967	4.8	4.4
Sheep	15	884	66735	75.5	59.0
Goats	1	15	194	12.9	6.3
Pigs	3	124	3511	28.3	29.2
Laying hens*	11	17	10279	604.6	116.0
Geese*	14	15	3954	263.6	133.2
Ducks*	10	10	3319	331.9	229.3

*data from 2017.

Additional information was derived from the EFABIS (European Farm Animal Biodiversity Information System), which is part of the FAO DAD-IS information system.

Considering the results of international studies and the analysis of conservation programmes implemented in Poland, we propose a model based on two main factors: number of females (L) and effective population size (N_e); as well as an additional factor (D) composed of 6 elements (sub-factors): 1. geographical concentration in the country; 2. demographic trend over the last 5 years; 3. cultural value; 4. parentage control; 5. *ex situ* conservation; 6. anthropogenic factors (breeders organizations, financial support, activity and age of breeders). The risk status was calculated based on the following formula:

$$X = (L + N_e + 0.5D)/3$$

where:

X – risk status,

L – total number of females,

N_e – effective population size,

D – sum of additional elements (sub-factors).

The final score, results in risk status assessment, is as follows: ≤1 – critical; > 1 and ≤2 – an endangered breed requiring action; > 2 and <3 – an endangered breed requiring monitoring; ≥ 3 – not at risk.

Measurable factors (L and N_e) were defined according to the degree of endangerment as: *critical status, endangered breed in need of conservation, endangered breed in need of monitoring, and non-endangered breed*, scored as 0, 1, 2 or 3 points respectively.

Components of additional factor 3 (from D1 to D6), were scored as 1, 0.5 or 0. As the assessment of these components was subjective, this factor was weighted as 1/2 to reduce its effect on the end result, and to decrease the estimation error.

Main factor – total number of females (L)

Based on a study by Verrier et al. (2015), a modified method for converting the number of females into the score scale was adopted, taking into account reproductive capacity of a species, the time required to double population size, and the generation interval: 8 years for horses, 6 years for cattle, 3 years for sheep and goats, 1 year for pigs, and 0.5 year for poultry. Species with lower reproductive capacity and greater generation interval (horses, cattle, sheep, goats) are considered more vulnerable to extinction, than species with higher reproductive capacity and shorter generation intervals (poultry and pigs). For the 65 populations under study, the number of females within each breed/variety/strain, was converted into a point scale as illustrated in Table 2.

Table 2. Scores for factor L

Score	0	1	2	3
	Number of females			
Horses	150	1250	10 000	30 000
Cattle	150	1000	7500	25 000
Sheep and goats	150	1000	6000	20 000
Pigs	75	300	1000	3000
Poultry	75	200	500	1500

It was assumed that regardless of the final score, based on all three factors, a population smaller than 150 females (horses, cattle, sheep and goats), or 75 females (poultry and pigs), denotes that the breed is endangered, and accordingly in need of conservation efforts.

Main factor – effective population size (N_e)

Effective population size is a key parameter for describing genetic diversity in animal populations, and predicting rate of inbreeding. While it is possible to use more sophisticated estimation of the effective population size based on pedigree data (Leroy et al., 2013, 2019), for practical reasons, effective population size was calculated based on Wright's formula (1931):

$$N_e = 4\ N_M N_F / (N_M + N_F)$$

where:

N_M = the number of males,

N_F = the number of females.

Correction to random selection of males and females for mating was applied based on Santiago and Caballero (1995), where: N_e = original N_e x 0.7. The following thresholds were adopted: $N_e \leq 50$ – 0 points, critical status; $50 < N_e \leq 200$; – 1 point, endangered breed in need of conservation; $200 < N_e \leq 1000$; – 2 points, endangered breed in need of monitoring, and $N_e > 1000$ – 3 points, non-endangered. It was also assumed that regardless of the final score, if $N_e \leq 50$, a breed is considered endangered and in need of conservation, as there is a direct and inversely proportional relationship between the effective population size and the rate of inbreeding.

Complex factor D (6 partial elements – *sub-factors*)

Preliminary analysis of models developed in other countries demonstrated that these methods are not well suited to conditions in Poland, and the simulation results differed considerably from the actual situation. This concerned, in particular, the additional (environmental and socio-economic) factors (Krupiński and Polak, 2018). Based on the preliminary analysis and expert opinions, we chose the following 6 factors with relevance to the assessment of risk status in Poland:

D1 – geographical concentration in a country. Poland is over 312,000 km^2 with many diverse environmental conditions. Therefore, it was necessary to use a factor that accounted for the regions where a breed is found. We adopted after Alderson (2010), a score scale where 1 point was awarded when ≥ 75% of the population was concentrated in the region of origin, 0 if only ≤ 25% of the breed occurred in the region of origin, 0.5 points if the breed concentration was intermediate. Where the population occurred in a small number of herds (≤ 2), regardless of the end results, the breed was considered endangered and in need of conservation.

D2 – the demographic trend over the last 5 years. This is an important and objective factor indicative of the population's development. Three scores were awarded: 1 point – upward trend; 0.5 – stable trend; and 0 – downward trend.

D3 – the cultural value of a breed (documented links with tradition, culture and the region): 1 point – no cultural/historical value; 0.5 – little cultural/historical value; 0 – has cultural/historical values. Points awarded by experts of the species specific Working Groups – that serve as advisory bodies to the National Research Institute of Animal Production. Some breeds have been present in Poland for centuries and are an important part of the country's cultural heritage. The value of the breed was assessed on the basis of specific elements, such as it being used locally directly or indirectly in contributing to handicraft, folklore, artistic expression and religious traditions, it being used in local gastronomy and products, and any roles provided in maintaining a specific landscapes. The scoring was as follows: 1 point – no cultural/historical value; 0.5 – little cultural/historical value; 0 – has cultural/historical value.

D4 – parentage control: 1 point – present; 0.5 – present to a small extent; 0 – absent;

D5 – *ex situ* conservation: 1 point – present; 0.5 – present to a small extent; 0 – absent;

D6 – anthropogenic factors, assessed by experts and on the basis of age of breeders, their activity in implementation of existing conservation programmes (e.g. participation in exhibitions, popularization of breeds and their products, collaboration with breeding organizations), and possibility of financial support for breed conservation: 1 point – anthropogenic factors present; 0.5 – partly present; 0 – absent.

Results

The final assessment of the risk status of all Polish breeds currently included in genetic resources conservation programmes, calculated on the basis of a new algorithm, is presented in Table 3.

When analyzing results (Table 3) obtained for the three factors taken into account in estimating the risk status of 30 breeds of cattle, horses, pigs, sheep and goats under conservation programmes, it was found that in the case of factor L – number of females registered in herdbooks, only Wielkopolski horses were assigned to have critical status. In other populations, L > 150 for cattle, horses and sheep, and > 75 for pigs, indicated that none of these populations were determined to have a critical risk status. Most populations (50%) fell into the category of: an *endangered breed in need of conservation*. For three cattle breeds, the number of females were in the 1000–7500 range (Table 2), which have the status of an *endangered breed in need of monitoring*; and one breed (White-backed cattle) was *endangered and in need of conservation* due to the small population size of 610 cows.

Among horse breeds, the lowest numbers were recorded for the Wielkopolski and Małopolski breeds, which did not exceed 500 mares. The Hucul and Polish Konik breeds were subjected to traditional female family and male line breeding. In Hucul breed, efforts were made to keep the Polish female families and male lines in balance, acknowledged by the Hucul International Federation. The situation was similar for the Polish Konik breed. This means that despite a relatively large total number of mares, some lines within the breed could still show a downward trend.

For the three breeds of pigs, the lowest number of sows occurred in Złotnicka Spotted breed (820), while in the other breeds (Złotnicka White and Puławska) the number of sows exceeded 1200. This means that in terms of factor L, the Złotnicka Spotted breed is *endangered and in need of conservation;* and the other two breeds are *endangered and in need of monitoring.*

Out of the 15 sheep breeds and varieties examined, 10 were *endangered and in need of conservation.* The most dire situation is observed within the Coloured Merino sheep breed which has a small number of ewes (732) and rams (52). The other sheep breeds are *endangered and in need of monitoring*. The only conserved goat breed – the Carpathian goat – was also assessed as *endangered and in need of conservation,* as the number of females is very low.

Table 3. Overall estimation of the risk status of 64 native breeds under study, based on L, N_e and D factors of breeds in 2018, converted into points

Species	Breed/ variety/strain	No. of females L	**Score**	N_e	**Score**	D1	D2	D3	D4	D5 *ex situ* conser-vation	D6 factors	Score D cumulative total	**Total score: Re-sults**	Esti-mated Risk status
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cattle	Polish Red (RP)	2996	**2**	170.1	**1**	0	0.5	0	0.5	1	0.5	2.5	**1.4**	EC**
	White-backed (BG)	610	**1**	38.3	**0**	1	1	0.5	0.5	1	0.5	4.5	**1.1**	EC
	Polish Black-and-White (ZB)	1640	**2**	77.1	**1**	1	0	0.5	0.5	1	0.5	3.5	**1.6**	EC
	Polish Red-and-White (ZR)	3395	**2**	66.7	**1**	1	0.5	0.5	0.5	1	0.5	4.0	**1.7**	EC
Horses	Hucul	1289	**2**	514	**2**	0	0.5	0	1	0	1	4	**1.7**	EC
	Polish Konik	1616	**2**	402.1	**2**	0	1	0	1	0	1	4	**1.7**	EC
	Małopolski (conserved)	471	**1**	330.5	**2**	0	0.5	0	1	0	0.5	1.5	**1.3**	EC
	Silesian (conserved)	932	**1**	616.6	**2**	0	1	0.5	1	0	0.5	3	**1.5**	EC
	Wielkopolski (conserved)	125	**0**	113.5	**1**	0	0.5	0	1	0	0.5	1.5	**0.9**	Critical
	Sokólski	1229	**1**	656.9	**2**	1	1	0.5	1	0	0.5	3	**1.5**	EC
	Sztumski	1305	**2**	877.8	**2**	0	1	0.5	1	0	0.5	3.5	**1.9**	EC
Sheep	Merino old-type	7595	**3**	1106.8	**3**	1	0.5	0.5	0.5	0	1	3.5	**2.6**	EM***
	Podhale Zackel	7874	**3**	1166.8	**3**	1	0.5	0	0.5	0	1	3	**2.5**	EM
	Blackheaded	2757	**2**	400.8	**2**	0	1	1	0.5	0	0.5	3	**1.8**	EC
	Kamieniecka	5574	**2**	771.8	**2**	1	1	1	0.5	0	0.5	4	**2.0**	EC
	Corriedale	1941	**2**	278.9	**2**	1	1	1	0.5	0	0.5	4	**2.0**	EC
	Coloured Merino	738	**1**	136.0	**1**	1	1	1	0.5	0	0.5	3.5	**1.3**	EC
	Olkuska	1291	**2**	276.7	**2**	0	0.5	0.5	0.5	0	0.5	2	**1.7**	EC
	Pogórza sheep	1254	**2**	165.4	**1**	1	1	1	0.5	0	0.5	4	**1.7**	EC
	Pomeranian	8092	**3**	1029.0	**3**	1	0.5	0.5	0.5	0	1	3.5	**2,6**	EM
	Świniarka	2161	**2**	335.9	**2**	0.5	1	0.5	0.5	0	0.5	2.5	**1.8**	EC
	Uhruska	7458	**3**	961.6	**2**	1	0.5	1	0.5	0	1	4	**2,3**	EM
	Wielkopolska	7850	**3**	1611.3	**3**	1	0.5	1	0.5	0	0.5	3.5	**2,6**	EM
	Wrzosówka	8264	**3**	994.2	**2**	0	0.5	0	0.5	0	1	2	**2.0**	EC
	Żelaźnieńska	1916	**2**	215.0	**2**	1	1	1	0.5	0	0.5	4	**2.0**	EC
	Coloured Polish Mountain Sheep	1970	**2**	263.9	**2**	1	1	0	0.5	0	1	4	**2.0**	EC

Goats	Carpathian	194	**1**	118.6	**1**	1	1	0	0	0	1	3	**1.2**	EC
	Puławska	1399	**3**	144.3	**1**	0.5	1	0.5	0.5	0.5	0.5	3.5	**1.9**	EC
Pigs	Złotnicka White	1200	**3**	87.3	**1**	0.5	0.5	0.5	0.5	0	0.5	2.5	**1.8**	EC
	Złotnicka Spotted	820	**2**	81	**1**	0.5	0.5	0.5	0.5	0	0.5	2.5	**1.4**	EC
	Greenleg Partridge (Z-11)	1033	**3**	310	**2**	0	0	0.5	0	0	0.5	0.5	**1.8**	EC
	Greenleg Partridge (Zk)	1034	**3**	294	**2**	0	0	0.5	0	0	0.5	0.5	**1.8**	EC
	Polbar (Pb)	938	**3**	255	**2**	0	0	0	0	0	0.5	0.5	**1.8**	EC
	Yellowleg Partridge (Ż-33)	1034	**3**	310	**2**	0	0	0	0	0	0.5	0.5	**1.8**	EC
	Rhode Island Red (R-11)	851	**3**	248	**2**	0	0	0	0	0	0.5	0.5	**1.8**	EC
Hens*	Rhode Island Red (K-22)	945	**3**	271	**2**	0	0	0	0	0	0.5	0.5	**1.8**	EC
	Rhode Island White (A-33)	996	**3**	284	**2**	0	0	0	0	0	0.5	0.5	**1.8**	EC
	Sussex (Polish Sussex S-66)	854	**3**	253	**2**	0	0	0	0	0	0.5	0.5	**1.8**	EC
	Leghorn (Polish Leghorn G-99)	717	**3**	211	**2**	0	0	0	0	0	0.5	0.5	**1.8**	EC
	Leghorn (Polish Leghorn H-22)	855	**3**	248	**2**	0	0	0	0	0	0.5	0.5	**1.8**	EC
	Leghorn (Polish Leghorn H-33)	1022	**3**	414	**2**	0	0	0	0	0	0.5	0.5	**1.8**	EC
	Mini-duck (K-2)	200	**1**	108	**1**	0	0	0	0	0	0.5	0.5	**0.8**	Critical
	Hybrids (KhO-1)	195	**1**	106	**1**	0	0	0	0	0	0.5	0.5	**0.8**	Critical
	English Pekin (LsA)	180	**1**	90	**1**	0	0	0	0	0	0.5	0.5	**0.8**	Critical
	Danish Pekin (P-8)	175	**1**	76	**1**	0	0	0	0	0	0.5	0.5	**0.8**	Critical
Ducks*	French Pekin (P-9)	196	**1**	106	**1**	0	0	0	0	0	0.5	0.5	**0.8**	Critical
	Polish Pekin (P-33)	177	**1**	86	**1**	0	0	0	0	0	0.5	0.5	**0.8**	Critical
	Polish Pekin (P-11)	435	**2**	246	**2**	0	0	0	0	0	0.5	0.5	**1.4**	EC
	Polish Pekin (P-22)	567	**3**	316	**2**	0	0	0	0	0	0.5	0.5	**1.8**	EC
	Polish Pekin (P-44)	613	**3**	332	**2**	0	0	0	0	0	0.5	0.5	**1.8**	EC
	Polish Pekin (P-55)	581	**3**	320	**2**	0	0	0	0	0	0.5	0.5	**1.8**	EC

Table 3 – contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Geese*	Lubelska (Lu)	203	**2**	147	**1**	0	0	0	0	0	0.5	0.5	**1.4**	EC
	Kielecka (Ki)	236	**2**	169	**1**	0	0	0	0	0	0.5	0.5	**1.4**	EC
	Podkarpacka (Pd)	247	**2**	144	**1**	0	0	0	0	0	0.5	0.5	**1.4**	EC
	Garbonosa (Ga)	210	**2**	156	**1**	0	0	0	0	0	0.5	0.5	**1.4**	EC
	Kartuska (Ka)	254	**2**	165	**1**	0	0	0	0	0	0.5	0.5	**1.4**	EC
	Rypińska (Ry)	262	**2**	168	**1**	0	0	0	0	0	0.5	0.5	**1.4**	EC
	Suwalska (Su)	242	**2**	157	**1**	0	0	0	0	0	0.5	0.5	**1.4**	EC
	Pomeranian (Po)	212	**2**	154	**1**	0	0	0	0	0	0.5	0.5	**1.4**	EC
	Roman (Ro)	234	**2**	168	**1**	0	0	0	0	0	0.5	0.5	**1.4**	EC
	Slovak (Sł)	251	**2**	167	**1**	0	0	0	0	0	0.5	0.5	**1.4**	EC
	Landes (LsD-01)	338	**2**	249	**2**	0	0	0	0	0	0.5	0.5	**1.4**	EC
	Kuban (Ku)	316	**2**	211	**2**	0	0	0	0	0	0.5	0.5	**1.4**	EC
	Biłgorajska (Bi)	593	**3**	431	**2**	0	0	0	0	0	0.5	0.5	**1.8**	EC
	Zatorska (ZD-1)	356	**2**	267	**2**	0	0	0	0	0	0.5	0.5	**1.4**	EC

* data from 2017.
** EC: endangered, requiring conservation.
***EM: endangered, requiring monitoring.

Among gallinaceous poultry populations, the number of hens ranged from 717 to 1033, indicating that these populations are *endangered and in need of conservation*. Among the 10 strains of ducks, 6 were classified as *critical*. This results from the small population size in some strains (KhO, K2 Mini-duck, English Pekin, Danish Pekin, French Pekin and Polish Pekin P-33), which did not exceed 200 females. The current low number of females is due to limited capacities of collections where they are kept.

The second factor – effective population size (Table 3), was in most cases in the range of $50<N_e\leq200$ – *endangered and in need of conservation,* and $200<N_e\leq1000$ – *endangered and in need of monitoring*. Among cattle, horse, sheep, goat and pig breeds, the effective population size ≤50 (*critical status*), was only established in one breed, the White-backed cattle.

Despite the very small number of female waterfowl registered in flockbooks, no critical status was observed among poultry. The effective population size was in the range of $50<N_e\leq 200$ due to the relatively high number of males.

The third factor D, showed the highest mean score in sheep breeds, followed by pig breeds. Among the examined poultry species, the lowest mean score was awarded to duck varieties, which also showed the highest total score variation resulting from high differences in population size among varieties.

The use of the third factor D in relation to poultry is disputable due to the low trend in population increases, dangerous concentrations limited to 1–2 flocks, lack of parentage control and unknown cultural values (except for Greenleg Partridge hens). The only positive impact was made by breeders organizations. In the final assessment, most poultry populations regardless of the algorithm result, were assigned the status of an *endangered breed in need of conservation*, due to the small (<2) number of purebred flocks (Table 3).

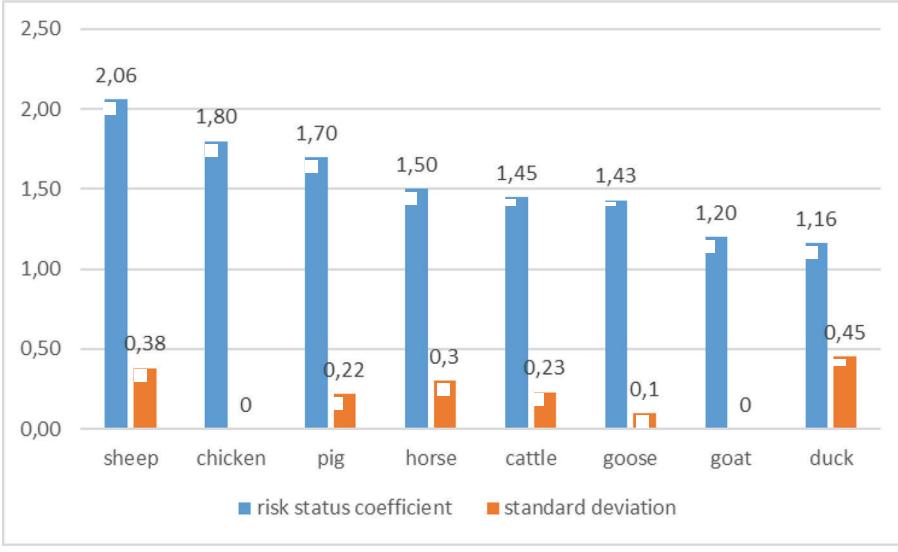


Figure 1. Mean risk status coefficient and standard deviation for individual species

The final assessment of the risk status for each of 65 analyzed breeds/varieties/strains, based on the new algorithm is presented in Table 3. The results confirm that all of the conserved breeds are endangered. For four breeds of cattle, the risk score ranged from 1.1 to 1.7, which resulted in categorizing the breeds as *endangered and in need of conservation*. Among seven horse breeds, the *critically endangered* status was assigned to the Wielkopolski breed. The other breeds were classified as *endangered and in need of conservation*, which is similar to the three breeds of pigs, one goat breed and 10 sheep breeds. The other 5 breeds of sheep were classified as *endangered and in need of monitoring*. Figure 1 shows the mean risk status coefficient at the species level, and the standard deviation in risk status of individual breeds within a given species. It is clear that strains of ducks and one goat breed have the lowest scores, followed by breeds of geese, cattle and horses (1.43, 1.45 and 1.50 respectively). Figure 2 provides an overall view of the number of breeds/varieties/strains in respective risk status categories.

In all of the 65 populations studied, the value of the risk indicator was in the range of > 0.8 to ≤2.5. Most of the populations (53, or 81.5%), were endangered and in need of conservation. Seven populations were classified as critical, the conserved Wielkopolski horses and 6 lines of ducks. In three poultry species, all 35 examined populations were endangered and in need of conservation, or were critically endangered.

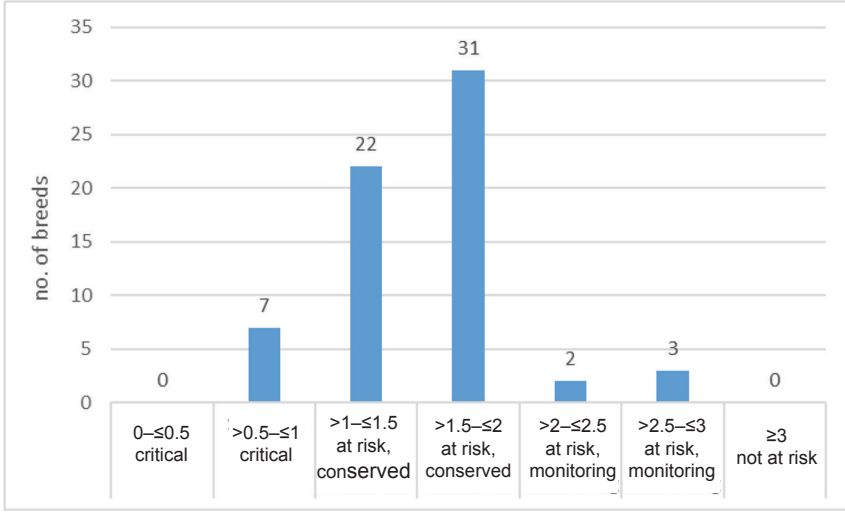


Figure 2. Distribution of risk status among 65 breeds/varieties/strains under study

Discussion

Measures to conserve native breeds of farm animals in Poland are supported by subsidies to compensate for their lower performance (MRiRW, 2012, 2013). Currently, 83 populations are included in genetic resources conservation programmes,

which is not high in comparison with some other states in the European Union – 176 in France (Verrier, 2015), 161 in Spain (https://www.mapa.gob.es/es/ganaderia/temas/zootecnia/razas-ganaderas/razas/catalogo/default.aspx), and 277 in Italy (Ministero delle Politiche Agricole Alimentari e Forestali, 2013). These countries not only have conservation programmes, but have also succeeded in promoting high quality products derived from native breeds. In Poland, where agriculture is based mainly on small family farms, often located with Natura 2000 areas, there are excellent conditions for production of high-quality foods, development of native breeds, and promotion of traditional products. The high quality and dietetic value of existing traditional products has been proved by research (Krupiński, 2019; Siekierski, 2018). Risk status simulations showed that all of 65 populations under current study require urgent conservation due to the threat of extinction and their future potential to contribute to agriculture and rural development, and is justified by past conservation success. Monitoring of populations that are at risk of losing genetic diversity is of high importance as genetic erosion decreases fitness and therefore contributes to extinction (Leroy et al., 2017). Research by Gicquel et al. (2019) showed that the introduction of conservation measures had a positive impact on the demography and genetic variability of livestock breeds studied.

The model proposed here moves away from one-factor analysis (number of breeding females), and introduces additional factors that improve the overall risk assessment approach. The major new components in the proposed model are the extended ranges of female numbers, the effective population size, and adjustment to the specific production context in Poland using additional socio-economic factors than previously employed. The simulated estimation of the risk status, which had been performed in an earlier study (Krupiński and Polak, 2018), based on research and methods employed by other authors (Alderson, 2010; Gandini et al., 2005), showed that they are inadequate for conditions in Poland, with the risk categories not fully grounded in the reality of locally specific conditions. The selection of additional factors in the current study differs from those adopted in the model developed for France (Verrier et al., 2015), where most native breeds are concentrated in historic regions of their origin. In Poland, native breeds are widely distributed over the country, which reflects both the implementation of current conservation programmes, as well as past measures undertaken to save certain native breeds from extinction.

In Poland, specific situations exist for the 35 poultry populations, where conservation measures are necessary, and currently all populations are maintained in closed public flocks, for which the score for the number of females does not reach 3 points. The current management system was necessary to maintain breed purity and to avoid accidental crossing, which is difficult to prevent on small family farms. However, the approach has the disadvantage of increased risk of breed extinction in the event of disease outbreaks or other type of disaster. For this reason, regardless of the end result, all of the poultry breeds/strains were considered to be endangered and in need of conservation. Comparisons of the mean value of N_e for geese from conservation flocks estimated for 2012 (Dobrzański et al., 2019), shows that this indicator increased by around 20 until the current study, but it still falls within the $50<N_e\leq200$ range. In the conserved populations of hens, N_e showed a downward trend between

2009 and 2017, indicating increased risk of diversity loss within conserved strains (Krawczyk and Calik, 2010).

The application of *effective population size* in the described method allows for inclusion of genetic factors. There is a number of methods for pedigree based N_e estimation (based on sex ratio, on the variance of progeny size, on inbreeding rate between two successive generations, on coancestry rate between two successive generations, on individual inbreeding rate and on individual coancestry rate) (Leroy et al., 2013, 2019).

However, reliance on pedigrees is not always appropriate due to errors in breeding records. Molecular studies comparing the effective population size among the livestock breeds included within conservation programmes, has showed divergent results (Gurgul, unpublished data), generally at lower levels than estimated in this study. The highest mean N_e value was shown for horse breeds (97), followed by cattle (94), with relatively low values for pig breeds, and intermediate values for sheep. These findings confirm the need for molecular method applications for assessing risk status in future.

Another major factor contributing to the increased risk are anthropogenic factors: low levels of awareness among breeders of the value of native breeds as an element of Polish rural culture. Moreover, unlike in Western Europe, there is low participation of breeders in breeding activities (e.g. low attendance level at livestock shows) (Polak, 2016). Also, *ex situ* conservation is limited and mainly used for cattle breeds. For other species, *ex situ* conservation needs to be used to complement *in situ* conservation measures.

The new algorithm, providing more reliable assessment of the risk status will help to prioritize support for conservation. As suggested by Wainwright et al. (2019), investments in rare breed conservation should be cost effective and based on multi criteria decision. Well assessed risk status of Polish breeds under conservation will contribute to improved implementation of conservation programmes.

Conclusions

1. The risk status of endangered breeds kept in Poland was estimated using a proposed new algorithm, and showed varying degrees of endangerment and the need to continue genetic resources conservation programmes for all breeds currently under conservation.

2. The use of the newly developed model for risk status assessment, allowed assessment of the current state of the conservation programmes, where 10.8% of the conserved populations were designated as being of critical status, 81.5% of breeds endangered and 7.7% in need of monitoring.

3. The use of the multifactorial risk status algorithm, takes into account measurable and non-measurable (socio-economic) features of breeds included in current conservation programmes, which are fully applicable to cattle, horse, sheep and goat and pig breeds. In the final assessment of poultry, all current populations were assigned the status of endangered breeds due small population and not more than 2 separate breeding units constituting the entire population

4. The new more comprehensive approach to undertaking the risk status assessments should in future contribute to improved effectiveness of identifying and

achieving enhanced conservation measures, and should help to draw attention to socio-economic factors that can contribute to enhanced utilization of especially local or traditional breeds currently in decline.

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