



# The state of conservation of animal genetic resources in Slovakia

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**Abstract:** To effectively conserve animal genetic resources, countries need to periodically review their conservation efforts and reflect on actual problems and challenges. This study provides a review of animal genetic resources conservation activities, as well as the related existing legislative measures, strategies and funding in Slovakia. We present the development of endangered and supported breeds, discuss the impact of subsidies and the importance of awareness raising, and provide a SWOT analysis of the current animal genetic resources conservation framework in the country. In Slovakia, conservation is primarily based on animal breeding in natural conditions (*in situ*) without any limitations to breed improvement, and cryoconservation of animal genetic resources is in its initial phase. Most of the funding for conservation measures is provided by the Rural Development Programme. In general, the animal genetic resources system in Slovakia is open in terms of including new breeds eligible for support and this paper shows that the provided subsidies helped to stabilize most of the supported populations. Promoting the presence, characteristics and advantages of local breeds in times of intensive import of exotic breeds into the country is crucial to motivate breeders to prefer local livestock breeds. While the future challenge for the government is to improve conservation and facilitate related activities, research should address not only diversity, pedigree studies and cryoconservation, but also focus on the characterization of animal genetic resources for food security and climate change.

**Keywords:** biodiversity, conservation, animal genetic resources, endangered breeds, genebank

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## Introduction

Biodiversity for food and agriculture is indispensable to food security, sustainable development and the supply of many vital ecosystem services (FAO, 2019). Animal genetic resources (AnGR) are also sources of social and cultural benefits. Their contribution to a country's economy is not just in the form of animal products but also of employment opportunities for people in rural regions. AnGR are also an important part of landscape management and the agrotourism sector.

Despite all their roles and characteristics, according to the Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture of the Food and Agriculture Organization of the UN (FAO), 17% of all breeds are classified as being “at risk of

extinction” (FAO, 2015). In the case of local breeds, the main reason for rapid erosion is the lack of economic profitability (Gandini and Oldenbroek, 1999). This is closely related to the import of specialized and highly productive breeds, and their cross-breeding with local breeds.

Recently, local breeds are getting more attention thanks to their adaptability to local environmental conditions, their suitability for extensive agriculture and their expected roles in climate change adaptation. The increasing interest of consumers in animal production brings challenges but also opportunities to breeders. Advances in biotechnologies lead to more intensive research on the genetic level, increasing demands for establishing genebanks and providing AnGR material from already existing genebanks (Groeneveld *et al*, 2016).

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Countries adopt different policies and implement different approaches to address the conservation and use of AnGR, including local and endangered breeds, and to raise awareness of the need to conserve them. The main guidance is provided by the Global Plan of Action (GPA) for Animal Genetic Resources (FAO, 2007) and implementation progress in the four priority areas is monitored. The latest results show that globally, the greatest progress in the last years was achieved in the field of policies, institutions and capacity-building, while the lowest progress was achieved in conservation (Cao et al, 2021).

This review aims to provide a summary of the activities related to AnGR conservation in the Slovak Republic, with examples of the development and conservation of several breeds in the country. The information provided here should serve as a starting point in the preparation of the national strategy for the conservation of AnGR in the Slovak Republic.

### History of AnGR in the Slovak Republic

Slovakia is located in the heart of Europe and its relatively small area has made it difficult to maintain its local livestock breeds. In the past, intensive imports and crossbreeding contributed to forming the actual livestock diversity in the country. The main drivers for change in livestock diversity were improving performance and adaptedness of local breeds, often directed by landowners or the government. In the second half of the 20<sup>th</sup> century, the intensification of animal production and planned agriculture led to the creation of a list of recognized and allowed breeds (Act No. 110/1972 Coll. on livestock breeding, Edict 108/1974 on Act No. 110/1972), which could be kept by cooperatives and farmers, and contributed to a narrowing of livestock diversity. The massive planned use of Holstein bulls for crossing with Slovak Spotted and Slovak Pinzgau cows led to a decrease in both populations (Kadlečík et al, 2013). Unifying existing breeds contributed to the loss of within-breed diversity. For example, in the case of the Valachian sheep, which was considered undeveloped in the starting period of intensification, the planned unification and improvement of the population led to the loss of diversity of exterior animal characteristics (colour varieties, horn shapes). Similar to other countries, mechanization in agriculture and decline of their use in the army during the second half of the 20<sup>th</sup> century had a significant effect on horse populations. Their number decreased dramatically and has not recovered to this day. In those times, there was no national interest in the conservation of local breeds and some of them became completely extinct in the country (e.g., Red Carpathian and Gray Carpathian cattle). To improve production and adaptedness, new specialized breeds were created. In poultry, the Oravka breed was developed for adaptation to the colder regions of northern Slovakia following a request from the government. The breed became a favourite among small breeders, spreading around the

whole country, and its current population is estimated to be up to 9,000 animals. On the other hand, some of the new breeds created were outperformed by other specialized and well-established breeds or their breeding process failed in later phases and these breeds became extinct (e.g. Slovak White and Slovak meaty pig). In horses, the creation of three breeds started in this period, including Noric of Murany, Slovak Sport Pony and Slovak Warmblood.

After the political changes in the 1990s in Central Europe, agriculture and animal production started to transform and the overall number of livestock decreased rapidly in these countries (Oravcová et al, 2004). For example, at the breed level, in 30 years the number of Slovak Pinzgau cattle decreased from more than 90,000 at the end of the 1980s to just 11,000 at present. The Improved Valachian sheep population decreased from almost 200,000 in the mid-1990s to 100,000 animals, currently. Some breeds became endangered according to effective population size (Table 1). Breeders started to import exotic specialized breeds to improve production and be competitive at the international level. These changes put more pressure on the breeds with a long tradition in the country. While most of the breeders were improving production, some turned their attention to endangered breeds and also breeds that were already extinct in the country. Thanks to common history (Czechoslovakia, Austro-Hungarian monarchy), animals from these breeds could still be found in neighbouring countries and the exchange of these animals allowed the recovery of their populations in Slovakia. In the case of the almost extinct Valachian sheep, in the 1990s, breeders started to select phenotypically acceptable animals from the Improved Valachian population and have continued to import animals from breeders in the Czech Republic, who have maintained the rest of the original Valachian population. Occasional imports of Valachian sheep from Germany, where a part of the Valachian sheep population was exported in the 1990s, have also occurred. Since the exchange of breeding animals between Slovakia and neighbouring countries continues, most of the breeds can be considered as being transboundary in terms of FAO definitions (FAO, 2005). Due to common history and changes in animal production, including intensive crossbreeding, it is quite difficult to strictly distinguish between native and non-native breeds. There is no legal definition of an autochthonous/native/traditional breed in the country and no legal criteria are set for the recognition of an endangered breed. However, references to generally accepted autochthonous or traditional breeds can be found across the literature (Oravcová et al, 2006; Weis and Hrnčár, 2009; Šidlová et al, 2015; Kadlečík et al, 2017). While a common understanding of autochthonous breeds was also reported in Poland, Austria has a more precise definition, which includes breeds having a herdbook in Austria before 1938, or ample evidence that they have always been present and bred in a part of Austria, or stem from the Austro-

Hungarian monarchy and have had relations to regions of Austria (Kompan, 2014).

In poultry, big producers use hybrids, while continuous breeding activities of small farmers have led to the creation of new colour and dwarf types. For example, in the case of Oravka chicken, three new colour types and dwarf types have been created since the original type's official recognition in 1990. The number of registered breeders, which can be considered a reliable source of breeding animals, is small and thus the number of breeding animals is also small compared to the population size (Table 2). Similarly in rabbits, big producers use hybrids. Breeding activities of small farmers are considered a hobby and are focused on the stabilization of existing and newly created breeds' characteristics as well as the creation of new breeds. The estimated size of rabbit populations and the number of breeding animals reflect the length of a breed's existence (Table 2). While populations of breeds recognized before 1990 are estimated to be more than 200 animals strong (Blue of Holic, Nitra, Slovak Greyblue rex, Zemplin), populations of breeds recognized after this year are smaller.

### Legislation and policies

The Slovak Republic signed the Convention on Biological Diversity (CBD, 1992) in 1993 and became a Party to the CBD after approval in the following year. Issues related to biodiversity and its protection fall under the Ministry of Environment of the Slovak Republic. After affirmation of its commitments in 2007 (Interlaken Declaration on Animal Genetic Resources (FAO, 2007)), the Slovak Republic started to implement the GPA for Animal Genetic Resources. According to Strategic Priority 20 of the GPA for Animal Genetic Resources (FAO, 2007), countries should periodically review their national policies in order to investigate their direct and indirect effects on the use, development and conservation of AnGR. At present, the main responsibility for AnGR conservation in the country lies on the Ministry of Agriculture and Rural Development of the Slovak Republic and NPPC – Research Institute for Animal Production Nitra (National Focal Point for Animal Genetic Resources in Slovakia). In the Slovak Republic, the most important legislative measure is Act No. 194 of 1998 Coll. (last amended in 2020) on livestock breeding, which, in general, specifies the rights and duties of authorized breeders' associations to carry out their professional activities connected with animal breeding. It also addresses endangered breeds to a limited extent. Similar to the EU regulation 2016/1012 (EU, 2016), the national Act No. 194/1998 under Paragraph 3 Section 1e) lists the protection of endangered populations and provision of livestock genetic reserves as an important part of breeding development. Although recently not strictly followed, under Paragraph 2 Section 7 of Act No. 194/1998, protected farms are defined as farms keeping animals of endangered breeds that are used for the conservation of the breed's gene pool and maintenance of its historical value. According to Para-

graph 13 Section 2 of Act No. 194/1998, the transfer of breeding stock and genetic reserves originating from such farms should be controlled and permitted only after approval of the state. Contrary to this general approach, there are legislative acts of neighbouring countries, where the legislative basis for AnGR conservation, especially the setting of a national conservation programme, is part of the breeding acts (e.g. Czech Republic – Paragraph 14 of Act No. 154/2000 Coll. (last amended in 2021) (breeding act), or Poland – Art. 34 of Coll. of Laws 2021, item 36, act on the organization of breeding and reproduction of farm animals). Based on the Slovak National Act, there are authorized breeders' associations responsible for breeding the main livestock species including cattle, sheep, goats, horses, pigs, rabbits and poultry. These associations maintain breeding books, studbooks and breeding registers and are providing information to the National Focal Point for Animal Genetic Resources in Slovakia as part of the regular AnGR monitoring. Authorized breeders' associations differ in organization and number of breeds managed. For instance, the Slovak Pinzgau cattle are represented by an association solely responsible for this breed, thus making it easier to promote and take actions aimed at this particular breed. On the other hand, Valachian sheep are represented by an association responsible for several breeds of sheep and goats. All the activities are undertaken by the association. A group of breeders has been created within this association to improve collaboration and the breeding process of Valachian sheep. The same applies to the breeders of poultry (different groups according to species and breeds) and rabbits. In horses, National Stud is responsible for managing the studbook of Lipitsa, Hutsul, Arab and Shagya Arab. Studbooks of other breeds, except for English Thoroughbred, are managed by one horse breeders' association.

Regarding AnGR cryoconservation, the national legislation addresses only insemination centres with no considerations or exceptions for endangered breeds conservation and genebank activities. A description of the technical requirements for establishing genebanks is lacking, and so far, only scientific experience and rules for insemination centres are followed. The same applies to requirements for the acquisition and use of AnGR samples stored in genebanks. The actual status of the national veterinary legislation (Act No. 39/2007 Coll. (last amended in 2021) on veterinary care) therefore does not address and reflect the actual needs of AnGR conservation in the country and further steps are needed to fill this gap.

The Slovak Republic became a Party to the Nagoya Protocol (CBD, 2011) in 2016. The responsibility for the Nagoya Protocol implementation in the Slovak Republic lies with the Ministry of Environment. In order to facilitate access to its AnGR and taking into account that almost all livestock breeds in Slovakia are considered transboundary, Slovakia decided not to control access to its AnGR. Following the EU regulation 511/2014 (EU, 2014b), the Slovak national law (Act. No. 263/2015

**Table 1.** Numbers of purebred registered breeding males and females and endangerment class of supported breeds of livestock in the Slovak Republic according to 2020 monitoring data. Endangerment class was set according to effective population size calculated according to the formula  $N_e = (4 \times M \times F)/(M + F)$  (Falconer and Mackay, 1996) and assuming mass selection  $N_e(\text{sel}) = 0.7 \times N_e$  (Santiago and Caballero, 1995). The degree of endangerment was assessed according to the following limits: critically endangered ( $N_e \leq 50$ ), endangered ( $50 < N_e \leq 200$ ), monitored ( $200 < N_e \leq 1,000$ ) and not endangered ( $N_e > 1,000$ )

Species	Breed	Males (M)	Females (F)	Endangerment class
Cattle	Slovak Pinzgau	31	2,025	Endangered
	Valachian	45	907	Endangered
Sheep	Tsigai	360	5,613	Monitored
	Improved Valachian	616	8,175	Not endangered
	Askanian Merino	6	68	Critically endangered
Goat	White shorthaired	50	708	Endangered
	Brown shorthaired	9	81	Critically endangered
	Lipitsa	6	165	Critically endangered
	Shagya arab	16	154	Critically endangered
Horse	Hutsul	7	133	Critically endangered
	Furioso	17	161	Critically endangered
	Nonius	7	28	Critically endangered
	Noric of Murany	18	137	Critically endangered
	Slovak Sport Pony	7	84	Critically endangered
	Slovak Warmblood	16	857	Critically endangered

**Table 2.** Estimated population size, purebred breeding males and females of registered breeders and endangerment class of poultry and rabbit breeds in the Slovak Republic according to 2020 monitoring data. Endangerment class was set according to effective population size calculated according to the formula  $N_e = (4 \times M \times F)/(M + F)$  (Falconer and Mackay, 1996) and assuming mass selection  $N_e(\text{sel}) = 0.7 \times N_e$  (Santiago and Caballero, 1995). The degree of endangerment was assessed according to the following limits: critically endangered ( $N_e \leq 50$ ), endangered ( $50 < N_e \leq 200$ ), monitored ( $200 < N_e \leq 1,000$ ) and not endangered ( $N_e > 1,000$ )

Species	Breed	Population	Males (M)	Females (F)	Endangerment class
Chicken	Oravka	9,000	59	465	Endangered
Goose	Suchovy	250	19	33	Critically endangered
	Slovak White	270	22	40	Critically endangered
Rabbit	Blue of Holic	420	30	80	Endangered
	Liptovsky Lysko	160	20	42	Critically endangered
	Nitra	1,250	38	200	Endangered
	Slovak Pastel rex	105	15	40	Critically endangered
	Slovak Greyblue rex	600	28	92	Endangered
	Zemplin	280	15	55	Critically endangered
	Zobor	60	8	18	Critically endangered
	Strbsky gepardi rex	100	15	35	Critically endangered
Chrabrany	120	19	38	Critically endangered	

Coll. on competences in the area of access to genetic resources and sharing of benefits arising from their utilization) sets only rules for the users of genetic resources falling under the Nagoya Protocol.

The national legislation pays limited attention to endangered breeds and their conservation and lacks direct strategies for AnGR conservation. These are partly compensated for by a few cross-sectorial strategies that refer to AnGR. As part of biodiversity, some actions related to AnGR conservation were included in the Updated National Strategy For Biodiversity Protection 2020 (MZP SR, 2013). These were broadly defined, and included monitoring of AnGR, support for *in situ*

conservation of traditional breeds, genetic analysis of diversity, support for *ex situ* conservation, including the development of a genebank, and identification of ecosystem services provided by AnGR. To a certain extent, the inclusion of these activities into the strategy may be considered a formality since they have been carried out even before the strategy was adopted, and the funds for most of them were allocated regardless of the strategy. Additional issues related to AnGR have been also addressed in the updated version of the Adaptation Strategy of the Slovak Republic to Climate Change (MZP SR, 2018). The disadvantage of including AnGR conservation in

multiple strategies is that some activities may be duplicated, for example, the monitoring of livestock species. Moreover, the number of AnGR conservation activities has increased over time and new conservation approaches are being applied. Therefore, cross-sectoral policies are no longer sufficient to address specific activities related to AnGR conservation, as demonstrated in the case of poultry breeders. While cross-sectoral policies have been grouping the main responsible AnGR stakeholders from different biodiversity sectors, the involvement of small stakeholders that are important from an AnGR perspective has been very limited. While the overall AnGR monitoring was included in the strategy, no attention was paid to gaps and the limited registration system of local poultry breeds and farmers in the country. This led to further problems in providing financial support to these farmers. The limited implementation of the actions listed in the cross-sectoral policies resulted also from the lack of funding since not all actions have financial cover granted. In contrast to this approach, functional conservation programmes have been implemented across European countries, which have been closely tied with funds provided by the EU (Ligda and Zjalic, 2011).

### Monitoring

The livestock monitoring system in the Slovak Republic is based on the use of already existing data. Population data for monitoring purposes come from two sources. The first is the Breeding Services of the Slovak Republic, a state enterprise which provides actual sizes of cattle, horse, goat and sheep populations at the breed level. These data represent the number of obligatory registered livestock animals according to the breed. The reliability of these data is very high since this obligation applies to all farmers of the four mentioned species and the portion of non-registered animals is assumed to be negligible from a population size perspective. Horse breeding has some specificities and discrepancies exist in their registration, therefore the final number of animals is estimated based on data from the register and numbers from studbooks. The second source of data is the authorized breeders' associations which maintain the herdbooks/studbooks and breeding registers, and provide relevant information on registered breeding animals. Although it does not cover the whole population, this information is of high interest, because these animals represent the part of the populations that can actively participate in the breeding process and serve as a basis to create future generations. It provides the numbers of purebred and crossbred animals and a picture of crossbreeding in the populations. To compare between years and exclude fluctuations during the year, actual numbers relevant for the last day of the previous year are used in the monitoring. The reliability of information on cattle, horses, goats, sheep and pigs is high since it comes from reliable existing registration sources. On the other hand, information on poultry and rabbits is less reliable since

the registration of animals of these species is limited and some information is based on estimates. This arises from the fact that while registration is obligatory for every animal from big livestock species, only farmers with more than 350 poultry animals are obliged to register them. Furthermore, due to the already mentioned fact that purebred animals of local breeds are mostly kept by small farmers and in small numbers as a hobby activity, limited information on the population size is available. A similar situation can be observed in the registration of purebred animals of these species, as only a few small farmers keep track of their animals' pedigree and performance. Similar obstacles were reported in the Czech Republic (MZe CR, 2017). In this situation, since the identification of eligible farmers/animals is very complicated, the breeding process becomes difficult and financial support from the state is limited.

Although population data are available for most breeds, active monitoring is performed only for those breeds that are considered established in the country. This is due to the high fluctuation of exotic breeds in the Slovak Republic and to the limited information about small populations of those breeds in the country. The examples of Tarantaise cattle or Lincoln sheep show the farmers' enthusiasm for exotic breeds. However, they were unable to keep breeding them for different reasons, and currently, there are less than ten animals of these breeds in the country. In 2020, more detailed monitoring included 15 cattle, 11 horse, 27 sheep, 5 goat, 6 pig, 49 rabbit, 21 chicken, 3 duck and 3 goose breeds. Among those breeds, 34 were considered autochthonous or traditionally kept in the country, 6 new and 100 exotic. Results of monitoring were used to evaluate the status of endangered breeds Tomka *et al* (2016); Tomka and Huba (2019) and to update population data in FAO's Domestic Animal Diversity Information System.

In addition to population monitoring, communicating with breeders of endangered breeds to understand their needs and expectations is important. This was already shown by Wanner *et al* (2021) who interviewed farmers of German-speaking parts of the Alps and found that the opinions and expectations of farmers differ from studies and opinions of other stakeholders. A short survey among the registered breeders of Valachian sheep (11 out of 14) and Askanian Merino sheep (1 out of 1), Slovak White goose (5 out of 8) and Suchovy goose (9 out of 11), was conducted by NPPC in 2017 and 2018. The survey aimed to investigate the breeders' motivation for the choice of breed, their breeding purposes and future plans for endangered breeds in Slovakia. The results of the survey can help predict trends in these populations since it provides a glimpse of the breeders' attitudes towards monitored endangered breeds. Some outputs of this survey are presented and discussed in this review to show the breeders' motivation and attitudes.

### Conservation

The AnGR conservation activities in the Slovak Republic are primarily oriented toward measures supporting

*in situ* breeding of live animals by private bodies (cooperatives, farmers). This way, endangered breeds can be further developed and continually adapted, e.g., to changing climate conditions (FAO, 2013). There are no restrictions on breeding goals compared to other European countries, where breeders have to commit to maintaining the traditional characteristics of the animals. For instance, for the Slovak Pinzgau cattle, part of the population has already been transformed from dual-purpose to beef production (cow–calf system) (Pavlík et al, 2013). The reason for changing to a cow–calf system may be explained by the fact that the Slovak Pinzgau cattle is still predominantly kept in big herds owned by cooperatives and expected to make a profit primarily from milk production. Therefore, cooperatives have to either improve the milk performance of animals (through e.g. crossbreeding, choice of a different breed) or change the orientation of production. A positive change trend toward beef production is shown by the numbers of living cows registered in different sections of the herdbook (dual-purpose vs. beef). While 1,030 purebred dual-purpose cows and 667 beef cows were reported in 2012 in the population of Slovak Pinzgau cattle, the opposite ratio was reported in 2020, i.e. 841 purebred dual-purpose cows and 1,183 beef cows. At the moment, animals of both groups are eligible for financial support. Although this free approach allows breeds to change their breeding purposes and become more competitive, it can also bring tensions within breeding organizations (Lauvie et al, 2011). At the moment, there are no disagreements on the two different types of Slovak Pinzgau in the association. However, this may change in the future if beef animals divert significantly from the dual-purpose type. A different approach to *in situ* conservation of AnGR with defined requirements is applied in the Czech Republic, where conditions for animal breeding must be as similar as possible to those in which the breed was developed, and modern breeding technologies should be used to a limited extent. Most importantly, the selection of animals is not aimed at improving their performance, but at stabilizing their characteristics and/or maintaining their original characteristics (MZe CR, 2017). An approach based on maintaining the animals' original characteristics can be found in the Valachian sheep population in Slovakia. At the moment, the selection of animals is based primarily on exterior characteristics, since the breed is known for its different colours of wool and different types of horns. Less pressure on selection for productivity traits in this breed may be explained by their ownership. These animals are mostly kept by small farmers as a hobby and for agrotourism, or by cooperatives along with other more productive sheep breeds. The results of the short survey conducted by NPPC showed that resilience, low requirements for feeding and adaptation to the local environment were the most mentioned advantages of these animals. A similar situation can be observed in poultry and rabbit populations. In Oravka chicken,

selection is based primarily on exterior characteristics. This comes as no surprise since the breeding of these animals is considered a hobby activity or is done to ensure small-farmers self-sufficiency.

One of the disadvantages of *in situ* conservation, especially in small populations, is the risk of increasing inbreeding. The responsibility for following breeding programmes and maintaining low inbreeding levels lies with breeders' associations. Therefore, cooperation between breeders' associations and research and academic institutions is crucial for the effective development and implementation of breeding programmes. Recently, several national research projects have been carried out to study the actual status of local breeds populations, and published papers showed different levels of inbreeding in several cattle and horse populations. While pedigree-based inbreeding under the acceptable level of 1% was estimated in Slovak Spotted and Slovak Pinzgau populations of cattle (Kukučková et al, 2017; Kasarda et al, 2019a), genomic analyses showed higher levels of inbreeding and thus increasing trends of inbreeding are expected in both populations. A low level of pedigree-based inbreeding (0.23%) and genomic inbreeding (0.11%) was observed in the relatively small population of Noric of Murany (Kasarda et al, 2019b). Sufficient levels of variability were observed in the populations of Lipitsa, Furioso and Nonius (Kasarda et al, 2018). In older studies (Pjontek et al, 2012), which investigated populations of horses, higher levels of relatedness and expected higher levels of inbreeding based on pedigree information were reported in the population of Hutsul (6.26%) and Slovak Sport Pony (2.67%). A preliminary assessment of inbreeding trends in Valachian sheep (Oravcová and Margetín, 2011) showed a lack of pedigree information in animals resulting in unclear coefficients of inbreeding, while a more recent analysis (Pavlík et al, 2017) showed a low average coefficient of inbreeding (0.85%). A low level of pedigree-based inbreeding (0.69%) was also calculated in the population of White Shorthaired goats (Oravcová, 2013).

Other conservation activities include *in situ* and *ex situ* conservation of live animals by state organizations. While horse breeds (Norc of Murany, Lipitsa, Hutsul, Shagya Arab) are maintained *in situ*, live sheep (Valachian) and chicken (Oravka) are conserved *ex situ*. Conservation activities of the state organizations are aimed mostly at stabilizing and maintaining the original characteristics of these breeds. Additionally, two of these organizations also receive national funds for the long-term storage of AnGR samples. While National Stud provides long-term storage of horse breeds samples (samples are stored as a reserve and are not distributed to breeders), the Genebank of the National Agricultural and Food Centre (GB NPPC-VUZV) stores samples of other livestock species and breeds. This is similar to other European countries, where the long-term storage of AnGR is mostly carried out by public research institutes (Passemard et al, 2018).

Samples stored in GB NPPC-VUZV are owned by the state and are expected to be available for cooperation with breeders and research purposes. In the past, private and public insemination centres used to cooperate on the storage of samples for conservation purposes. This is the case of the Slovak Pinzgau cattle, whose old bull lines were kept by a private insemination centre for commercial and long-term storage purposes. Due to costs associated with cryoconservation, the Slovak Pinzgau samples were later transferred to GB NPPC-VUZV. There was no involvement of Slovak Pinzgau breeders in the process of animal and sample selection. Currently, there is no information available on the number of long-term samples stored by these private insemination centres. The participation of the private sector in long-term conservation activities, however, should be restored because it can reduce collection development costs (Pizzi *et al*, 2016). Moreover, it is assumed that the private sector storing samples of transboundary commercial breeds can allow the public sector to focus more on the country's local and endangered breeds. In December 2021, GB NPPC-VUZV reported 3,058 samples, from which the majority is represented by semen samples from 12 breeds and 4 species (cattle, sheep, chicken, rabbit). These represent mainly endangered local breeds including Slovak Pinzgau cattle, Valachian sheep, Oravka chicken, Blue of Holic, Nitra, Slovak Greyblue rex and Zobor rabbit. In the case of Valachian sheep and Oravka chicken, samples are primarily collected from animals kept *ex situ in vivo* by NPPC-VUZV. This means, that there is no involvement of breeders in the process of sample selection and only limited participation of breeders in providing samples to the genebank. The predominant storing of semen is understandable here and across other countries (Leroy *et al*, 2019) and may be explained by the long and routine use of artificial insemination in some breeds. The collection of samples for long-term storage in GB NPPC-VUZV is rather random, not following any conservation plan or breed-specific attributes (e.g. endangerment, economic return). Such an opportunistic approach was already presented by Blackburn (2009), who described the initial phase of germplasm collection development in the USA. In 2021, GB NPPC-VUZV has become a member of the European Genebank Network for Animal Genetic Resources (EUGENA). This step should help to increase the genebank visibility at the national level and improve cooperation at the international level. From the transboundary breeds perspective, joining the network in combination with strategic collection and storage planning can lead to saving cryoconservation costs in the future (Silva *et al*, 2019). On the other hand, joining the network does not imply that overlapping of collected AnGR samples should be strictly avoided (Danchin-Burge *et al*, 2011).

## Funding and valorization

In order to identify endangered breeds requiring support, breed definitions by FAO (2005) have been followed and endangerment of breeds has been evaluated by the National Focal Point for AnGR in agreement with the rules laid down by the current European legislation. As a result of this approach, different breeds have been supported during the last decades based on their needs. The open approach of the Slovak Republic is demonstrated, for instance, by the Askanian Merino sheep breed. Although not originating in Slovakia, this breed has become eligible for subsidies because of its long breeding tradition in the country, its unique wool performance and its status of critically endangered breed not just at country level but also in the EU. With such an approach, immediate actions can be taken to support critically endangered breeds.

In the mid-1990s, state incentives were provided for live purebred females, but the support varied in the amount per head and number of breeds, because public funds were limited (Oravcová *et al*, 2004). In 2003 these incentives supported two cattle breeds (Slovak Spotted, Slovak Pinzgau), seven horse breeds (Hutsul, Lipitsa, Furioso, Nonius, Shagya-Arab, Noric of Murany, Slovak Sport Pony), three sheep breeds (Valachian, Improved Valachian, Tsigai) and three poultry breeds (Oravka hen, Slovak White goose), including Japanese quail.

After joining the European Union in 2004, a new funding scheme for *in situ* conservation of endangered breeds was applied. Support was provided through the Rural Development Plan (MP SR, 2003) as in many other European countries (Ligda and Zjalic, 2011). In the period 2004–2006 this support was provided only to one sheep (Valachian), one goat (White Shorthaired), eight horse (Slovak Warmblood, Hutsul, Furioso, Nonius, Slovak Sport Pony, Lipitsa, Shagya Arab, Noric of Murany) and nine poultry breeds (Oravka hen, Plymouth Rock hen, Rhode Island Red hen, New Hampshire hen, Vlaska hen, Sussex hen, Slovak White goose, Suchovy goose and Bronze turkey). Due to significant changes in the list of supported breeds, one can argue there have been inconsistencies in the approach and big pressure from breeders to include other breeds on the list of supported ones. The main changes in the list of supported breeds were the consequence of the transition from very limited national funds to European funds. Also, new conditions for support were set after joining the EU. During this period, the number of registered purebred females in herdbooks decreased in Slovak Pinzgau cattle (Table 3). Unfortunately, no data were available to present the trend of registered females of Valachian sheep and White Shorthaired goat, which were supported in this period. However, it can be assumed that this number increased in Valachian sheep and decreased in White Shorthaired goats (Table 3). In horses, the number of registered females increased in Lipitsa, Shagya Arab, Hutsul, Furioso and Slovak Sport Pony, decreased in Noric of Murany and stayed at low levels in Nonius.

**Table 3.** Development of purebred breeding females registered in herdbooks. \*, Year 2003, source: (Oravcová et al, 2004); \*\*, data for 2007; n.a. – data not available.

Species	Breed	Registered purebred females (monitoring data)							
		2003*	2006	2010	2012	2014	2016	2018	2020
Cattle	Slovak Pinzgau	2,500	1,600	1,969	1,697	1,491	n.a.	1,479	2,024
	Valachian	50	n.a.	65	225	349	553	820	907
Sheep	Tsigai	13,000	13,000**	11,406	12,734	7,277	5,571	5,433	5,613
	Improved Valachian	24,000	21,000**	15,724	14,682	9,412	7,641	6,971	8,175
	Askanian Merino	n.a.	n.a.	n.a.	34	27	39	52	68
Goat	White Shorthaired	1,000	n.a.	864	832	1,031	634	752	708
	Brown Shorthaired	3	n.a.	29	102	67	116	152	81
	Lipitsa	60	105	145	186	352	165	181	165
	Shagya Arab	85	102	165	197	359	128	151	154
Horse	Hutsul	50	115	120	110	280	106	141	133
	Furioso	40	80	211	162	150	175	158	161
	Nonius	40	35	39	26	32	28	26	28
	Noric of Murany	115	70	219	104	106	114	119	137
	Slovak Sport Pony	42	60	145	92	70	109	98	84
	Slovak Warmblood	320	n.a.	1,794	868	925	863	836	857

EU regulation 1698/2005 (EU, 2005) allowed to provide support for *in situ* conservation (under Article 39 (2,4)) and *ex situ* conservation (under Article 39(5)) of genetic resources in agriculture. Financial support for *in situ* conservation was defined as compensation of additional costs and income foregone resulting from the commitment made. EU regulation 1974/2006 (EU, 2006) and, in its Annex IV, defined the thresholds for endangered local breeds eligible for *in situ* conservation support. These criteria included a number of purebred breeding females of local breeds in all EU Member countries registered in the herdbook kept by an appropriate breeding organization. Within the period 2007–2013, support for endangered breeds from the Rural Development Programme (MP SR, 2007) was provided to one cattle breed (Slovak Pinzgau), one sheep breed (Valachian), one goat breed (White Shorthaired), eight horse breeds (Slovak Warmblood, Hutsul, Furioso, Nonius, Slovak Sport Pony, Lipitsa, Shagya Arab, Noric of Murany) and eight poultry breeds (Oravka hen, Plymouth Rock hen, Rhode Island Red hen, New Hampshire hen, Vlaska hen, Sussex hen, Slovak White goose, Suchovy goose). Contrary to other European countries, subsidies were paid solely for livestock unit, without any differences made between sexes or level of endangerment or any further required goals (Ligda and Zjalic, 2011).

During the next period (2014–2020), similar support for endangered breeds from Rural Development Programme (MP SR, 2015) continued based on EU regulation 1305/2013 (EU, 2013). Some changes were introduced in Slovakia regarding the list of eligible breeds based on the experience from the previous period, while the same conditions for support were applied. Since almost no support was provided to poultry breeds during the previous period, these breeds were excluded from the support scheme. On the other hand,

three more sheep breeds (Askanian Merino, Improved Valachian, Tsigai) and one goat breed (Brown Shorthaired) were included in the support scheme. EU regulation 807/2014 (EU, 2014a), introduced transitional provisions and the role of a relevant scientific body to identify endangered breeds. In Slovakia, the assessment of endangerment was based partly on the criteria used in the previous period (number of registered purebred breeding females), as well as on effective population size calculated following Falconer and Mackay (1996).

One of the main goals of AnGR conservation is to stop the loss of biological diversity of livestock. Thanks to funding from rural development programmes, the negative trends of population sizes of endangered breeds from the 1990s were more or less stabilized in the 2000s (Oravcová et al, 2010), and these trends were repeatedly reported by Tomka et al (2016) and Tomka and Huba (2019).

The number of registered purebred Slovak Pinzgau cows decreased in the period 2003–2006 (Table 3), but it recovered to 2,000 females by 2010. The stabilized trend with small fluctuations may be observed both in population size (Table 4) and the number of registered purebred females in the recent period 2010–2020 (Table 3). It should be noted again that, while the number of registered females has been more or less stabilized at around 2,000 heads, the transfer of cows from milk production to cow–calf system is ongoing. This means breeders are trying to increase the competitiveness and profit generated from these cows. At the moment, it is unclear whether the number of registered purebred females would decrease if the subsidies were lowered for more competitive cows in cow–calf systems.

The continuous decrease of Improved Valachian and Tsigai populations and increase of the Valachian population are significant (Table 4). The number of regis-



tered purebred Improved Valachian and Tsigai females decreased in the period without subsidies (2003–2016). This number levelled off in 2016 (Table 3). This can be attributed to the start of subsidies provided to the breeders of these breeds. The decreasing trend of population size and stabilized number of registered purebred females after the implementation of subsidies suggest that further decrease could occur if the financial support is terminated. It may be assumed that in such a case, these populations will not become extinct, but their possible reduced sizes will lead to problems due to the availability of a smaller number of purebred breeding animals. On the other hand, the case of the original type of Valachian sheep shows positive trends in the population size and number of registered purebred females. While only 50 females were registered in 2003 (Table 3), recently, 900 females were registered in the herdbook. Although these trends may be attributed to subsidies provided for this breed, breeders did not state that subsidies were the motivation for choosing and breeding this breed in the short survey conducted by NPPC. The stable trend of Askanian Merino may be explained by the fact that there has been only one registered breeder of this breed in Slovakia.

Two breeds of goats are eligible for financial support in Slovakia. However, the trends in their population sizes are different (Table 4). While the larger population of White Shorthaired goats can be considered stable, the smaller population of Brown Shorthaired slightly increased during the period 2010–2020. Different patterns may be observed in the number of registered females. The number of registered White Shorthaired goats has been slightly decreasing since 2003, despite subsidies. On the other hand, a small increase of registered Brown Shorthaired goats can be observed even before support was provided (2003–2012) and the number stabilized in the following period 2012–2020. These findings show that providing financial support in Slovakia does not automatically lead to an increase in population size or in the number of registered females. These findings also support the fact that the motivation of farmers plays an important role.

In horses, the estimated population sizes are stable (Table 4). The number of registered purebred females increased compared to the year 2003 (Table 3) and can be considered stable in the last years (2016–2020). However, some of them (Nonius, Slovak Sport Pony) have been staying at very low levels since then and there is a big risk of losing these populations. While the Nonius horse is a transboundary breed and cooperation with neighbouring countries can help to prevent the loss of the breed in the country, the population of Slovak Sport Pony is extremely vulnerable due to its local distribution and the presence of only a few breeders.

A positive effect of subsidies on the demographic development of endangered breeds in Europe was presented by Gicquel *et al* (2020) who argue that correctly setting the conditions and level of subsidies are crucial elements of a subsidiary system. Based on

previously published data (Kompan, 2014), it can be speculated that while some population sizes increased over time thanks to a sufficient level of subsidies (e.g. in Hungary and Poland) and/or also thanks to the support only to active breeding animals in some countries (e.g. Austria), subsidies had a stabilizing or even no effect in other countries including Slovakia. On the other hand, an insufficient level of subsidies was identified as a possible reason for the continual decrease of supported animals, especially in horses (e.g. in Austria). This may be explained by limited economic income from horse breeding, which requires higher compensation for income loss. Stabilized trends of registered animals and the number of subsidy applicants in Slovakia suggest that the support for *in situ* breeding of endangered breeds is set correctly to prevent population sizes, and most importantly the number of registered animals, from decreasing in most breeds. This means that the value of a subsidy is not so high to attract speculative breeders, who would primarily keep animals of endangered breeds only to profit from the subsidies and not for breeding and developing endangered breeds. This can be illustrated in the case of Askanian Merino. One could expect that farmers of traditional Merino sheep would switch to breeding Askanian Merino since they are phylogenetically closely related breeds. However, after the introduction of financial support for the Askanian breed, no dramatic change in the number of farmers and animals has been observed. The number of existing breeders of supported endangered breeds is not decreasing, so it can be assumed that, at the moment, subsidies provide sufficient support for these breeders to keep endangered breeds. Such an approach is in line with Strategic Priority 8 of GPA, i.e. in the long-term perspective, the emphasis should be put on the sustainable use of local breeds without the need for support from public funds or extra funding. However, it is questionable whether the support would be efficient with lower subsidies and reflect the level of endangerment of breeds. It is also questionable whether the number of animals would increase if some requirements were implemented, e.g. only active breeding animals eligible for subsidies.

Strong tools to improve the competitiveness of local breeds are the products related to the breed (Verrier *et al*, 2005). Unfortunately, no breed-related animal products exist in Slovakia. Therefore, new ways of promoting products from endangered breeds have to be exploited. As an example of efforts, activities of the sheep and goat breeders' association resulted in the official certifications of animal products that originate exclusively from Slovak sheep and goat milk and meat. The aim of the 'Golden sheep' and 'Golden goat' certificates is to ensure the quality of animal products originating from sheep and goats, and fair price for producers. Such efforts, however, are not aimed at the breed level, but rather at species. At the moment, Slovakia has no animal products registered as protected designation of origin. However, there

**Table 4.** Development of Slovak breed populations in the period 2010–2020.

Species	Breed	Population size (monitoring data)					
		2010	2012	2014	2016	2018	2020
Cattle	Slovak Pinzgau	9,883	11,384	10,166	9,895	12,004	10,982
	Valachian	2,391	2,372	2,231	2,437	2,834	2,906
Sheep	Tsigai	122,253	142,944	127,071	123,660	113,135	91,239
	Improved Valachian	130,207	143,757	134,403	131,573	121,807	100,235
	Askanian Merino	350	541	341	345	418	440
Goat	White Shorthaired	8,389	6,798	7,685	8,036	8,166	7,576
	Brown Shorthaired	1,485	812	1,137	1,627	1,912	1,901
	Lipitsa	750	500	575	775	900	900
	Shagya Arab	600	500	500	650	700	700
	Hutsul	500	450	400	550	500	500
Horse	Furioso	450	450	375	475	475	475
	Nonius	110	110	93	105	105	125
	Noric of Murany	400	400	350	475	475	450
	Slovak Sport Pony	200	200	225	250	250	250
	Slovak Warmblood	2,500	2,500	2,150	3,250	2,500	2,500

are several cheese products registered as a protected geographical indication, four of which are related to certain regions and the rest is related to the whole country. The connection of local breeds to these regions may bring some interest in consumers. The promotion of animal products coming from local breeds raised in protected areas may have a similar impact. This approach, however, needs the involvement of the environmental sector and the facilitation of protected areas used for sustainable grazing. This is in line with recent European strategies (The European Green Deal, Biodiversity Strategy for 2030, Farm to Fork Strategy), which are calling for environment-friendly agriculture and high-quality animal products while referring also to local AnGR in this regard.

More straightforward use of non-productive services of livestock may be found in some cases. While national legislation sets strict rules on farming in protected areas, the environment sector is already searching for livestock species and breeds that are adapted to specific natural conditions in order to use them for maintaining valuable ecosystems in the country. These measures may be presented by including extensive pasture of different livestock species as a management tool in the projects 'Restoration and management of Danube flood plain habitats (LIFE14 NAT/SK/001306)' and 'Restoration of Natura 2000 sites in cross-border Bratislava capital region (LIFE10 NAT/SK/000080)'. Livestock animals in these projects are primarily used to maintain the traditional character of meadows and pastures while preventing the spread of invasive plant species and securing the wide biodiversity related to these ecosystems. In some cases, the production roles of livestock are neglected in favour of these non-productive ecosystem maintenance services. In the long-term perspective, such an approach may lead to the loss of the breeds' productive characteristics. Some authors

have pointed out that this non-productive approach may lead to the use of livestock solely for environmental reasons without any production benefits, and may be vulnerable to lack of external payments, making the sustainability of such measures questionable (Wilson, 1996; Evans and Yarwood, 2000). Recently, however, studies suggested that conservation should aim beyond genetic and production goals since the distribution of breeds is changing in favour of more productive environments, where the diversity of breeds is lower and areas with higher breed diversity are being abandoned (Velado-Alonso et al, 2020).

### Awareness raising

AnGR conservation has its specific features compared to wild biodiversity conservation. The most important one is the ownership of AnGR. While the government is committed to conserving AnGR under its jurisdiction, the animals are owned by private bodies. Since the decision to keep animals lies on the private person, awareness raising of breeders about the characteristics, roles and benefits arising from breeding endangered livestock breeds is crucial. This is because in many cases, breeders of endangered breeds are hardly aware of the value of their animals as genetic resources (Herold et al, 2012). Economic aspects and modern technologies, which increase availability and enable the exchange of AnGR across Europe and the world, make it very difficult to motivate breeders to prefer raising endangered and less productive breeds. In some cases, breeders follow 'fashion trends' and decide to prefer an exotic breed because of its unique appearance or assumption of high profits from selling its progeny and products. They are often not aware of whether the breed is fit for their environment, and this may lead to low production. Even in cases when only non-productive livestock services are expected, exotic breeds are preferred. Of

**Table 5.** SWOT analysis of AnGR conservation activities in Slovakia

Strengths	Weaknesses
<ul style="list-style-type: none"> <li>• Breeding activities of each breed in Slovakia are covered by breeders' associations.</li> <li>• Data from herdbooks/studbooks and data from animal registration system are available.</li> <li>• AnGR sector has been a part of cross-sectoral policies.</li> <li>• Open system of conservation allows to include new breeds in the list of supported breeds.</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of national legislation and policies that specifically address conservation of AnGR.</li> <li>• Lack of registration in poultry and rabbits.</li> <li>• Limited inclusion of stakeholders and farmers in planning conservation activities and cryoconservation of AnGR.</li> <li>• Limited transfer and implementation of results from research.</li> </ul>
Opportunities	Threats
<ul style="list-style-type: none"> <li>• Cooperation between breeders' associations of neighbouring countries.</li> <li>• New technologies, establishment of genebanks and public funding to improve cryoconservation of AnGR.</li> <li>• New European strategies</li> <li>• Introduction of new ways of valorization of AnGR products and services.</li> </ul>	<ul style="list-style-type: none"> <li>• Small number of breeders of local breeds.</li> <li>• Conservation measures may be at risk if the funding is limited.</li> <li>• Lack of awareness and personal motivation of breeders and their successors.</li> <li>• Trends of preferring extensive systems and decreasing livestock numbers.</li> </ul>

course, local breeds are not the only ones able to provide services related to landscape and ecosystem maintenance (Leroy *et al.*, 2018), but some studies showed their specific abilities in harsh environments. In this case, awareness raising can help to promote local and endangered breeds, which can perform better in more diverse conditions. The already described short survey conducted by NPPC showed that one of the main reasons to raise local breeds in the country is patriotism. This finding suggested that choosing a local breed depended on breeders' enthusiasm and thus small populations may be vulnerable to changes in their motivation. Results of the survey also suggested that breeding these animals is strongly connected to the breeder and low interest from the breeder's successors can cause a further decrease in the local breed population. Similar findings were already presented by Yarwood and Evans (1998) in the UK, who suggest that the motivation of new breeders is important. This can be primarily achieved by financial support, but in many cases improving and acknowledging the status of breeders of local breeds can increase the attractiveness of local breeds.

In Slovakia, breeders' associations also have limited awareness of cryoconservation activities; the recent initiatives for cryoconservation are coming from state organizations, differently from neighbouring countries (Czech Republic, Poland), where the management of preserved breeds' sample acquisition and conservation involves farmers and their associations. Limited involvement of breeders' associations in decisions on AnGR sample selection is not considered a big problem in the initial phase of sample collection, but it may result in limited harmonization of cryoconservation and breeding programmes of endangered breeds in the future. Therefore, AnGR cryoconservation should be promoted widely

among breeders as a complement to *in situ* conservation. New schemes of cryoconservation funding should be investigated to improve the active involvement of breeders and the overall state of long-term conservation of AnGR.

The predominant presence of big cooperatives and the separation of farmers from their land until the 1990s resulted in a weak connection between farmers and consumers at the national and local levels. After the 1990s, people started to return to their land. However, the establishment of direct channels between farmers and consumers is still underway. In this situation, raising public awareness about AnGR, their roles and products is very important for generating demand. General promotion at the national level brings attention to AnGR. At the local level, it is very important to also acknowledge the breeders who keep endangered breeds to facilitate the creation of local niche markets.

### SWOT analysis

A SWOT analysis of AnGR conservation activities in Slovakia was conducted in order to facilitate the preparation of a national conservation strategy (Table 5). The absence of a legal basis for AnGR conservation makes it difficult to adopt any long-term conservation programme, clearly define breed categories and criteria to assess endangerment and provide related financial support, and complicates the operation of genebanks. There are also problems with records in poultry and rabbits, which hamper the identification and support of eligible farmers and animals. The adoption of a specific national strategy could facilitate this support. Cross-sectoral policies allow closer cooperation with the environment and wild biodiversity sector and this increases awareness of agricultural biodiversity as part of overall biodiversity. They can also help in achieving

common goals, including ecosystem maintenance and adaptation to climate change in the future.

Breeding activities are well organized in Slovakia. This gives a good baseline for appropriate management of populations and population structure monitoring. Breeders should not only act as keepers of AnGR and providers of their samples but should be involved in the decision-making of national cryoconservation goals and related activities. Moreover, participation of private insemination and cryoconservation centres could bring new opportunities, e.g. long-term storage of samples from commercial breeds.

The majority of livestock breeds in Slovakia are considered transboundary as defined by FAO. This creates an opportunity for breeds at risk to be recovered from resources coming from neighbouring countries. In this light, data from DAD-IS as a tool to provide information on transboundary breeds in different countries are very important. In some cases, even a sign of the presence of a breed in a country presented in DAD-IS may serve as a starting point to search for animals and farmers. On the other hand, a very small number of breeders of local breeds, like Slovak Sport Pony, are considered a risk. Big efforts should be made to attract new breeders to such breeds to spread the population among more breeders and lower the risk of losing the whole population when old breeders quit breeding or decide to change breed.

Early identification of and financial support to endangered breeds can serve well as a preventive tool. On the other hand, the number of animals of some endangered breeds may decrease despite financial support. This applies in particular to horse breeds, where economic income from breeding is limited. Awareness raising and personal motivation of breeders and their successors are in many cases the key to keeping endangered breeds. Modern trends of acquiring popular exotic breeds and the decreasing interest of breeders' successors in animal breeding are a big challenge for the conservation of AnGR. Connection of products to the environment, acknowledgement of breeders and monetary expression of non-productive services related to landscape maintenance may improve the valorization of AnGR products.

Changing attitudes of the public toward animal breeding and production, and corresponding European strategies create opportunities for more research activities in the field of non-productive roles of AnGR in extensive livestock systems with a positive impact on the environment and studies of unique traits that are linked to adaptability (and resilience) of local breeds. On the other hand, these European strategies may lead to favour extensive systems and decreasing livestock numbers to reduce emissions. This may also have a harmful effect on AnGR in the country. For example, local breeds, which are at present kept in bigger herds by traditional cooperatives, may be abandoned without or with limited replacement if smaller farmers decide not to keep

them or to keep them in smaller herds in more extensive systems.

### Author contributions

Ján Tomka contributed to the concept and design of the manuscript. All authors contributed to drafting and reviewing the manuscript.

### Conflict of interest statement

The authors declare that no conflict of interest exists.

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