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Inbreeding and relationship in the German Shepherd dog population in area of Cracow Branch of Polish Kennel Club

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The German Shepherd seems to be most popular and widely used dog breed in the world and also in Poland. The aim of the work was to estimate inbreeding and relationship coefficients in the population of German Shepherd dogs from the herdbook of Cracow Branch of the Polish Kennel Club. As the material, four-generation pedigrees of 60 animals (17 dogs and 43 bitches) born in 1994-2005 were used. The inbreeding (F_X) and relationship (R_{XY}) coefficients among all animals for each sex separately and R_{XY} between dogs and bitches were calculated. Among all 60 animals 54 were inbred (90%). The F_X values for all and for inbred animals were: 0.1286 and 0.1429, respectively. In the group of 17 males 16 were inbred (over 94%) and in the group of 43 females 38 were inbred (88.4%). Average F_X was 0.1560, 0.1178, 0.1658, 0.1333 for all dogs, all bitches, inbred dogs and inbred bitches, respectively. About 98.9% of 1770 pairs of individuals were related; for all and related pairs the values of R_{XY} were 0.0391 and 0.0395, respectively. In 136 male pairs, 100% were related with average R_{XY} 0.0414. For the females those values were 903 pairs and 98.4% related pairs with R_{XY} 0.0353 and 0.0359, respectively. From the total number of 731 dog x bitch pairs 99.2% were related and average R_{XY} were 0.0433 and 0.0436, respectively.

KEY WORDS: inbreeding / relationship / dog / German Shepherd dog

The German Shepherd dog, according to the FCI (Fédération Cynologique Internationale) standards, belongs to the large Sheepdogs and Cattle Dogs Group, where it is assigned to the section of sheepdogs, and also classified as subject to working trial. The breed originates from Germany, where it was formed as late as 1899. The direct ancestor of the German Shepherd was the medieval European sheepdog called „hovawart" which, in turn, is traced back to the Bronze Age subspecies *Canis familiaris matris optimae*. „Hovawart" is an old German word, which may be translated as "estate guard dog". German Shepherds are work dogs, used originally to watch sheep flocks [19, 27].

Due to its strength, intelligence and perfect learning ability, the breed was soon recognized as police working dogs, border guard working dogs and military working dogs. German Shepherds are trained for emergency services e.g. as avalanche dogs in Mountain Rescue, and also in Fire Rescue. The dogs of that breed confirm their competence as assistance dogs for the disabled (particularly for the blind). They are often used as therapy dogs for children and youngsters with Down syndrome, with cerebral palsy, damaged locomotion organs or psychic and mental disorders. As therapy dogs, they help also elderly people suffering from Alzheimer's disease, depression or schizophrenia. At present, the German Shepherd is often a family dog or a watchdog [15]. During its seventy-year history, the breed confirmed its versatility, ranking high among dog breeds worldwide.

German Shepherds were considered popular by dog breeders in Poland as early as before World War II. At that time, the most of the dogs of that breed were registered in The Society of Working Dog Breeders, and then in The Polish Association of Pedigree Dog Breeders. In 1938 the Polish Kennel Club (which later suspended its activity, and resumed it in 1948) was established. During the first years of its existence not only a few pedigree dogs, but all shepherd-looking dogs with unknown origin were registered in the Club [24].

In the 1960's a lot of dogs were imported from GDR, and later also from FRG. The German Shepherd breeding improved; the process continued in the 1980's due to the increasing import from Germany [1, 24].

Breeding of pedigree dogs, for example German Shepherds, is quite a peculiar kind of breeding due to frequent changes in owners' or breeders' preferences, and remarkably scattered genetic base. It results often in mating more or less related individuals. This, in turn, reveals numerous genetic defects in puppies, e.g. in Icelandic Sheepdogs [21], and sometimes characterological problems, like excessive aggression. Since German Shepherds are a multi-purpose breed, aggression should be particularly avoided. Breeding dogs and bitches are tested for genetic disorders; their conformation and character is assessed as well. The individuals which did not pass all that tests become mostly companion dogs, despite the potential risk for the owner. The inbreeding level in German Shepherd populations was recently monitored in many countries worldwide [2, 3, 16]. In Poland, such analyses were performed in the 1990s [4], therefore it would be useful if they are repeated.

The purpose of the work was to estimate the inbreeding and relationship level in the population of German Shepherd dogs registered in the Cracow branch of Polish Kennel Club.

Material and methods

For this study four-generation pedigrees of 60 German Shepherd dogs (17 males and 43 females), born between 1994 and 2005 and being registered as stock animals in Cracow Branch of Polish Kennel Club, were used. Inbreeding coefficients (F_X) for all 60 animals and for each sex separately were calculated. This allowed preparing the list of individual F_X values from the highest to the lowest. Also the distribution of animals (total and for each sex) in following inbred classes: 0%; 0-1.5%; 1.5-6.5%, and over 6.5%, was analyzed.

Relationship coefficients (R_{XY}) for all pairs of animals, and separately for pairs of males, for pairs of females and also for male x female pairs, were estimated according to the Tier [25] algorithm with recursive modification, which takes advantage of repeatability of some parts of calculations of inbreeding and relationship coefficients [6, 14].

Results and discussion

Table 1 shows mean inbreeding coefficients with the range of F_X for all animals, all male and all female dogs and also for inbred animals, inbred dogs and inbred bitches. In the examined German Shepherd dog population about 90% animals was inbred, from which there were over 94% inbred dogs and more than 88% inbred females.

Table 1
Inbreeding coefficients (F_X) of German Shepherd dogs

Sex	All animals			Inbred animals		
	No N	F_X (%)		No N	F_X (%)	
		mean	range		mean	range
Dog	17	15.60	0 – 10.55	16	16.58	0.05 – 10.55
Bitch	43	11.78	0 – 6.44	38	13.33	0.19 – 6.44
Total	60	12.86	0 – 10.55	54	14.29	0.05 – 10.55

In the whole population males showed the highest inbreeding level, reaching over 15.5%, and mean F_X for all animals was about 13%. Average F_X values for inbred individuals amounted to more than 14%, and it was higher for dogs (over 16.5%) than for bitches. The inbred females had the mean F_X reaching over 13% (Table 1), which was a very high value, exceeding 12.5%, i.e. the level considered safe for a population [5].

The distribution of animals to classes by inbreeding coefficient values was analyzed (Table 2). The highest number of animals was reached in the groups with F_X values in the range of slightly over 0% to 1.5% and from 1.5% to 6.5%. In this two groups there were together 53 individuals (15 males and 38 females), whereas in non-inbred group there were only six animals (one dog and five bitches).

Table 2
Total number of animals and number of dogs and bitches by inbreeding classes

Inbreeding class	Number of animals		
	total	dogs	bitches
$F_X = 0\%$	6	1	5
$0 < F_X \leq 1.5\%$	39	11	28
$1.5\% < F_X \leq 6.5\%$	14	4	10
$6.5\% < F_X$	1	1	0

Most of the animals, about 90%, in the examined German Shepherds population seems to be less or more inbred (Table 2).

The list of inbred animals with inbreeding coefficients reaching over 1.5%, were presented in Table 3.

Table 3
List of German Shepherd dogs with F_X more than 1.5%

Animal ID	Name	Sex	F_X (%)
PKR.I-33351	Vux z Beroliny	dog	10.55
PKR.I-51262	Xantia vom Robinson Park	bitch	6.44
26661/94	Kimon Dhla Roven	dog	4.68
47924	Kia Dhla Roven	bitch	4.39
PKR.I-49063	Doxi Adi	bitch	3.91
PKR.I-35635	Maxi Temperton	bitch	3.13
PKR.I-52414	Afra Adi	bitch	2.39
PKR.I-49968	Dacota Avax Hof	bitch	2.05
PKR.I-58206	Alex Skilos	bitch	1.99
PKR.I-52653	Zaphyr Vitaxis	dog	1.95
PKR.I-32610	Yambo Vitaxis	dog	1.76
PKR.I-36721	Reda ze Skalnego Wzgórza	bitch	1.76
PKR.I-55223	Kazan Mavic	dog	1.61
PKR.I-53629	Yella z Lintichu	bitch	1.56
PKR.I-53130	Fani z Ligoniowej Góry	bitch	1.54

Table 4 shows the average relationship coefficients with the range of R_{XY} for all and related pairs of individuals and the percent of related pairs for: all pairs of animals, pairs of dogs, pairs of bitches and for mixed pairs (dog x bitch).

In the examined German Shepherd dogs population the total of 1770 pairs of animals were related, which was 98.9% of all possible pairs. All dog x dog pairs (100%). over 98% bitch x bitch pairs and more than 99% mixed male x female pairs seem to be related (Table 4).

Mean relationship coefficients for the whole population was about 4% and reached 4.14%, 3.53% and 4.33% between dogs, between bitches and between dogs and bitches, respectively (Table 4). Average R_{XY} between animals with common ancestors was 3.95%. In case of the related pairs, the highest mean R_{XY} value, over 4%, occurred for mixed pairs (dog x bitch). The relationship coefficient was the lowest, about 3.6%, between related females (Table 4). The individual R_{XY} values for related animals ranged from less than 1% to almost 52%, which was higher value than the relationship for siblings.

In Table 5 inbreeding and relationship results of other authors obtained for different dog breeds were presented, and Table 6 shows F_X and R_{XY} results for other species of domestic animals.

Table 4
Relationship coefficients (R_{XY}) of German Shepherd dogs

Comparison	All pairs			Related pairs		
	no of pairs	R_{XY} (%)		no of pairs	R_{XY} (%)	
		mean	range		mean	range
Dog x dog	136	4.14	0 – 51.27	136	4.14	0.390 –51.27
Bitch x bitch	903	3.53	0-51.79	889	3.59	0.097-51.79
Dog x bitch	731	4.33	0-51.69	725	4.36	0.098-51.69
Total	1770	3.91	0-51.79	1750	3.95	0.097-51.79

Table 5
Inbreeding and relationship coefficients in different dog breeds

Breed	F_X (%)	R_{XY} (%)	Source
German Shepherd dog	0.23-3.11	0.34-0.39	[4]
Rottweiler	1.12-5.85	0.72-1.01	[4]
German Boxer	0.68-4.26	0.52-2.68	[4]
Great Dane	0.61-8.79	0.56-0.70	[4]
Polish Hound	7.1-37.0	–	[9]
German Shepherd dog	0-26.2	0.16-25.3	[2]
Labrador Retriever	0-22.0	0.15-15.5	[2]
Icelandic Sheepdog	21.0	–	[21]
German Shepherd dog	5.1-10.4	–	[3]
61 of dog breeds in France	0.2-8.8	0.4-8.8	[16]
Tatra Shepherd dog	1.06-6.44	4.53-14.92	[13]

The results obtained in this work for Cracow German Shepherd dog population, when compared to the literature cited (Table 5) for different dog breeds were, in general, high. It seems to be true as well for other German Shepherd dog populations as for other dog

Table 6
Inbreeding and relationship coefficients in different livestock breeds

Breed	F_X (%)	R_{XY} (%)	Source
Pastel foxes	0.02-0.12	–	[12]
Arab horses	1.49-6.30	–	[7, 8]
Friesian horses	14.5-15.8	–	[22]
Catalonian Donkeys	0.73-7.22	1.39-6.61	[10]
Hanoverian horses	1.19-1.33	–	[11]
Jersey cattle	3.4	4.7	[23]
Holstein cattle	3.9	4.7	[23]
Danish Red cattle	1.4	3.2	[23]
Angus Red cattle	3.0-10.6	0.92-5.33	[18]
Finnsheep breed	0.57-4.76	0.5-1.6	[17]
Pannon White rabbits	5.6	5.4	[20]
Duroc pigs	3.2	8.3	[26]
Berkshire pigs	7.8	13.5	[26]
Landrace pigs	5.3	12.9	[26]
Hampshire pigs	3.6	12.2	[26]
Yorkshire pigs	3.9	11.6	[26]

breeds [3, 4, 13, 16]. However, so far the F_X values of German Shepherds from Cracow region have not achieved the level of about 20% mentioned by some authors cited [2, 9, 21]. Similarly, the R_{XY} values in the examined population were much higher than those obtained in dog populations by other authors (Table 5).

The results concerning the inbreeding and relationship achieved in German Shepherds population studied here were also higher in comparison to the results for other domestic species like cattle, horses or fur animals, obtained by other authors. In most cases, the R_{XY} and F_X values calculated for Cracow German Shepherds were much higher (Table 6), apart from several exceptions like Friesian Horses [22], which had inbreeding coefficients comparable to German Shepherd dogs studied here and some pig breeds [26],

in which the values of relationship coefficients were higher than obtained in this study (Table 6).

All in all, it should be concluded that the examined German Shepherd dog population was inbred to a great degree (over 90% animals), and the mean F_X values estimated here exceeded the permissible safety limit of 12.5%. The relationship values, however not too high in average, in some cases reached even about 52% and, what is more important, from 90 to 100% of the population was related. In the future it may cause problems to cumulate and the increase of inbreeding may affect fitness of animals. In such situation it is necessary to monitor the Cracow German Shepherd dog population and to make a proper mating plan to avoid further increase in inbreeding and relationship.

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