Inbreeding and relationship analysis of the Golden and Labrador Retriever populations in the Cracow Branch of the Polish Kennel Club*

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The study examines the values of inbreeding and relationship coefficients in the active population of Golden Retrievers (GR) and Labrador Retrievers (LR) recorded in the herd book of the Cracow Branch of the Polish Kennel Club. Pedigrees of 191 GR dogs (84 males and 107 females), born in 1998-2007, and 270 Labradors (109 males and 161 females), born in 1997-2007, were used in the study. Inbreeding coefficients were estimated for all GR and LR animals and for each sex separately. Relationship coefficients were calculated for all animals separately for each breed, for each sex separately, and between dogs and bitches. Over 49% of GR and 32% of LR animals were found to be inbred. The proportion of inbred individuals was over 52% for males and about 47% for females in the Golden Retriever breed, and about 32% for both males and female Labrador Retrievers. The mean F_x values for all animals and for inbred individuals in the GR breed were rather low: 0.82% and 1.67%, respectively. The corresponding F_x values for LR were 0.83% and 2.58%. In the Golden Retrievers divided by sex, F_x averaged 0.9% and 0.76% for all dogs and all bitches, respectively, and 1.72% and 1.62% for inbred dogs and bitches. The corresponding F_x values in the Labradors were 1.08% and 0.66% for all dogs and all bitches, and 3.36% and 2.05% for inbred dogs and bitches. The average inbreeding coefficients for the inbred dogs and bitches were higher in the Labradors than in the Golden Retrievers. Nearly 90% of GR pairs and over 68% of LR pairs were related. Among males, over 90% of GR pairs and 65% of LR pairs were related. The values in females were slightly lower: over 89% related pairs for GR bitches and over 70% for LR bitches. Among all the relationship coefficients calculated none exceeded 10%. This is because of the increasing popularity of both breeds and the continual import of breeding animals from abroad. However, more careful attention should be paid to the pedigrees of imported animals to avoid a possible future increase in the indicators examined in this study.

KEY WORDS: inbreeding / relationship / Labrador Retriever / Golden Retriever

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Golden and Labrador Retrievers can currently be considered the most popular dog breeds in the world. Both breeds belong to FCI Group 8, which includes Retrievers, Flushing Dogs and Water Dogs, in Section 1, i.e. Retrievers. Golden and Labrador Retrievers, bred in the 19th century in the United Kingdom, were originally used as hunting dogs for the retrieval of small game. In the 20th century they became the most popular companion breeds, as both breeds are friendly and unaggressive. Labradors and Golden Retrievers are intelligent and exhibit a natural ability and willingness to work. They are used as guides and companions for people with disabilities, in dog therapy, especially for children, and as police dogs, border control dogs, or rescue dogs in mountain rescue services or fire brigades [10, 11, 12].

The first Golden and Labrador Retrievers appeared in Poland in the early 1980s. At the end of the century, the number of animals of both breeds in the country grew steadily, which can currently be observed at most dog shows. Golden and Labrador Retrievers are recommended as family dogs, especially for children, as they are gentle and friendly [10, 11, 12]. However, as with many newly introduced breeds, the genetic structure of such populations, defined in part by the levels of relationship and inbreeding, should be thoroughly investigated to avoid reducing the genetic pool to a dangerous level and the potential for inbreeding depression.

Both breeds of Retrievers began to be very popular in Poland at the beginning of the 21st century, resulting in a relatively rapid increase in the number of dogs of both breeds registered by the Polish Kennel Club. According to data of the Cracow Branch of the Kennel Club, while in the 1990s single litters of Labradors and Golden Retrievers were registered, in 2006-2007 there were more than 20 litters of Labradors per year and about 12-14 litters of Golden Retrievers. Due to the increasing numbers of animals of both breeds, of which only some were imported, the need arose to examine the level of relationship, given the possibility of inbreeding and its negative effects, e.g. genetic diseases such as hip dysplasia, especially since such tests have not previously been conducted on retrievers in Poland.

The aim of the study was to analyse the relationship and inbreeding of Golden and Labrador Retrievers registered in the books of the Cracow Branch of the Polish Kennel Club.

Material and methods

The material for the study consisted of two sets of pedigree data, containing the pedigrees of 191 Golden Retrievers (GR) and 270 Labrador Retrievers (LR). The Golden Retrievers were born in the years 1998-2007, and the Labradors in 1997-2007. All animals analysed were registered as breeding animals in the Cracow Branch of the Polish Kennel Club. More detailed data on the pedigree structure of both populations are presented in Table 1.

Table 1

Population structure of the Golden and Labrador Retriever populations examined

Specification	Sex	
	male	female
Golden Retrievers		
Number of animals in active population	84	107
Number of animals in pedigrees	345	495
Total number of founders	120	152
Maximum number of generations traced	9	9
Equivalent number of complete generations known per animal	4.21	4.01
Maximum number of progeny per sire	103	67
Labrador Retrievers		
Number of animals in active population	109	161
Number of animals in pedigrees	476	672
Total number of founders	152	287
Maximum number of generations traced	9	9
Equivalent number of complete generations known per animal	3.42	3.50
Maximum number of progeny per sire	34	31

The inbreeding coefficients (F_X) for all animals were estimated separately for each set. This allowed us to compile lists of inbred individuals of each breed, from the highest to the lowest inbreeding values. Relationship coefficients (R_{XY}) were estimated for each breed, all pairs of animals, pairs of male dogs, pairs of females, and mixed male and female pairs. Tier's algorithm [21] with a recursive modification [5] was used in the calculations.

Results and discussion

Table 2 shows the mean inbreeding coefficients for the Golden and Labrador Retrievers, broken down by sex. Of the 191 Golden Retrievers, 94 individuals (49.21%) were

Table 2

Average inbreeding coefficients (F_X) for Golden Retrievers and Labrador Retrievers

	Sex	
	male	female
Golden Retrievers		
Number of inbred animals	44	50
Mean F_X (%) – all animals	0.90	0.76
Mean F_X (%) – inbred animals	1.72	1.62
Labrador Retrievers		
Number of inbred animals	35	52
Mean F_X (%) – all animals	1.08	0.66
Mean F_X (%) – inbred animals	3.36	2.05

inbred. The average F_X value was 0.82% for all Golden Retrievers and 1.67% for those that were inbred. The percentage of inbred animals was 52.38% in the group of 84 males and 46.73% in the group of 107 females.

In the group of 270 Labrador Retrievers, 87 individuals (32.22%) were inbred. The average F_X value was 0.83% for all Labradors and 2.58% for inbred Labradors. F_X values above 0 were obtained for 32.11% of males and 32.30% of females (Table 2).

Analysis of the mean inbreeding coefficients for both breeds (Table 2) reveals generally low values, reaching about 1% for all individuals in both breeds, slightly over 1.5% in inbred Golden Retrievers, and a bit more – from 2% to about 3.5% – in inbred Labradors.

Table 3 lists the 21 inbred Golden Retrievers in the active population, whose F_X exceeded 2%. There were 11 females and 10 males in this group. The highest inbreeding coefficient, of over 13%, was obtained for two males: Agat z Garlicy Duchownej (PKR.VIII-19789) and Aramis z Garlicy Duchownej (PKR.VIII-20773), which were full siblings from the same kennel. The next female, Ravenna Vexator (PKR.VIII-13965), had an F_X of over 9%. The inbreeding coefficients of the next three individuals (females) ranged from over 6% to 4%. Inbreeding in the remaining individuals in this group did not exceed 4%. The largest number of inbred Golden Retrievers (4 individuals) came from the *z Zagłębia* kennel, followed by the *Bochenskie Wzgórze* kennel, with three inbred individuals (Table 3).

Table 3

List of inbred animals from the Golden Retriever population with $F_X > 2\%$

Animal ID	Name	Sex	F_X (%)
PKR.VIII-19789	Agat z Garlicy Duchownej	male	13.18
PKR.VIII-20773	Aramis z Garlicy Duchownej	male	13.18
PKR.VIII-13965	Rawenna Vexator	female	9.38
PKR.VIII-15867	Afrodyta Gold Driver	female	6.45
PKR.VIII-7669	Eris Yavanna	female	6.25
PKR.VIII-7203	Gala z Żywieckiej Kotliny	female	4.69
PKR.VIII-11547	Ivo z Zagłębia	male	3.32
PKR.VIII-16564	Olivia z Zagłębia	female	3.32
PKR.VIII-15826	Furora Renmil	female	3.13
PKR.VIII-16097	Prado z Zagłębia	male	3.13
PKR.VIII-16301	Perry Szczęśliwa Trzynastka	male	3.13
PKR.VIII-17838	Pamir z Zagłębia	male	3.13
PKR.VIII-19568	Golden Serene Baloo	male	3.13
PKR.VIII-18647	Greta z Oświeceniowego Wzgórza	female	2.83
PKR.VIII-18892	Gracja z Oświeceniowego Wzgórza	female	2.83
PKR.VIII-13995	Atos Rimandell	male	2.54
PKR.VIII-13783	Luna Bocheńskie Wzgórze	female	2.34
PKR.VIII-16274	Long Hary Bocheńskie Wzgórze	male	2.34
PKR.VIII-20780	Lukas Bocheńskie Wzgórze	male	2.34
PKR.VIII-20777	AzuraAspra	female	2.,22
PKR.VIII-20094	Afrodyta Słońce Olimpu	female	2.15

Table 4 lists the 23 active Labrador Retrievers whose F_X coefficients were higher than 2%. These included 13 females and 10 males. The highest inbreeding coefficients were obtained for two males: Haps Sądecki Ratownik (PKR.VIII-20712) and Indus Horand Plus (PKR.VIII-11446), with values of approximately 13.3% and 12.8%, respectively. The next five animals had the same inbreeding coefficient, i.e. 12.5%. These were two females and three males, two of which were full siblings from the same kennel (*od Marka Pollo*). The F_X values of the remaining inbred Labradors did not exceed 8%, but the next five animals, three of which were also from *od Marka Pollo*, had identical values of 7.81%. The F_X values in the third group of five females were about 6%, but in the remaining inbred animals they did not exceed 4% (Table 4).

Table 4

List of inbred animals from the Labrador Retriever population with $F_x > 2\%$

Animal ID	Name	Sex	F_x (%)
PKR.VIII-20712	Haps Sądecki Ratownik	male	13.28
PKR.VIII-11446	Indus Horand Plus	male	12.79
PKR.VIII-11250	Gabi z Rydzyńskiego Lasu	female	12.50
PKR.VIII-11297	Hiroshima Herbu Zadora	female	12,50
PKR.VIII-12677	Largo od Marka Pollo	male	12.50
PKR.VIII-15785	Monte Negro Macquajeet	male	12.50
PKR.VIII-9155	Gapo od Marka Pollo	male	12.50
PKR.VIII-15052	El'Ninio Perfect	male	7.81
PKR.VIII-16340	Waszyngton od Marka Pollo	male	7.81
PKR.VIII-16341	Wulkan od Marka Pollo	male	7.81
PKR.VIII-16765	Uster od Marka Pollo	male	7,81
PKR.VIII-7234	Tora z Tuszyna	female	7.81
PKR.VIII-15413	Nesca z Miechowskiej Doliny	female	6.93
PKR.VIII-19977	Lulu AnpiBuffyland	female	6.50
PKR.VIII-20481	Hermina Nasze Uroczysko	female	6,50
PKR.VIII-19155	Fifth Element Power Of Dream	female	6.25
PKR.VIII-19876	Ferrari Power Of Dream	female	6,25
PKR.VIII-18638	Terra Lemniscatus El Labrro	female	3.52
PKR.VIII-20760	GiffreLemniscatus	female	3.27
PKR.VIII-12065	Balbina Niskowiaki	female	3.13
PKR.VIII-20139	Mandala z Dębowego Gaju	female	3.13
PKR.VIII-17735	Amanda z Garlicy Duchownej	female	2.54
PKR.VIII-19978	Gaspar z Grodu Hrabiego Malmesbury	male	2.29

It should be noted, however, that in the case of two Golden Retrievers (Table 3) and as many as seven Labradors (Table 4), the inbreeding coefficients were equal to or even exceeded the critical value of 12.5%, given in the literature [4].

Table 5 shows the mean relationship coefficients in the Golden and Labrador Retriever populations. There were 18,145 pairs of individuals in the Golden Retriever population, of which 16,299 (89.83%) were related, with a mean relationship of 5.39% for all pairs and 6% for related pairs. Of 3,486 pairs of male Golden Retrievers, more than 90% were related, while among 5,671 pairs of GR females over 89% were related. Of a total of 8,988 mixed male-female pairs, about 90% were related.

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Table 5

Mean relationship coefficients (R_{XY}) for Golden Retrievers and Labrador Retrievers

	Pairs of		
	male	female	mixed*
Golden Retrievers			
Total number of pairs	3486	5671	8988
Number of related pairs	3151	5054	8094
Mean R_{XY} (%) – all pairs	6.10	4.98	5.38
Mean R_{XY} (%) – related pairs	6.75	5.59	5.97
Maximum R_{XY} (%) value	59.39	52.34	59.63
Labrador Retrievers			
Total number of pairs	5886	12880	17549
Number of related pairs	3826	9022	11887
Mean R_{XY} (%) – all pairs	3.09	3.27	3.02
Mean R_{XY} (%) – related pairs	4.54	4.67	4.46
Maximum R_{XY} (%) value	58.93	55.14	53.22

*Mixed – male x female pairs

In the Labrador Retriever population, 24,735 pairs (68.11%) from a total of 36,315 pairs were related, and the mean relationship was 3.09% for all pairs and 4.54% for related pairs. Of 5,886 pairs of LR males, 65% were related, while of 12,880 pairs of LR females slightly over 70% were related. Of the total of 17,549 mixed male-female pairs, nearly 68% had non-zero relationship values (Table 5).

Inbreeding and relationship coefficients obtained by other authors are presented in Table 6.

The mean inbreeding coefficients of the Cracow populations of Golden and Labrador Retrievers, as compared to literature data for various breeds of dogs (Table 6), were low [1, 2, 3, 6, 8, 13, 15, 16, 17, 20, 22]. The Cracow Golden Retriever population had nearly twice as many inbred animals as the Labrador population. In certain inbred animals of both breeds, relatively high F_X values of 12.5% and higher were recorded, with more of these among Labradors than Golden Retrievers, and in both breeds they were male. For

Table 6

Inbreeding (F_X) and relationship (R_{XY}) coefficients in different dog breeds obtained by other authors

Breed	F_X (%)	R_{XY} (%)	Source
German Shepherd	0.0-26.20	0.16-25.30	[1]
Labrador Retriever	0.0-22.00	0.15-15.50	[1]
German Shepherd	5.10-10.40	–	[2]
German Shepherd	0.23-3.11	0.34-0.39	[3]
Rottweiler	1.12-5.85	0.72-1.01	[3]
German Boxer	0.68-4.26	0.52-2.68	[3]
Great Dane	0.61-8.79	0.56-0.70	[3]
Beagle	0.68-5.65	0.95-9.26	[6]
Polish Hound	7.10-37.00	–	[7]
Tatra Shepherd	1.06-6.44	4.53-14.92	[8]
German Shepherd	11.78-16.58	3.53-4.36	[9]
10 dog breeds in France	2.30-9.00	0.70-8.90	[13]
French dog breeds	0.0-16.00	–	[14]
61 dog breeds in France	0.20-8.80	0.40-8.80	[15]
Cimarrón Uruguayo	3.00	4.00	[16]
Nova Scotia Duck Tolling Retriever	26.00	26.00	[17]
Lancashire Heeler	10.0	8.00	[17]
Icelandic Sheepdog	21.0	–	[18]
Icelandic Sheepdog	0.0-27.0	0.0-55.0	[19]
Czech Dachshund	1.32-2.93	–	[20]
Bavarian Mountain Hound	4.51	–	[22]
Hanover Hound	6.78	–	[22]
Tyrolean Hound	9.47	–	[22]

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the individuals that were most inbred, the inbreeding coefficients had not reached the level of 20% or higher reported by some authors [1, 7, 9, 14, 17, 18, 19].

In the case of both breeds, there was a tendency to use a few of the best dogs for breeding, and the large groups of their progeny could be even further related through their mothers. This problem was greater in the case of Golden Retrievers, with a single sire having over one hundred descendants in his career. This value was also high in Labradors, amounting to over 60 descendants (Table 1). Even assuming that some of the offspring are not allowed to breed, this practice may reduce the genetic pool of both breeds within a short time and lead to inbreeding depression with its adverse effects, e.g. the appearance of genetic defects.

The mean relationship coefficients in the Golden and Labrador Retriever populations were much lower than those reported by other authors for various breeds of dogs (Table 6). However, the highest R_{XY} values in both Retriever populations (about 60%) exceeded the values reported in the literature [1, 8, 17, 19]. It is important to note that the percentage of related males and females was dangerously high, reaching over 90% in Golden Retrievers and about 70% in Labradors. This may make it difficult for breeders to select pairs for mating and necessitate the search for sires at a greater distance from their place of residence, or increased import of animals.

In conclusion, although as yet there is no risk of inbreeding depression in either population, there is a continual unfavourable trend towards a reduction in the gene pool. To address this situation, it could be useful to conduct a more thoughtful search for sires, whose relationship with the females of the populations should be as low as possible.

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