Animal Science Papers and Reports vol. 31 (2013) no. 1, 45-54
Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

Analysis of founder and ancestor contribution to the Golden and Labrador Retriever populations in the area of Cracow Branch of the Polish Kennel Club

Joanna Kania-Gierdziewicz[1]*, Maciej Gierdziewicz[1], Bożena Kalinowska[2]

[1] Department of Genetics and Animal Breeding, University of Agriculture, 30-059 Cracow, Al. Mickiewicza 24/28, Poland

[2] Cracow Branch of the Polish Kennel Club, Żywiecka 36, 30-427 Cracow, Poland

(Received April 25, 2012; accepted December 3, 2012)

The study examines the founder and ancestor contribution to the active population of Golden retrievers (GR) and Labrador retrievers (LR) recorded in the herdbook of Cracow Branch of the Polish Kennel Club. Pedigrees of 192 GR dogs (84 males and 108 females) born in 1998-2007 and 272 LR (110 males and 162 females) born in 1997-2007, were used. The effective numbers of founders were 52 and 96 for GR and LR, respectively. In the GR reference population the contribution of 22 main founders explained about 51% of the gene pool. Four founders contributed from 2% to ca. 6% of genes; the others only 1-2%. Of the 23 main founders in the LR population four top founders contributed from 2% to 4% of genes, while the rest only 1-2%. The group of the LR main founders explained about 41% of the gene variation. In the GR population 28 main ancestors explained over 71% of their gene pool. Four GR ancestors made from 3% to over 9% gene contribution. The rest of the GR ancestors contributed 1-3%. Also 28 main ancestors were found in the LR reference population, with contributions explaining over 63% of variation. Six of them had the highest gene contribution – from 3% to 6.5%, the next 5 – from 2% to about 3%, and the rest 1-2%. Six animals in the GR reference population, and 5 in the LR, were both main founders and main ancestors. At present, the gene pools of both populations are not endangered.

KEY WORDS: ancestor / founder / gene / Golden retriever / Labrador retriever / population

*Corresponding author: rzkania@cyf-kr.edu.pl

Golden and Labrador retrievers both belong to group VIII of FCI including retrievers, flushing dogs and water dogs. Retrievers are Section 1 of that group. Both breeds origin from British Isles and were bred in XIX century as hunting dogs, to retrieve shot water birds. Later both breeds became more and more popular in the world. They are now excellent companion dogs, because of their friendly and confident character with no trace of aggression or undue shyness. The dogs of both breeds are biddable, good-tempered, intelligent, very agile and having natural working ability. They are versatile breeds in many fields of human activity, both being trained and used as guide dogs for disabled people, for dogotherapy (especially for children), and also for the detection of drugs, explosive charges or flammable substances. Both Retriever breeds work as police or border guard dogs, and also as avalanche dogs in Mountain or Fire Rescue [Kilgore Bauer 2000, Kuźniewicz 2010a, 2010b, Rauth-Widmann 2000, 2006, Tarułka 2004].

The first Golden Retriever appeared in Poland in 1981 in the British Embassy in Warsaw while the first three Labrador Retrievers were imported in 1985 from Czech Republic. From the end of the XX century, the number of animals of both breeds in Poland is steadily increasing, as can be observed at any dog show. Because of their mild and friendly character, retrievers of both breeds are often preferred as family dogs, especially for children [Kuźniewicz 2010ab]. However, as for any introduced breed, the genetic structure of their populations, characterized eg. by number of founders and ancestors, should be carefully detected to avoid reducing the gene pool to the dangerously low level.

The aim of this study was to investigate the founder and ancestor contribution to the active populations of Golden retriever and Labrador retriever dogs bred in Cracow Branch of the Polish Kennel Club.

Material and methods

Two pedigree data sets of dogs were considered: (1) the Golden retrievers (GR) and (2) the Labrador Retrievers (LR). The 192 GR dogs, born between 1998 and 2007 and the 272 LR dogs born between 1997 and 2007, were registered as stock animals in Cracow Branch of Polish Kennel Club. More detailed description of the two data sets is given in Table 1.

The active populations of each breed (GR and LR) were treated separately as the reference populations in founder and ancestor analysis. The total and effective numbers of founders and ancestors were estimated, and those with the highest gene contribution to the each reference population were identified. The effective numbers of founders (f_e) and ancestors (f_a) were calculated following the procedure proposed by Lacy [1989,1995] modified by Boichard *et al.* [1995, 1996, 1997].

Results and discussion

The total population size of GR dogs was about two thirds of that of Labradors. This holds also for the reference populations, each of them comprising about one fifth of the respective total population (Tab. 1).

Table 1. Data description

Item	Golden retrievers	Labrador retrievers
Number of animals in active population	192	272
males	84	110
females	108	162
Number of animals in pedigrees	1034	1418
males	431	585
females	603	833
Pedigree depth (generations)		
maximum	9	9
mean	6.3	6.0

In GR animals the total number of founders was almost double, and the total number of ancestors roughly half the reference population size. The proportions for corresponding effective numbers were smaller – approximately one fourth for founders and one fifth for ancestors. The analogous proportions for LR population were higher, except that for the effective number of ancestors, which was similar. For both breeds, the total number of ancestors was about one third of the total number of founders. The ratio for the effective numbers was roughly 1/2. In general, the effective numbers were one sixth (founders) or about one third (ancestors) of the total ones (Tab. 2). When comparing breeds, all numbers for GR dogs in Table 2 were smaller than those for LR, reflecting their population sizes.

Table 2. Total number of founders and ancestors and effective number of founders (f_e) and ancestors (f_a) for reference populations (active breeding populations) of GR and LR dogs

Breed	Founders		Ancestors	
	total	f_e	total	f_a
Golden retriever (GR)	335	52	106	33
Labrador retriever (LR)	618	96	165	43

The founder group with the highest gene contributions to the GR active population, shown in Table 3, included 22 animals (15 males and 7 females). The top four founders contributed from 2-6% of genes. The first three places were occupied by two dogs and one bitch, each of them with over 5% of the gene contribution. The

leader *Standfast Angus* (NHSB1650350) had about 5.9%. Next two dogs contributed 3.66% and 3.38%, respectively. The other main founders had contributions of up to 3%. About 51% of the genetic variability in this reference population can be explained by the contribution of the 22 main founders (Tab. 3).

Table 3. Founders with more than 1% gene contribution to reference population of 194 Golden retriever dogs (GR) registered in herdbook of Cracow Branch of Polish Kennel Club. Names of animals being both main founders and main ancestors are printed in italics

Identity No.	Name	Sex	Contribution (%)
NHSB1650350	*Standfast Angus*	male	5.89
SF05147/87	*Lovehayne Darter*	male	5.63
CLP/GR/1257/98	Baronessa of Blue Erinor	female	5.31
CLP/GR/377/94	*Hayjoy Signia to Araukarity*	male	3.66
Met.Gold.R.1052/96	*Homokgyongy Szigeti*	male	3.38
KCSB2131BU	Sansue Golden Ruler	male	2.59
KCSB2202BK	Nortonwood Faunus	male	2.21
NHSB1400339	Chevanne of High Endeavour	male	2.19
0459BP	Gaineda Consolidator of Sansue	male	1.83
NHSB1494857	Lady Brenda v.d.Beerse Hoeve	female	1.76
SF09198/89	Linchael Corniche	male	1.74
Clp1063/90	Dorion Belaja	male	1.74
PKR.VIII-II-359	Fredonia Francy Work's	female	1.64
KCRK1700402K06	Styal Scottalia	female	1.61
PKR.VIII-7540	*Astra spod dębu*	female	1.43
W5543501W04	*Garbank Lislone Jackpot*	male	1.33
PKR.VIII-19789	Agat z Garlicy Duchownej	male	1.29
KCSB4247BW	Sansue Golden Ruler	male	1.16
NHSB2025808	Sansue hi'land storm	male	1.13
PKR.VIII-14657	Amigo Ordynacja	male	1.13
CLP/GR/554/88	Gabi ze Slunecne Strane	female	1.12
NKK28069/88	Waterloo's Christmas Star	female	1.12
		total:	50.89

Table 4 shows the main ancestors with more than 1% of gene contribution to the GR reference population. Twenty-eight animals (12 males and 16 females) were identified as main ancestors. Among those, 4 animals (3 males and 1 bitch) made the highest gene contribution to the above population: from 3% to more than 9%. The male *Tweedledum steamy Windows* (SF41242/92) was the largest contributor (9.44%). One bitch and two dogs had over 4.5% contribution. Each of the next five ancestors accounted for 3-4% of genes. The gene contributions of 4 ancestors (bitches) ranged from 2 to 2.5%, while the rest of the main ancestors contributed only 1-2% of genes. In total, the 28 main ancestors contributed over 71% of genes to the gene pool of the GR reference population (Tab. 4).

In the GR reference population six individuals were found to be both main founders and main ancestors. Their names are printed in italics in Tables 3 and 4.

Table 4. Ancestors with more than 1% gene contribution to reference population of 194 Golden retrievers (GR) registered in herdbook of Cracow Branch of Polish Kennel Club. Names of animals being both main founders and main ancestors are printed in italics

Identity No.	Name	Sex	Contribution [%]
SF41242/92	Tweedledum steamy Windows	male	9.44
NHSB1464306	Noeska	female	6.62
SF05147/87	*Lovehayne Darter*	male	5.63
PKR.VIII-4223	Qajun Zeus	male	4.75
Met.Gold.R.273/92	Templomteri Bright Caroline	female	3.84
PKR.VIII-3907	Jako's as dream cames true	male	3.39
Met.Gold.R.1052/96	*Homokgyongy Szigeti*	male	3.38
CLP/GR/1077/97	Tartarus of bridge four	male	3.16
NHSB1650350	*Standfast Angus*	male	3.04
SPKP107/97	Lousiana	female	2.41
SKKS.56384/93	Sundazzle's Bonnie Bee	female	2.21
PKR.VIII-4189	Tidy Trixy	female	2.05
PKR.VIII-7609	Karin	female	2.02
PKR.VIII-4418	Mona Lisa v.d.Vijf Lijsterbessen	female	1.80
CLP/GR/377/94	*Hayjoy Signia to Araukarity*	male	1.63
PKR.VIII-5492	Complement Extasy Senator	female	1.56
PKR.VIII-XVI-3357	Golden Game Oligarchia	female	1.46
PKR.VIII-7540	*Astra Spod Dębu*	female	1.43
W5543501W04	*Garbank Lislone Jackpot*	male	1.33
PKR.VIII-XIV-2989	Trollsangens Toy	female	1.30
S0838204	Chardine Love Bug	male	1.30
CLP/GR/11/96	Oxana Erinor	female	1.17
NKK11775/90	Waterloo's around the clock	male	1.16
PKR.VIII-6214	Elizabeth Bohemian Gold	female	1.07
PKR.VIII-4419	Midas v.d.Vijf Lijsterbessen	male	1.04
S0596201S01	Camrose Unatamsin with shutan	female	1.04
PKR.VIII-11105	Neda Sen o Viktorii	female	1.04
PKR.VIII-8654	Jurina od Himalajskiego Cedru	female	1.04
		total	71.31

The group of 23 main founders (13 males and 10 females) with the highest gene contribution to the LR active population is shown in Table 5. The top four animals contributed from 2% to 4% of the genes to LR reference population. The first place was taken by the bitch *Bonnie z Daleskeho Haje* (CLP/LR/2016/94) with 3.58% of gene contribution, closely followed by three males contributing 3.45%, 3.01% and 2.43% of genes. The contributions of the remaining main founders did not exceed 2% of genes. About 41% of the genetic variation in this reference population can be explained by the contribution of the 23 main founders (Tab. 5).

Table 5. Founders with 1% and more of gene contribution to reference population of 272 Labrador retrievers (LR) registered in herdbook of Cracow Branch of Polish Kennel Club. Names of animals being both main founders and main ancestors are printed in italics

Identity No.	Name	Sex	Contribution (%)
CLP/LR/2016/94	Bonnie z Daleskeho Haje	female	3.58
PKR.VIII-4544	*Beniamin ze Zahoranskeho Lesa*	male	3.45
PKR.VIII-7766	*Strongline's Kernel*	male	3.01
NHSB1900519	Ixor du Bois Des Lilas	male	2.43
NHSB2050094	Master of chocolat du taillis madame	male	1.97
PKR.VIII-3524	*Aprilmist Yolands*	female	1.93
AKCSBSN216388	Dickendalls Davaron Argyle	male	1.89
KCH3116201H09	Lawnwoods wish me look	male	1.74
KCRK5637404K12	Poolstead Pretentious at Rocheby	male	1.72
W5397809W04	Follytower sky Lark Over Rocheby	female	1.71
IKCS18114	Phlipstopstown Fairytale	female	1.66
PKR.VIII-4989	*Rockystar's Buckie of Macduff*	male	1.60
SKKS24432/91	Guideline's Copyright	male	1.57
KC03	Ellis v.Ohrfeld	female	1.57
KCSB2687BV	Boothgates Healiner	male	1.51
KCSB10598BW	Rocheby Acorn	female	1.46
SF11979/89	Jayncourt Jingle Jangle	female	1.41
NHSB1858422	Fairywoods's Unic Senna	female	1.22
PKR.VIII-4963	Zaira Golden Erinor	female	1.19
KCS0614505501	Carromer's Charlie Chalk	male	1.16
KCRN2933103N02	Boothgates Kountry Kraft	male	1.10
PKR.VIII-8798	*Puma Górska Fantazja*	female	1.02
CLP/LR/287/84	Tullin Eri	male	1.00
		Total:	40.90

Table 6 shows the main ancestors with more than 1% of gene contribution to the LR reference population. In this reference population 28 animals (19 males and 9 females) were also identified as main ancestors. Among those, six individuals (all males) made the highest gene contribution to the above population – from 3% to more than 6.5%. The largest contributor (6.64%) was the dog *Ladylands Boy* (PKR.VIII-5394). The next five dogs contributed 6.02%, 5.67%, 4.86%, 3.45% and 3% of genes. The gene contributions of 5 ancestors (3 dogs and 2 bitches) ranged from 2% to about 3%, while the rest of the main ancestors contributed only 1-2% of genes. In total, 28 main ancestors contributed over 63% of genes to the gene pool of the LR reference population (Tab. 6).

In the LR reference population 5 animals were found to be both main founder and main ancestor. Their names are printed in italics in Tables 5 and 6.

In this study the estimates of effective number of founders (f_e) and ancestors (f_a) of GR and LR populations were found slightly higher than those reported by Cole *et al.* [2004] for much larger populations of German Shepherds and Labrador Retrievers working as guides.

Table 6. Ancestors with 1% and more of gene contribution to reference population of 272 Labrador retrievers (LR) registered in herdbook of Cracow Branch of Polish Kennel Club. Names of animals being both main founders and main ancestors are printed in italics

Identity No.	Name	Sex	Contribution (%)
PKR.VIII-5394	Ladylands Boy	male	6.64
PKR.VIII-7766	*Strongline's Kernel*	male	6.02
KCN123740N02X	Mallorn Missionary Man	male	5.67
PKR.VIII-5931	Belle Armani of The Music Forest	male	4.86
PKR.VIII-4544	*Beniamin ze Zahoranskeho Lesa*	male	3.45
CLP/LR/9314	Rocheby Smokescreen	male	3.00
PKR.VIII-6300	Blondella Blue Peter	female	2.87
PKR.VIII-7661	Ellington Ingver	male	2.64
PKR.VIII-11254	Tsunami Twa Zandalle	female	2.41
NHSB2172155	King Fiels Kilien	male	2.31
PKR.VIII-12134	Lab Treasures Indeed	male	2.13
PKR.VIII-6023	Tiverton Bonny Lad's Brian Trust Apollo	male	1.60
PKR.VIII-6846	Boothgates Kolour Scheme	female	1.53
LOF8 RET.L.133437	Roll A Taco Of Tintagel Winds	male	1.48
PKR.VIII-4008	Hera Ulvseth's	female	1.44
PKR.VIII-7303	Applejack's Hello Honky Town	male	1.44
PKR.VIII-6266	Kizi pod Jabłonią	female	1.39
PKR.VIII-8916	Flores Bazylia Złota Agrafka	female	1.30
CLP/LR/6214/98	Migt Be A snow Dog Of Tintagel Winds	male	1.27
PKR.VIII-3524	*Aprilmist Yolands*	female	1.27
PKR.VIII-4963	Zaira Golden Erinor	female	1.19
PKR.VIII-14603	Tsarodej Taylor Made	male	1.11
PKR.VIII-14025	Inujasha Górska Fantazja	male	1.11
CLP/LR/722/88	Brian Erinor	male	1.10
KC.X2640404X03	Birchbrook Paddnington Bear	male	1.02
PKR.VIII-8798	*Puma Górska Fantazja*	female	1.02
S35045/2002	Tjotte's Buffalo Bandit	male	1.02
PKR.VIII-4989	*Rockystar's Buckie of Macduff*	male	1.00
		total	63.29

When compared to the values calculated for GR and LR in the present work, the gene contribution of some founders to the population of Polish hounds assessed by Głażewska [2008] was much higher.

In a study by Leroy *et al.* [2009] the values of the effective number of ancestors (f_a) and effective number of founders (f_e) for 61 dog breeds in France ranged widely from 10 (in Barbets) to 656 (in poodles) for f_e, and from 9 to 209 for f_a. The size of the reference population was 112 and 8808 animals for Barbets and for poodles, respectively. Our results fell in the above range, however, they were estimated for a similar or even smaller reference populations (only 192 GR and 272 LR animals). The earliest paper by Leroy *et al.* [2006] concerning genetic variability of nine French dog breeds, showed the f_e and f_a values ranging from about 7 to over 91 and from ca.7 to over 40 depending on breed, respectively. Our results for GR and LR populations

are similar to those of Leroy *et al.* [2006]. They were, however, obtained on smaller reference populations.

For Bavarian mountain, Hanoverian and Tyrolean hounds, significantly lower f_e and f_a values were reported by Voges and Distl [2009]. In their study, covering much larger reference populations, the contributions of the top 10 ancestors to the Bavarian mountain, Hanoverian and Tyrolean hounds population gene pools, between over 54% to near 78%, were markedly higher than our results obtained for 28 top ancestors of CR and LR populations.

The values of f_e and f_a in a population of Tatra Shepherd dogs in Cracow Branch of Polish Kennel Club [Gierdziewicz *et al.* 2010] were markedly lower (34 animals) than the populations of GR and LR examined in this paper.

In the study by Mäki [2010], values of the effective number of ancestors (f_a) and effective number of founders (f_e) for Nova Scotia Duck Tolling Retriever and Lancashire Heeler dog populations ranged from about 10 to over 15 for f_e, and from more than 5 to about 14 for f_a. The size of the reference population was 7707 and 1291 animals for Nova Scotia Duck Tolling Retriever and for Lancashire Heeler dog, respectively. Our results presented here are much higher, however, they were estimated on a smaller reference populations (192 GR and 272 LR animals), but the gene contributions of the most influential founder and ancestor were significantly lower in our than in Mäki's study [2010].

The results of this study, showing the effective number of founders (f_e) and ancestors (f_a) of GR and LR populations are similar or even lower than those reported by Gierdziewicz *et al.* [2011] for slightly smaller population of Beagle dogs. In a population of Cimarron Uruguayo dog bred in Uruguay [Martinez *et al*. 2011], a population markedly bigger (1455 animals) than both populations of retrievers, the values of f_e and f_a were lower than the results presented in this study. In the study by Kania-Gierdziewicz *et al.* [2011] the f_e and f_a values calculated for smaller population of 60 German Shepherd dogs in Cracow were found similar to those reported in the present study.

To sum up the foregoing results it could be concluded that both relatively high values of the effective number of founders (f_e) and ancestors (f_a) in relation to the number of animals in GR and LR populations and the main founder and ancestor marginal contributions which were generally low (from 6 to about 10% in GR breed and from 4 to 7% in LR dogs), because of permanent importation of breeding animals of both breeds indicate that those populations are now not endangered due to risk of shrinking of their gene pool.

Acknowledgement. *The authors thank all the Golden and Labrador Retriever breeders registered in the Cracow Branch of the Polish Kennel Club for providing access to their animals' pedigrees.*

REFERENCES

1. BOICHARD D., MAIGNEL L., VERRIER E., 1995 – Estimation of the effective number of a population from pedigree information. 2nd European Workshop on Advanced Biometrical Methods in Animal Breeding, June 12-20, Salzburg, Austria.
2. BOICHARD D., MAIGNEL L., VERRIER E., 1996 – Analyse généalogique des races bovines laitieres françaises. ***INRA Production Animales*** 9(5), 323-335.
3. BOICHARD D., MAIGNEL L., VERRIER E., 1997 – The value of using probabilities of gene origin to measure genetic variability in a population. ***Genetics, Selection, Evolution*** 29, 5-23.
4. COLE J.B., FRANKE D.E., LEIGHTON E.A., 2004 – Population structure of a colony of dog guides. ***Journal of Animal Science***, 82(10), 2906-2912.
5. GIERDZIEWICZ M., KALINOWSKA B., KANIA-GIERDZIEWICZ J., 2010. Genetic structure analysis of Tatra Shepherd dog population in area of Krakow Branch of Polish Kennel Club. II. Contribution of founders and ancestors. ***EJPAU*** 13(3),#3 (http://www.ejpau.media.pl/volume13/issue3/art-03.html)
6. GIERDZIEWICZ M., KANIA-GIERDZIEWICZ J., KALINOWSKA B., 2011 – Analysis of genetic structure of the Beagle population in the area of Cracow Branch of the Polish Kennel Club. ***Animal Science Papers and Reports*** 29(4), 359-367.
7. GŁAŻEWSKA I., 2008 – Genetic diversity in Polish hounds estimated by pedigree analysis. ***Livestock Science*** 113, 296-301.
8. KANIA-GIERDZIEWICZ J., KALINOWSKA B., GIERDZIEWICZ M., 2011 – Analiza udziałów założycieli i przodków w populacji aktywnej owczarka niemieckiego w rejonie działania Krakowskiego Oddziału Związku Kynologicznego w Polsce (Analysis of the contribution of founders and ancestors to the active dog population of German Shepherd in the area of Cracow branch of the Polish Kennel Club). ***Roczniki Naukowe Polskiego Towarzystwa Zootechnicznego*** 7(2), 9-17 In Polish, summary in English.
9. KILGORE BAUER N., 2000 – Golden Retriever. Publ. by Rea. In Polish.
10. KUŹNIEWICZ J., 2010a. – Psy ratujące ludziom życie. Cz.1 Psy dogoterapeuci i ostrzegające przed występowaniem chorób (Dogs saving human lives. I. Therapy dogs and medical alert dogs). In Polish. ***Przegląd Hodowlany*** 7, 29-31.
11. KUŹNIEWICZ J., 2010b – Psy ratujące ludziom życie. Cz.2. Psy ratownicze i wspomagające osoby niepełnosprawne (Dogs saving human lives. II. Life saving dogs and assistance dogs). ***Przegląd Hodowlany*** 8, 31-33. Iin Polish.
12. LACY R.C., 1989 – Analysis of Founder representation in pedigrees. Founder Equivalents and Founder Genome Equivalents. ***Zoo Biology***, 8, 111-123
13. LACY R.C., 1995 – Clarification of genetic terms and their use in the management of captive populations. ***Zoo Biology***, 14, 565-578.
14. LEROY G., ROGNON X., VARLET A., JOFFRIN C., VERRIER E., 2006 – Genetic variability in French dog breeds assessed by pedigree data. ***Journal of Animal Breeding and Genetics*** 123, 1-9.
15. LEROY G., VERRIER E., MERIAUX J.C., ROGNON X., 2009 – Genetic diversity of dog breeds: within-breed diversity comparing genealogical and molecular data. ***Animal Genetics***, 40(3), 323-332
16. MARTINEZ M., ARMSTRONG E., GAGLIARDI R., Y LLAMBI S., 2011 – Estudio ógico del perro Cimarrón Urugayo (Pedigree analysis of the canine breed Cimarrón Uruguayo). ***Archivos de zootechnia*** 60(232), 1327-1330. In Spanish, summary in English..
17. MÄKI K., 2010 – Population structure and genetic diversity of worldwide Nova Scotia Duck Tolling Retriever and Lancashire Heeler dog populations. ***Journal of Animal Breeding and Genetics*** 127, 318-326

18. RAUTH-WIDMANN B., 2000 – Golden Retriever. Multico Oficyna Wydawnicza. In Polish.
19. RAUTH-WIDMANN B., 2006 – Labrador – poradnik opiekuna (The Labrador. The dog owner's quide). Wydawnictwo RM. In Polish.
20. TARUŁKA J., 2004. Labrador Retriever. ***Mój Pies*** 8, 30-32. In Polish.
21. VOGES S., DISTL O., 2009 – Inbreeding trends and pedigree analysis of Bavarian mountain hounds, Hanoverian hounds and Tyrolean hounds. ***Journal of Animal Breeding and Genetics*** 126, 357-365.