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EVALUATION OF INBREEDING AND RELATIONSHIP COEFFICIENTS IN HOVAWART DOGS AND ANALYSIS OF TRENDS IN COAT COLOUR CHANGES*

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Abstract

Analyses were conducted on pedigrees of 845 animals registered at the Hovawart Club in Poland (113 dogs and their ancestors). The degree of inbreeding was calculated for the whole population (0.0026) and separately for male dogs (0.0021) and bitches (0.0031), and the coefficient of mean relationship was calculated for the entire population (0.0064), among male dogs (0.0064), among females (0.0073) and between males and females (0.0061). The inbreeding and relationship coefficients obtained are lower than those estimated for Polish populations of other dog breeds. The calculated effective number of founders (268) and ancestors (233) may indicate rather low genetic diversity. Preferences of breeders concerning coat colour were discussed. Black and tan coat dogs dominated at first, followed by blond ones, and over the last five of the analysed years black coat dogs emerged.

Key words: Hovawart dog, inbreeding

Planning of breeding work is difficult in the case of dog breeding due to the fact that they are pet animals kept mostly for pleasure and their breeding is considered a hobby. This situation is a source of many problems because dog breeders are focused on selection and on choosing pairs of animals for mating while failing to consider the kinship of selected animals and the degree of inbreeding (Głażewska, 2005). The first Hovawart dog was imported to Poland from Germany in the 1980s. Currently the Hovawart Club of the Polish Kennel Club comprises 42 kennels of accredited

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breeders, which proves the growing popularity of this breed in Poland, although it is still not a very common one. For comparison, in Poland there are several hundred accredited German Shepherd kennels.

At present the largest population of Hovawart dogs (approximately 10 000) is kept in Germany. Dogs of this breed are found in Austria, Switzerland, Holland, Denmark, Finland, Sweden, Norway, France, Great Britain, the USA, the Czech Republic, Poland, Canada, Hungary and Russia. The Polish Hovawart population is based first of all on animals of Czech and German pedigrees. At present Polish breeders of Hovawart dogs continue to use German and Czech animals for mating, and it is therefore necessary to determine the degree of inbreeding and kinship among dogs of this breed to safeguard further breeding safety. The aim of this study was to analyse the level of inbreeding and kinship in the Polish population of Hovawart dogs and to analyse their coat colour.

Material and methods

Analyses were conducted on pedigrees of Hovawart dogs registered at the Hovawart Club in Poland, comprising 845 animals, of which 392 were males and 453 were females. Additionally, analyses were performed on data concerning hair colour of 512 puppies coming from 101 litters born in the years 1988–2004, which were registered in pedigree books.

Coefficients of inbreeding and relationship were calculated using the SAS statistical package (SAS, 2009). The coefficient of inbreeding of animals from the analysed population was determined by the additive relationship matrix using the INBREED procedure. Additionally, the analysis of founders and ancestors was performed (Boichard et al., 1995, 1996, 1997).

The effective number of founders for the population was calculated as the inverse of sum of squares for probabilities of origin of genes from individual founders (Lacy, 1989):

$$f_e = \frac{1}{\sum_{k=1}^{f} q_k^2}$$

where:

fe – effective number of founders,

f – number of founders,

q_k – probability of gene origin of the kth founder.

The effective number of ancestors was defined as the inverse of sum of squares for marginal shares of ancestors:

$$f_a = \frac{1}{\sum_{k=1}^{f} p_k^2}$$

where:

f_a – effective number of ancestors,
f – number of ancestors,
p_k – marginal share of kth animal.

Results

Table 1 presents results concerning inbreeding and relationships for the whole population of Hovawart dogs, as well as male and female animals separately. The mean inbreeding rate in the Polish population of Hovawart dogs was 0.0026. Out of 845 animals 70 were inbred, which accounts for 8.28% of the population. The coefficient of inbreeding calculated only for inbred animals was 0.0318. Among male animals 6.63% dogs were inbred, with the coefficient of inbreeding of 0.0316, while the mean coefficient of inbreeding for all males was 0.0021. The coefficient of inbreeding for all bitches was higher than for sires, amounting to 0.0031. Inbred bitches constitute 9.71% of the population, while the coefficient of inbreeding for inbred bitches was 0.0320.

Table 1. Coefficients of inbreeding estimated for all animals in the population as well as for male dogs and bitches

	Number of animals	Percentage of animals	Mean degree of inbreeding
Whole population			
all	845	100	0.0026
inbred	70	8.28	0.0318
Male dogs			
all	392	100	0.0021
inbred	26	6.63	0.0316
Bitches			
all	453	100	0.0031
inbred	44	9.71	0.0320

Table 2 presents coefficients of relationships for Hovawart dogs in Poland for the entire population, kinship between male dogs, bitches as well as between bitches and male dogs. Mean kinship for the entire population was 0.0064. Related animals comprise 7.69% of the whole population. Mean degree of relationship reached the highest value of 0.0073 between bitches, where the percentage of related pairs was also the highest. The highest mean degree of relationship between related animals (0.0833) was found between sires and bitches.

Table 2. Coefficients of relationship for Hovawart dogs in Poland calculated for the whole population, and for male dogs, bitches, and bitches with male dogs

	Number of pairs	Percentage of pairs	Mean degree of relationship
Whole population			
all	356590	100	0.0064
related	27408	7.69	0.0826
Male × Male			
all	76636	100	0.0064
related	4625	6.04	0.0826
Bitch × Bitch			
all	102378	100	0.0073
related	9671	9.45	0.0770
Male × Bitch			
all	177576	100	0.0061
related	13112	7.38	0.0833

Analysis of the proportions of founders and ancestors conducted on 845 animals is presented in Table 3.

Table 3. Total and effective numbers of founders and ancestors

	Total number	Effective number
Founders (according to Lacy, 1989)	338	268
Ancestors (according to Boichard, 1995, 1996, 1997)	389	233

In the gene pool in the analysed population 268 animals have identical shares (in terms of values). After the bottleneck effect was considered, the effective number of ancestors estimated according to Boichard (1995) was lower than the effective number of founders and amounted to 233 because it did not include ancestors, whose genes were eliminated from the gene pool of the population.

Since Hovawart dogs may have three different coat colours, the coat colour of sires was analysed as well as the number of offspring which were left by sires of a given coat colour (Table 4).

Table 4. The number of puppies and the proportions (%) of coat colour of the dog

Coat colour of the dog	Number of puppies	Percentage
Black and Gold	266	51.95
Gold	184	35.94
Black	62	12.11

In the analysed period black and gold dogs were selected most frequently for reproduction, followed by gold ones, while black dogs were selected least often. On the basis of the analysis of litters born between 1998 and 2004 it was found that over the years preferences of Polish breeders concerning coat colour of Hovawarts changed. Up to the year 2000 black and gold or gold puppies were born in Poland. The first puppies of uniform black coat were born in 2000, which resulted from the previous import to Poland of the first Hovawarts of this coat colour (Figure 1).

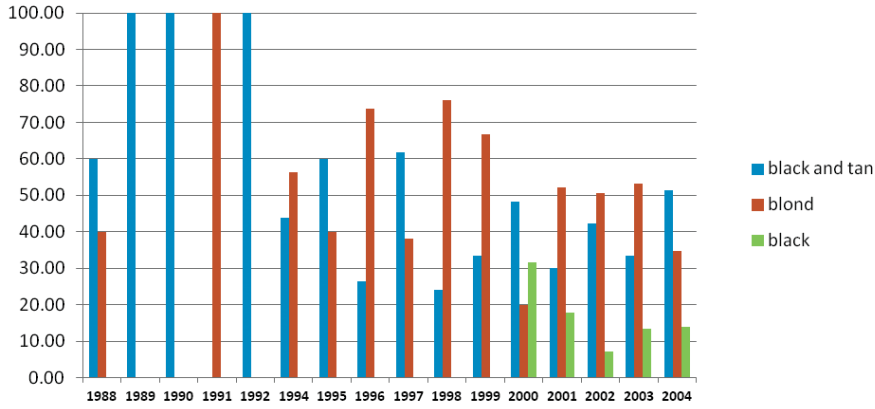

Figure 1. Proportions of coat colours in litters in the period 1988–2004

Discussion

Analysis of the literature shows that the mean coefficient of inbreeding among different breeds takes different values. There are also differences within the same breed in different countries. As reported by Moritz (2008), the mean degree of inbreeding in the population of Rhodesian Ridgeback dogs comprising 23 253 animals born in Australia in the period 1967–2007 was 0.125, with the highest value of the coefficient of inbreeding recorded at 0.4586 and the lowest at 0.0017. The coefficient of inbreeding for the population of dogs of that breed in the United States, comprising animals born in the period 2000–2006, was 0.1523, while in Sweden it was 0.0625. In turn, investigations conducted on 344 Rhodesian Ridgeback dogs in the period 1996–2005 yielded the coefficient of inbreeding at 0.019 (Moritz, 2008). Similar calculations conducted on the population of dachshunds in Poland gave the following results: for long-haired dachshunds (134 animals, 68 males and 66 females) the coefficient of inbreeding was 0.0354, while for wire-haired dachshunds (140 animals, 53 male dogs and 87 bitches) it was 0.0018 (Kosowska et al., 2005). The coefficient of inbreeding for the population of Polish Hounds ranged from 0.071 for animals born in the years 1960–1964 to 0.370 for animals born in the years 2000–2004 (Głażewska, 2008).

As can be observed from Table 1, results recorded for the Polish population of Hovawart dogs are lower than those cited above. The mean degree of inbreeding in the Hovawart population in Poland was 0.002. By way of comparison, the results recorded for this breed in the country of their origin are as follows: the coefficient of inbreeding calculated for Hovawart dogs registered in Rassezuchtverein für Hovawart-Hunde e.V. (RZV) is an average of 0.058, with the minimum value of 0.001 and the maximum of 0.306. For the German population of Hovawarts the coefficient of relationship was also calculated to be 0.086. For the Polish population this figure is 0.0064. Calculations performed by Hiller (2009) for the German population of

Hovawart dogs were based on all animals born in the years 1998 to 2001. The SAS statistical package (2004) was also used in the calculations. A comparison of these two populations shows that the coefficients of inbreeding and relationship between Hovawart dogs are lower in Poland than in Germany.

According to Chmiel (2007), inbreeding expressed by the coefficient within the range of 0.00–3.99% is considered low, that of 4.00–9.99% is defined as moderate, and is considered high only above 10.00%. However, Willis (1992) claimed that in practice he did not encounter a case of inbreeding which would exceed 45%, and even such pedigrees are found extremely rarely. A vast majority of dog breeders, even those who are supporters of inbreeding, never implement such a high coefficient of inbreeding.

Among dog breeders mating of related animals causes frequent disputes. Some use this method frequently and indiscriminately, while others are of the opinion that such activity leads to complete degeneration of animals. When investigating breeding of two guide dog breeds, i.e. German shepherds and Labrador retrievers, Cole et al. (2004) – apart from the coefficient of inbreeding and the degree of relationship – determined also the effective number of ancestors. Similarly as in the Polish population, the effective number of ancestors was lower than the effective number of founders. The effective number of ancestors for German shepherds was 532 for 4 699 animals, while for Labradors it was 19 for 3 573 animals. When examining Table 3 we may see that for the population of Hovawarts this number was 233 for 845 animals. The coefficient of inbreeding for German shepherds was 0.25, while for Labrador retrievers it was 0.15. The degree of relationship for the former breed was 0.16, whereas for the latter it was 0.15. As already mentioned, the coefficient of inbreeding over 0.1 is already defined as high.

Similarly, Leroy et al. (2009) reported for 61 of dog breeds analysed in France a considerable range of effective founder number (29 to 1216) and effective ancestor number (9 to 209) depending on the breed. For 60 individuals of the active German Shepherd breed population, Kania-Gierdziewicz et al. (2011) estimated 66 effective founders and 36 effective ancestors. In general it is assumed that a population is highly genetically diverse if the number of effective founders and effective ancestors is high in comparison to the actual population size.

As presented by Głażewska (2005), inbreeding has specific consequences, both positive and negative. Firstly, it promotes genetic consolidation of a population and establishment of desirable genotypes. It plays a positive role at the stage of development of a new breed. Secondly, homozygosity promotes the manifestation and elimination of disadvantageous genes, normally masked by dominant genes, from the gene pool of the population. Thirdly, inbreeding in relation to an elite ancestor is frequently used in breeding of domestic animals, since the accumulation of desirable genes of an outstanding ancestor in his inbred progeny contributes to an improvement of production traits. However, we need to remember disadvantageous phenomena related to inbreeding, particularly threatening small populations and those originating from a small number of ancestors. To the above mentioned effects of inbreeding depression we also need to add psychological disorders, consisting in hyperactivity or shyness of animals. All the symptoms mentioned so far are connect-

ed not only with the action of disadvantageous genes, but also with a considerable reduction of genetic variation in a population. A lack of genetic variation is a key problem, leading as a long-term effect to the extinction of a given breed or species. In a situation when there are no unrelated animals (i.e. having no common parents or grandparents) inbreeding is justified. However, this does not pertain to Hovawart dogs. In recent years their population in Poland has increased. According to the data of the Board of the Polish Kennel Club, in 2003 in Poland there were 109 male dogs, including 17 breeding dogs, 146 bitches (40 breeding females) and the registered 104 puppies coming from 12 litters. At present it is also much easier to travel to mate animals or to import breeding animals. If unrelated animals are going to be introduced to the Polish population, the gene pool will be increasingly rich, which may have an advantageous effect on future breeding results (Głażewska, 2005). However, it has to be stressed that when in a given breed there are only 100 puppies annually there is little chance of finding outstanding animals among them. For this reason we may consider Hovawarts to be a breed with a small population. Thus inbreeding is practically inevitable. Progeny testing towards breeding value is not possible, since most dogs do not have a sufficient number of puppies. In breeds of small populations it is necessary to undertake any actions leading to the extension of their breeding base. Single animals, even if they are elite, may not be used too intensively. Sometimes in breeding of a rare breed it is worthwhile to relinquish high requirements in relation to a specific trait, if thanks to such a decision we may obtain an improvement in the other traits. Breeding policy in the case of breeds with small populations may not be too restrictive. As indicated by Willis (1992), in mammals a certain degree of heterozygosity is necessary. Otherwise these animals become highly sensitive to environmental factors. However, much depends on the intensity of inbreeding. The higher it is, the higher the probability of negative consequences and the stronger they may be manifested. Moreover, effects of inbreeding may vary in different breeding lines or specific kennels. In one of them adverse effects are already observed when the degree of inbreeding is 10%, while in another even 20% inbreeding does not cause negative consequences. This may be the case when we compare two different breeds (Willis, 1992). As stated by Redlicki (1994), opponents of inbreeding forget that it is not a human concept – a pack of wolves is a small family, within which inbreeding matings take place. However, a long-term application of inbreeding may lead to the occurrence of inbreeding depression – fertility and vigour of animals decrease and their physical and psychological strength deteriorate. Studies conducted to date confirmed e.g. the effect of the level of inbreeding on the lifespan of a given animal. The higher the coefficient of inbreeding, the shorter the lifespan of a dog was observed (Hiller, 2009; Smid, 2001). Hovawart is a working, guard and watch dog breed. A highly balanced psyche is a necessary pre-condition for an appropriate work of a watch dog. Unfortunately, composure and the absence of shyness are traits particularly susceptible to the effect of inbreeding depression. Thus the more homozygous a given animal is, the greater the chance that it would not meet the requirements imposed on working dogs. Such inbred dogs are also more likely to have poor health and be sensitive to adverse living conditions (Rooney, 2009). Vigour, vitality and an appropriate psyche are traits typical of heterozygous dogs (Głażewska, 2005).

In all specifications of dog breed standards we may find information what types of coat colour are found in a given breed, which are preferred or admissible, and which are defects. However, the coat colour, characteristic of a given breed, is most frequently a manifestation of aesthetic preferences of its creators and breeders (Kaleta and Fiszdon, 2002). A breeder focused on a specific coat colour is limited to a considerably narrow selection of animals. When directed only by coat colour this may lead in breeding to the use of weaker animals, whose other important traits are far from perfect. In the long run, such an approach leads to a significant deterioration of the level of breeding (Willis, 1992). As stated by Kaleta and Fiszdon (2002), the best known and accepted theory concerning inheritance of coat colour in dogs assumes the existence of 9 basic loci and genes, including 29 alleles, of which 19 form four series of multiple alleles. This theory was created by C. C. Little on the basis of 40-year studies and it was presented in his publication in 1957. Other researchers developed and supplemented the above mentioned theory, while some proposed the existence of the 10th or even 11th locus (Kaleta and Fiszdon, 2002). The determination of the coat colour genotype of a given dog requires not only the knowledge of genes determining it, but also their interdependencies (Kaleta and Fiszdon, 2002). As indicated by Kerl (1996) for König, one of the main creators of the contemporary Hovawart breed, the statement that "a good dog does not have a bad coat colour" was the rule. At the initial stages of breeding there were Hovawarts with a gold coat colour and a black face, a grey or relatively frequent wolfish coat colour. According to Kerl (1996) after Wienrich, in the German population of Hovawart dogs black and gold animals predominated, accounting for approximately 60% of the population, while approximately 30% were gold dogs and approximately 10% were black Hovawarts. Similar proportions of coat colour started to appear in Poland as late as 2004 (for the following years only partial data are available). As may be observed in Figure 2, the first black puppies were born in Poland in 2000. At present official breeding standards admit three standard coat colours, i.e. gold, black, and black and tan.

In concluding, it has been observed that the coefficients of inbreeding and relationship estimated for the analysed population are low in comparison to other dog breeds and to the German population of Hovawarts, the world's most numerous one. It should be remembered, however, that the Polish population of this breed is rather small and not highly genetically diverse, which in the case of unresponsible breeding may result in a rapid increase of inbreeding.

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Ocena stopnia zinbredowania i spokrewnienia psów rasy hovawart oraz analiza tendencji zmian umaszczenia

STRESZCZENIE

Analizowano rodowody 845 osobników należących do Klubu Hovawarta w Polsce (113 osobników oraz ich przodków). Obliczono współczynnikinbredu dla całej populacji (0,0026) oraz oddzielnie dla psów (0,0021), suk (0,0031); średnie spokrewnienie dla całej populacji (0,0064), pomiędzy samicami (0,0073) oraz pomiędzy samcami a samicami (0,0061). Uzyskane wartości współczynników inbredu oraz spokrewnienia są niższe niż obliczone dla polskich populacji psów innych ras.

Obliczono także efektywną liczbę założycieli (268) oraz przodków (233), co może wskazywać na niezbyt dużą różnorodność genetyczną.

Prześledzono preferencje hodowców dotyczące umaszczenia zwierząt. Początkowo dominowały zwierzęta o umaszczeniu czarnym podpalanym, następnie o umaszczeniu blond, a w ciągu ostatnich pięciu analizowanych lat pojawiły się psy o nowym umaszczeniu – czarnym.