GEOGRAPHICAL DISTRIBUTION OF SHEEP AND GOAT BREEDS IN SLOVENIA

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Summary: Geographical distribution of small ruminant breeds kept in Slovenia and included into the National selection program was studied. Analyses of the population size and its structure were made together with the geographical distribution (geographical coordinates of flocks locations upon Gauss-Krueger coordinate system; the values of x and y). For individual flocks the radial distance from the geographic centre of gravity was calculated, and a distribution graph was made where cumulative distribution of animals depending on their distance from the geographic centre of gravity is presented. The calculated geographical centre for the autochthonous breeds is in the area of their origin, while traditional and foreign breeds gravitate towards the central part of Slovenia. It is characteristic of autochthonous breeds that the majority of their population is located within a small radius, compared to foreign and traditional breeds. So, the autochthonous breeds are mostly concentrated just to a smaller geographical area. Three Slovenian autochthonous breeds of sheep (Bela Krajina Pramenka, Istrian Pramenka and Bovec sheep) have 90 % of their population within a distance of less than 25 km, while the Slovenian autochthonous breed of Drežnica goat has 90 % of the total population within a radius of less than 30 km. Traditional and foreign breeds are not confined to only one region or area. Due to the occurrence of natural disasters or sudden outbreak of diseases the scarce Slovenian autochthonous sheep and goat breeds are considered as most endangered population.

Key words: sheep; goats; breeds; geographical distribution; endangered breeds; endemic area

Introduction

In the report entitled "The State of the World´s Animal Genetic Resources for Food and Agriculture" prepared by the International Organisation of the United Nations for Food and Agriculture [1] an urgent need is stressed to improve the overview of each animal breed population (size, endangerment, etc.). However, other important factors such as geographical concentration should also be taken into account [2]. This involves the study of the distribution of individual species, breeds and flocks of farm animals which is particularly important for the "*in situ*" conservation in an environment where the farm animal genetic resources originate from and where they developed their distinctive traits [3].

An assessment of the risk status of livestock breeds or populations is an important element in the planning of animal genetic resources management. The risk status of each breed informs stakeholders whether, and how urgently, actions need to be taken [1]. Gandini et al. [4] define "degree of endangerment" as a measure of the likelihood that, under current circumstances and expectations, the breed will

become extinct. Accurately estimating degrees of risk is a difficult undertaking and incorporates both demographic and genetic factors. Clearly, current population size is important factor in determining risk status. A small population concentrated in one area is at greater risk of being wiped out by natural disasters, disease, or inappropriate management [1]. An essential aspect of risk is the geographical distribution of flocks because potential threat for farm animal genetic resources is positively associated with high geographical concentration. Carson et al. [5] stresses that in determining the level of risk status of certain breed besides the number of population, the number of flocks within particular breed etc., special attention should be given also to other factors such as geographical concentration of an individual breed. The example of a large impact of the geographical concentration of animals on one area was clearly visible in the UK during the outbreak of foot-and-mouth disease in 2001 [5].

Small numerous autochthonous breeds are often kept in a well-defined (original) geographical area where they were selected to be maximally adapted to the local conditions. However, some breeds can be present in very small areas, while other breeds are more dispersed. The species, which is tied to a specific geographical area, can be considered as endemic [6]. Breed diversity in small ruminants in Slovenia is relatively large. Slovenian autochthonous (Jezersko-Solčava sheep, Bovec sheep, Istrian Pramenka, Bela Krajina Pramenka, Drežnica goat) and traditional (Improved Jezersko-Solčava sheep, Slovenian Saanen goat and Slovenian Alpine goat) breeds of sheep and goats and the foreign Boer goat are included into the National selection program according to the breeding program of each individual breed. The goal of the breeding program are selected purebred females and males that are suited to meet the individual needs and requirements of the sheep and goat breeders. This goal also helps in the recovery of endangered species by preserving the existing gene pool and prevents inbreeding especially in endangered breeds.

The aim of this work was to evaluate the potential threat for the spread of infection in purebred flocks due to geographical distribution in case the infection would arise in the vicinity. Based on these results the conservation policy could be modified or improved by considering the geographical component. The risk of losing an endangered breed due to infectious diseases could therefore be reduced.

Material and methods

Population data of sheep and goat breeds in Slovenia for 2011 were obtained from the database of National selection program for small ruminants. The database includes selection aspects for each individual animal (e.g. identification number, birth date, pedigree information and production recording) and is being updated daily. The proportion of sheep and goat breeds covered by the database of National selection program differs among breeds. For traditional and foreign breeds the number of animals included in the database is less than half of the whole population kept in Slovenia, while the percentage of animals by autochthonous breeds included in the database is as follows: Bovec sheep = 76.4 %; Istrian Pramenka = 83.74 %; Bela Krajina Pramenka = 88.86 %; Drežnica Goat = 83.12 % and Jezersko-Solčava sheep – the only non-endangered autochthonous breed = 29.22 %. All purebred males of individual breeds are used as breeding males. We analysed the population size and structure together with the geographical distribution (geographical coordinates of flocks according to the Gauss-Krueger coordinate system, values x and y). Gauss-Krueger coordinates system is commonly used in the Republic of Slovenia (http://www.spatialreference.org/ref/sr-org/7011/), where meter is used as a unit for x and y. A potential danger of endemic diseases for a particular breed is best show on the geographical map, where it is clearly seen how individual breed flocks are dispersed or concentrated in a particular geographic area. Data processing and presentation of the results was performed with the software package R [7]. By using coordinates (pairs of values x and y) we indicated the locations as well as flock size on the map of the Republic of Slovenia. Flock size is represented by a point size [8]. Due to the proximity of certain flocks we sketched a partially transparent point. In the case of multiple overlapping of nearby points it is plotted as a darker colour. Like Carson *et al.* [5] we calculated the geographical centre of gravity for flock locations and marked it on the map. The centre of gravity was calculated as the weighted median of coordinate values: X_T = median (x, w) and Y_T = median (y, w), where x and y are vectors of coordinates of individual flocks, while w is the vector of relative weights calculated in relation to the size of an individual flock (population number of a particular breed per farm). Compared to Carson *et*

al. [5] we used the median instead of the mean. It is clearly seen that a single strong isolated point can greatly affect the location of the centre of gravity, which is determined by the arithmetic mean. The median is insensitive to an individual remote flock and therefore more suitable for the evaluation of the centre of gravity, mostly for concentrated flocks. For individual flocks the distance from the centre of gravity was calculated, and a distribution graph was made where cumulative proportion (distribution) of animals depending on their distance from the centre is shown. Apart from the points on the map which represent location and flock size, there are also circles drown to show the distance from the calculated geographic centre of gravity, where 50, 90 and 95 % of all animals included into the National selection program for the individual breed are located.

Results

Geographical distribution of flocks and flock size for individual breeds of sheep and goats kept in Slovenia is presented in Figures 1-4. Individual flocks are presented by circle, while the calculated geographic centre of gravity is marked by an x. From the images it is clear that the geographical distribution differs among breeds.

Bela Krajina Pramenka

In 2011, there were 41 purebred males, 652 purebred females and 115 purebred young females included in the National selection program. Bela Krajina Pramenka is characterized by the concentration of a large part (95 %) of the population at a distance calculated from the geographic centre of gravity of less than 30 km while 90 % of the population is located within the radius of ~ 18 km (Figures 1a and 2a).

Jezersko-Solčava sheep

Jezersko-Solčava sheep is the only non-endangered Slovenian autochthonous small ruminant breed. In 2011, there were 126 flocks of 5202 purebred animals included in the National selection program which means 203 purebred males, 4247 purebred females and 752 purebred young females. The average flock size was relatively small, amounting only to 36.6 animals. Jezersko-

Solčava sheep is otherwise scattered throughout the entire territory of Slovenia. However, most of the flocks are in the area of two Slovenian statistical regions (Gorenjska and Savinjska). The breed is therefore in its native region, as well as outside and it is not geographically confined to only one statistical region or area (Figure 1b). A relatively uniform distribution of flocks depending on the distance from the calculated geographic centre of gravity is shown in Figure 2b. It is necessary to take into account the fact that the percentage of animals included into the National selection program according to the number of animals in the entire Jezersko-Solčava population is different in comparison to other Slovenian autochthonous breeds of sheep and goats. In less numerous breeds there are more than 80 % of the population included into the National selection program, while less than 30 % belong to Jezersko-Solčava sheep.

Bovec sheep

In 2011, there were 148 purebred males, 1886 purebred females and 640 purebred young females included in the National selection program. The average flock size was 64.6 animals. There are only a few flocks of bigger size. Most farmers keep a small number of animals, therefore the median for the flock size is 36.0 animals.

Istrian Pramenka

In 2011 there were 43 purebred males, 650 purebred females and 270 purebred young females included in the National selection program. The average flock size was 151 animals. Figure 1d shows the small size of Istrian Pramenka population and a local distribution in the Karst and Istria region. A little less than a half of the total population of Istrian Pramenka were bred in a single flock. For this reason a median for flock size is only 41.5 animals.

Improved Jezersko-Solčava sheep

Improved Jezersko-Solčava sheep is the most numerous sheep breed in Slovenia. In 2011, there were 151 purebred males, 4052 purebred females and 670 purebred young females included into the National selection program. Improved Jezersko-Solčava sheep is the most geographically dispersed breed in Slovenia (Figure 1e).
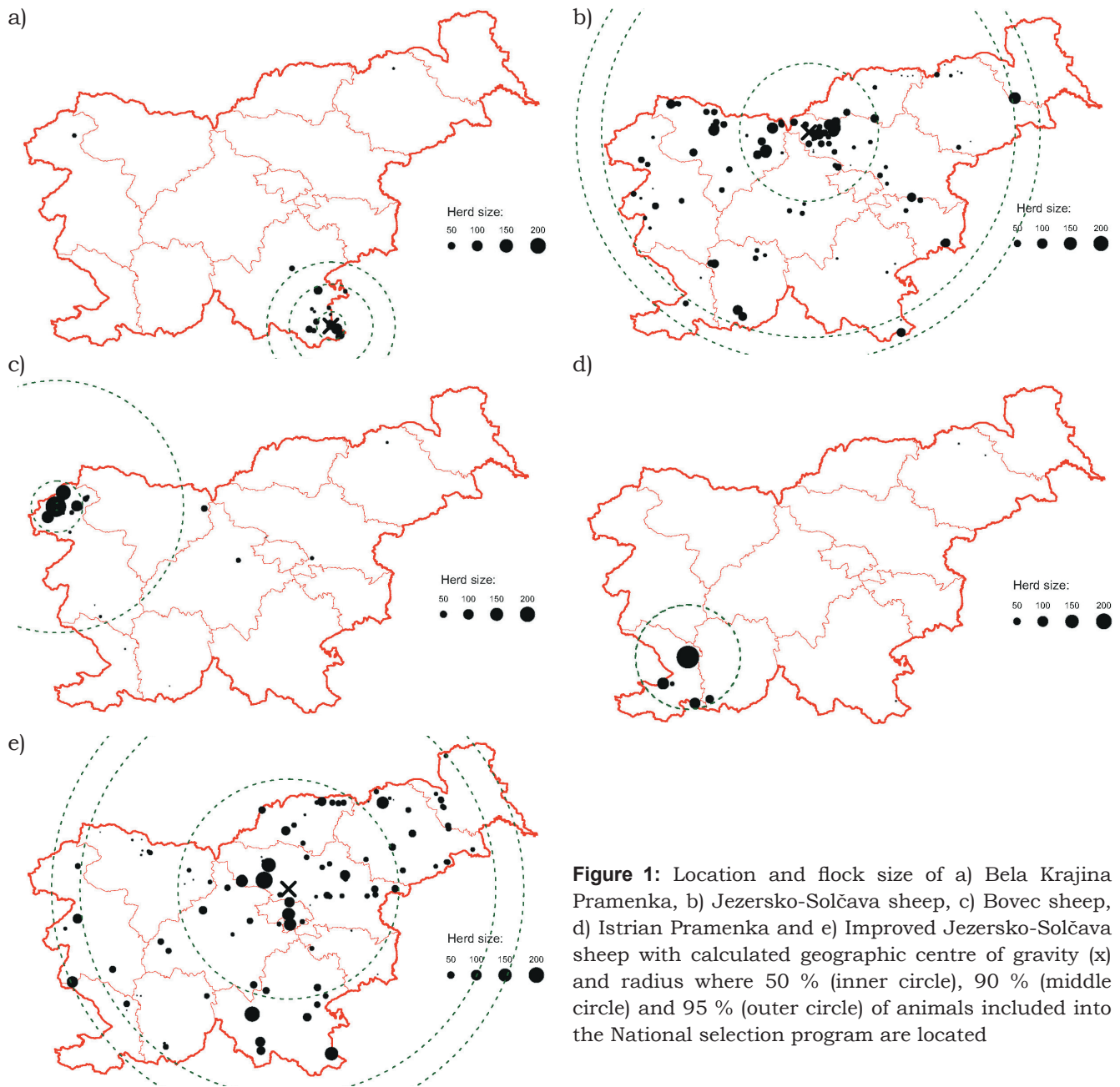
a)

b)

c)

d)

e)

Figure 1: Location and flock size of a) Bela Krajina Pramenka, b) Jezersko-Solčava sheep, c) Bovec sheep, d) Istrian Pramenka and e) Improved Jezersko-Solčava sheep with calculated geographic centre of gravity (x) and radius where 50 % (inner circle), 90 % (middle circle) and 95 % (outer circle) of animals included into the National selection program are located

Table 1: Flock dispersion of sheep breeds from the calculated geographic centre of gravity

Breed	Purebred females (n) in NSP* in 2011	Distance (km) from the calculated geographic centre of gravity			Calculated geographic centre of gravity by Gauss-Krueger coordinate system	
		Percentage of animals (%)				
		50	90	95		
Bela Krajina Pramenka	767	~ 6	~18	~ 28	x=523488, y=41375	Mala sela close to Adlešiči
Jezersko-Solčava sheep	4999	~ 35	~ 95	~ 103	x=135715, y=477431	Zg. savinjska dolina and Luče
Bovec sheep	2526	~ 1	~ 12	~ 55	x=133610, y=389289	Bovec
Istrian Pramenka	920	0	~ 25	~ 100	x=62814, y=423325	Gabrče close to Divača
Improved Jezersko-Solčava sheep	4722	~ 49	~90	~105	x=121970, y=502424	Gomilsko

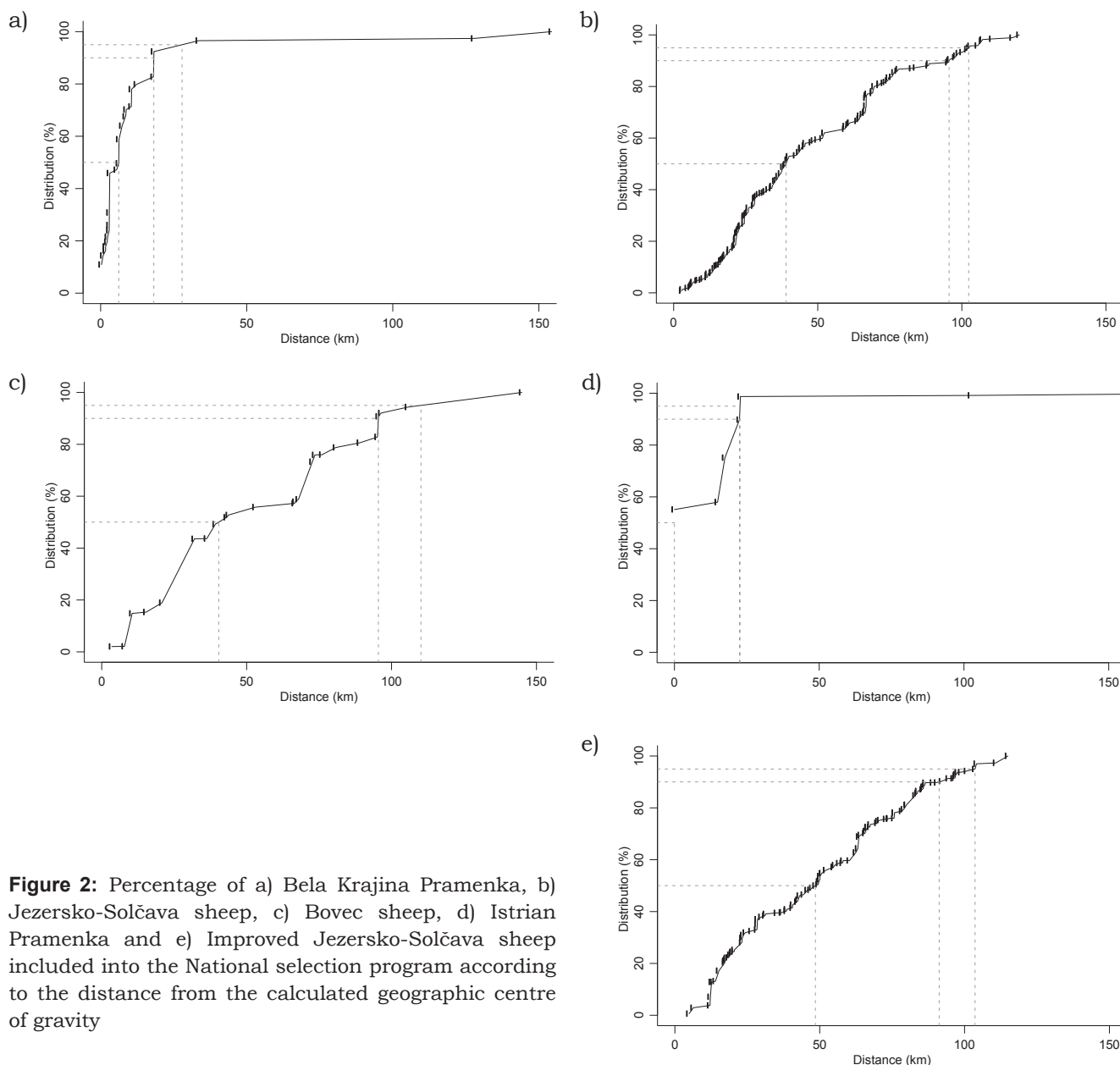*National selection program

Figure 2: Percentage of a) Bela Krajina Pramenka, b) Jezersko-Solčava sheep, c) Bovec sheep, d) Istrian Pramenka and e) Improved Jezersko-Solčava sheep included into the National selection program according to the distance from the calculated geographic centre of gravity

Based on the results for individual sheep breeds the distance (km) from the calculated geographic centre of gravity and the calculated geographic centre following Gauss-Krueger coordinate system is presented in Table 1.

Differences in flock dispersion among various sheep breeds occur mainly due to the group of breeds (autochthonous, traditional) (Table 1). Thus, the Slovenian autochthonous sheep breeds are mostly concentrated in their own calculated geographic centre of gravity. At the same time these centres are also their area of origin according to the historical sources on development of the individual breed. For example,

in Istrian Pramenka a half of the population is located in its own geographic centre of gravity, while a larger share of animals is located within a distance of about 25 km. The most numerous Slovenian autochthonous sheep breed (Jezersko-Solčava sheep) has a half of its population in a distance of about 35 km from the calculated geographic centre of gravity, whereas practically all animals are located within a distance of about 103 km from the calculated geographic centre of gravity. Traditional sheep breed (Improved Jezersko-Solčava sheep) is fairly evenly dispersed throughout the territory of Slovenia.
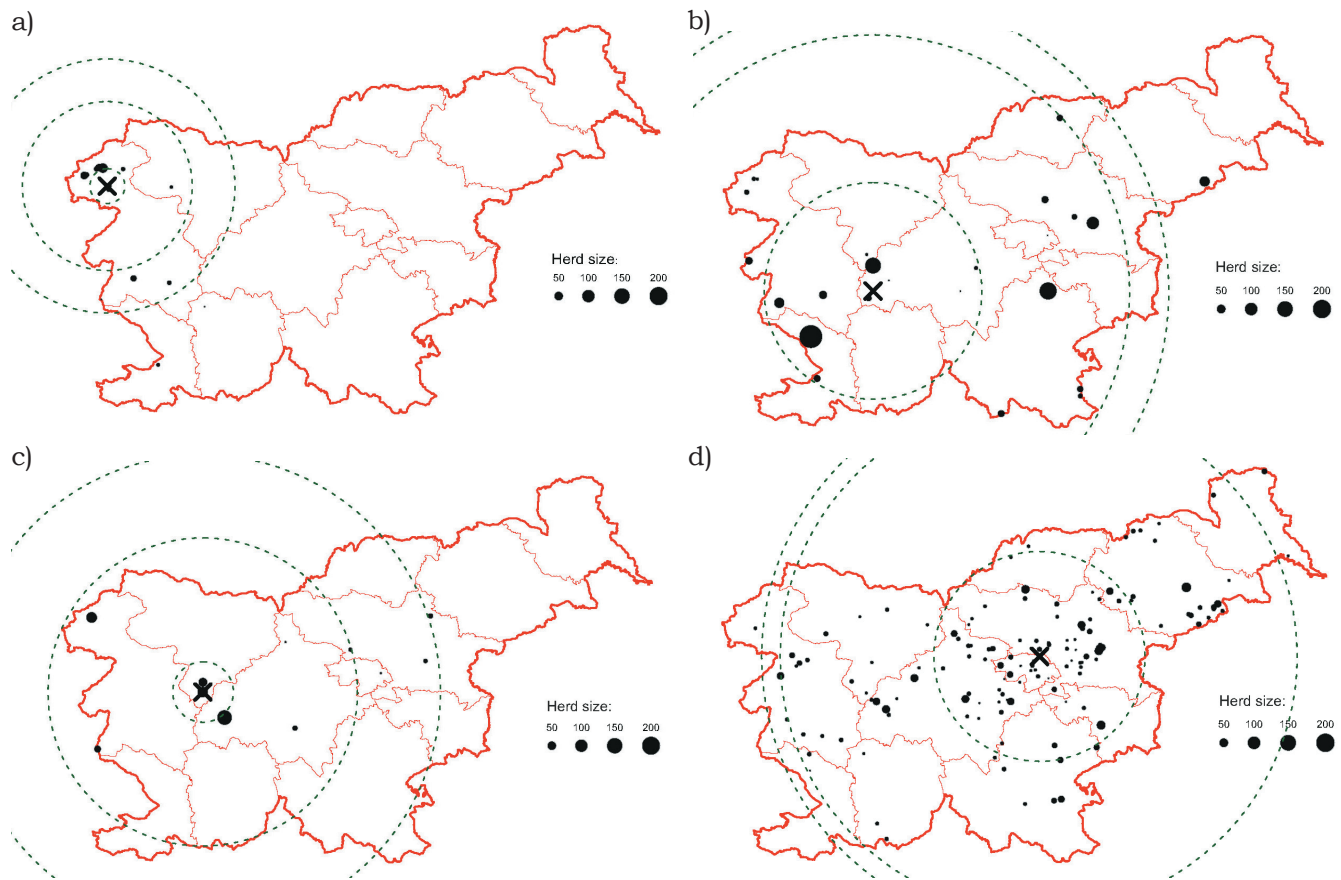
Figure 3: Location and flock size of a) Drežnica goat, b) Slovenian Alpine goat, c) Slovenian Saanen goat and d) Boer goat with calculated geographic centre of gravity (x) and radius where 50 % (inner circle), 90 % (middle circle) and 95 % (outer circle) of animals included in the National selection program are located

Drežnica goat

In 2011, there were 39 purebred males, 355 purebred females and 105 purebred young females included in the National selection program. Almost all flocks of Drežnica goat breed are located in the area of breed origin (Figure 3a). Within a distance less than 30 km there are 90 % of all population of Drežnica breed included in the National selection program (Figure 4a).

Slovenian Alpine goat

In 2011, there were 1241 animals; 37 purebred males, 976 purebred females and 228 purebred young females included in the National selection program. Based on the distance from the calculated geographic centre of gravity, flocks of Slovenian Alpine goat breed have a relatively even distribution throughout the country (Figures 3b and 4b).

Slovenian Saanen goat

In 2011, there were 526 animals; 26 purebred males, 324 purebred females and 176 young purebred females included in the National selection program. Slovenian Saanen goat breed is small in number, therefore it is difficult to speak of greater or lesser dispersion. Depending on the distance from the focus the flocks of Slovenian Saanen goat breed are relatively evenly distributed (Figures 3c and 4c).

Boer goat

Boer goat is the most numerous goat breed in Slovenia and it is spread throughout the country (Figures 3d and 4d). In 2011, there were 297 purebred males, 1465 purebred females and 640 young purebred females included in the National selection program.
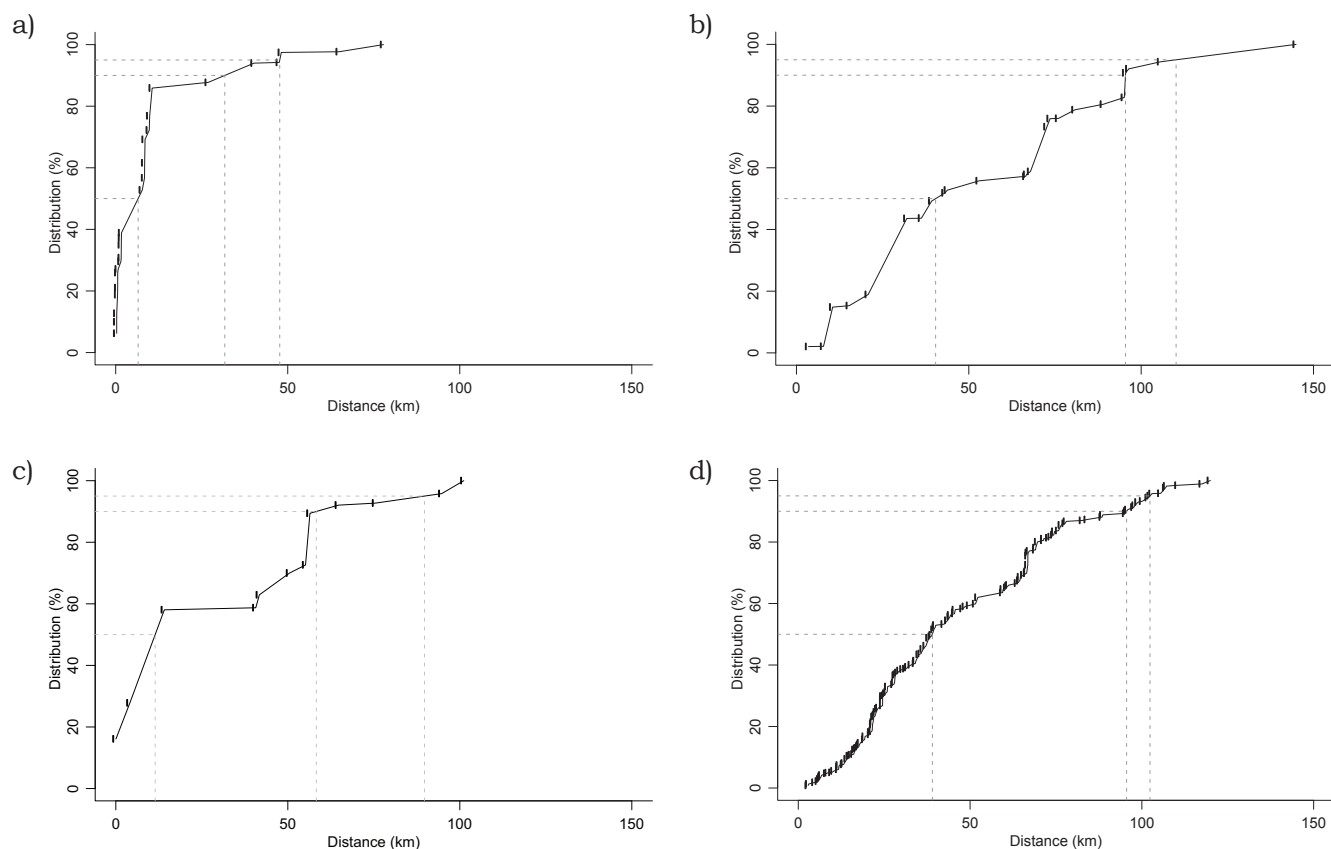
Figure 4: Percentage of a) Drežnica goat, b) Slovenian Alpine goat, c) Slovenian Saanen goat and d) Boer goat according to the distance from the calculated geographic centre of gravity

Table 2: Flock dispersion of goat breeds from the calculated geographic centre of gravity

Breed	Purebred females (n) in NSP* in 2011	Distance (km) from the calculated geographic centre of gravity			Calculated geographic centre of gravity by Gauss-Krueger coordinate system	
		Percentage of animals (%)				
		50	90	95		
Drežnica goat	460	~ 5	~ 29	~ 48	x = 126070, y = 392751	Drežniške Ravne
Slovenian Alpine goat	1204	~ 38	~ 96	~ 110	x = 87495, y = 437278	Žibrše close to Logatec
Slovenian Saanen goat	500	~ 10	~ 60	~ 90	x = 102600, y = 434683	Žirovski vrh
Boer goat	2105	~38	~ 95	~ 102	x = 115563, y = 505911	Marija Reka close to Trbovlje

*National selection program

The smallest distance from the calculated geographic centre of gravity has Slovenian autochthonous Drežnica goat breed (Table 2). A half of the entire population of this breed included in the National selection program is located within a distance of about 5 km. The calculated geographic centre of gravity of Drežnica goat is the area of its origin. Other goat breeds included in the analysis have a similar distance from the geographic centre of gravity calculated for 50, 90 and 95 % of the animals. Their calculated geographical focus gravitates away from the central part of Slovenia.

Discussion

Slovenian autochthonous breeds of sheep and goats are mostly concentrated in the area of their origin. The small numerous breeds of sheep such as Istrian Pramenka, Bela Krajina Pramenka and also Bovec sheep have 90 % of their population within a distance less than 25 km. Drežnica goat, the only Slovenian autochthonous goat breed has 90 % of their population within a distance less than 30 km. The calculated geographic centre reflects a single rearing centre of all Slovenian autochthonous sheep and goat breeds. In more dispersed traditional breeds like Improved Jezersko – Solčava sheep, Slovenian Saanen goat, Slovenian Alpine goat and the foreign Boer goat the calculated geographic centre is not a single rearing centre. Istrian Pramenka sheep is characterized by a small geographical dispersion (Figure 1d) and it is small in flock number (Figure 2d). In the event of any natural disaster or outbreak of infectious and communicable diseases this breed could suffer serious consequences, so we must emphasise the risk in this respect. It may be noted that due to the high concentration of flocks in smaller geographical areas in Slovenia a small population number is particularly vulnerable and dangerous for autochthonous breeds with the exception of Jezersko-Solčava sheep. It has its calculated geographic centre range in the area of its origin, but as a relatively productive meat type it is extended to other parts of Slovenia. In case of transfer of infectious diseases within a narrow range, the concentration of animals of certain species within the area is also important because in high concentrations animal diseases spread quickly. Geographical concentration of breeds indicates that the animals are very well adapted to their specific environment and to the traditional uses and farming management, as well as the attachment of breeders to them. Increased geographical dispersion of breeds to larger area of Slovenia means lesser possibility for spread of infection, while increased geographical concentration of breeds means higher possibility for spread of infectious diseases. The traditional Improved Jezersko – Solčava sheep breed dispersed in a large area of Slovenia and not confined to only one region or area, is therefore not highly at risk. Density of the same and different species located in the specific area is a risk factor for disease transmission, therefore further investigations on density would be necessary.

Acknowledgment

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GEOGRAFIJA RAZŠIRJENOSTI PASEM OVC IN KOZ V SLOVENIJI

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Povzetek: Proučevali smo geografijo razširjenosti pasem drobnice v Sloveniji, ki so vključene v Rejski program. Analizirali smo velikost populacije, njeno strukturo in geografijo razširjenosti (geografske koordinate rej po Gauss-Kruegerjevem sistemu; vrednosti x in y). Za vsako rejo smo izračunali zračno razdaljo oddaljenosti od geografskega težišča ter prikazali porazdelitveno sliko, ki prikazuje delež živali glede na oddaljenost od geografskega težišča pasme. Izračunano geografsko težišče za avtohtone pasme je njihovo izvorno območje, za tradicionalne in tujerodne pasme pa je usmerjeno proti osrednjemu delu Slovenije. Za avtohtone pasme je značilno, da večji del populacije obstaja znotraj manjšega radija, kot je le-ta v primerjavi s tujerodnimi in tradicionalnimi pasmami in da so reje večinoma skoncentrirane v manjšem geografskem območju. Tri slovenske avtohtone pasme ovc (belokranjska pramenka, istrska pramenka in bovška ovca) imajo 90 % populacije znotraj razdalje, ki je manjša od 25 km, slovenska avtohtona pasma koz drežniška koza pa znotraj radija, ki je okoli 30 km. Tradicionalne in tujerodne pasme niso omejene le na eno regijo ali območje. Zaradi ogroženosti in tveganj ob naravnih nesrečah ali nenadnih izbruhih bolezni so najbolj izpostavljene maloštevilne slovenske avtohtone pasme ovc in koz.

Ključne besede: ovce; koze; pasme; geografija razširjenosti; ogroženost; endemično področje