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Variability of estimates of performance traits and breeding value in raccoon dogs as evaluated by two models*

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The study aimed at comparing the genetic parametres estimated in raccoon dogs with two models, as well as determining precisely the dam's effect on variation of raccoon dog performance traits and breeding value estimates. The investigations covered 17 generations of animals. The effect of factors determining the level of the estimated reproduction and performance traits was verified using the multi-factor analysis of variance and the least squares method. The covariance components for performance traits were estimated by the REML method on the basis of two multi-trait individual models, differing in the random factors considered. The first model included exclusively the random additive effect of the individual and the random effect of the animal's specific environment. The second included additionally the random maternal additive effect.

The estimated values of genetic parametres markedly depended on the model used, significant inter-model differences occurring principally in the animals' conformation traits. The maternal additive effect proved to be a significant source of variation for a majority of performance traits analysed.

KEY WORDS: breeding value / genetic parametres / maternal additive effect / raccoon dog /variation

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An effective breeding programme must be based on reliable animal performance tests. In order to elaborate an optimum breeding programme it is necessary to obtain full information about the variability of traits included in the breeding goal, expressed by variation of components used for the estimation of genetic and environmental parametres. The precision of the estimates obtained depends considerably on the choice of a suitable model. Beside the random additive effect of the animal the model may also include the random effect of the dam. This effect results from genes that the animal received from its dam as also from the specific environment, which includes among much else the health, uterus size, amount of nutrients supplied to the foetus, milk production, or maternal instinct.

Studies on the maternal effect have a long history in animal breeding though they were conducted principally on sheep, cattle and pigs [Roehe and Kennedy 1993, Gutierrez *et al*. 1997, Lykins *et al*. 2000, Johnson *et al*. 2002]. Estimating the maternal effect is necessary for an effective modelling and predicting of selection results [Wilson *et al*. 2005]. When the maternal effect presents a significant source of variation, a model containing beside the individual's additive effect also the additive effect of the dam should ensure more precise estimations [Roehe and Kennedy 1993, Lykins *et al*. 2000].

In the present study two models were used, differing in random factors. The first model considered exclusively the random additive effect of the animal and the random effect of the animal's specific environment, while the second included also the random maternal effect. In the case of reproductive traits the maternal effect was in fact the effect of the grand-dam (dam's dam) of the litter.

Two models were used in order to compare the possible differences between the results obtained from estimating variation components and to ensure a precise determination of the maternal effect on the variation of performance traits and on estimates of the breeding value of raccoon dogs.

Material and methods

The material consisted of records collected on a raccoon breeding farm. The analyses covered 17 generations of animals. The data on reproductive traits came from 1724 females of the basic flock, out of which 4087 litters were obtained. In the population analysed females aged one year prevailed, comprising about 39% (Tab. 1). The information collected included the year of birth, age of females, date of mating and whelping in subsequent years, number of matings, length of pregnancy, and size of litters born and reared.

On the farm, conformation of young animals that reached the full fur maturity was assessed each year. The number of pups evaluated depended on the replacement needs of the farm. The conformation was characterized based upon records collected for 7273 animals (3678 males and 3595 females).

Table 1. Females' share in the basic flock as related to age

Age of females	No. of litters	Per cent share
1-year	1591	38.93
2-year	882	21.58
3-year	653	15.98
4-year and older	961	23.52

Table 2. Distribution of scores for conformation traits in young raccoon dogs in the period analysed

Trait	Score	Per cent of animals
Colour type	1	12.65
	2	46.57
	3	40.78
Colour purity	1	2.67
	2	87.39
	3	9.94
Coat quality	1	0.03
	2	0.04
	3	2.31
	4	4.44
	5	17.72
	6	39.56
	7	35.90
	8	0.03
Body size and conformation	3	3.41
	4	12.88
	5	27.54
	6	56.17
	1-2	0

During the period considered in the present study two conformation standards for raccoon dogs were accepted, slightly differing one from the other. A change of score was performed for individual traits, changing the score awarded according to a 30-point scale to a corresponding score in a 20-point scale. In the current work evaluations were standardized according to the currently accepted standard of raccoon dog conformation [CSHZ 1997], using PROC STDIZE method from the SAS [2000] software. The distribution of scoring of conformation traits is presented in Table 2.

The effect of factors determining the level of the reproductive and conformation traits examined was verified by a multi-factor analysis of variance (least squares method) using the SAS [2000] software.

Covariance components for performance traits were evaluated with the REML method based on a multi-trait individual model, using the DMU software [Madsen

Table 3. Factors included in the evaluation of genetic parametres in raccoon dogs

Trait	Size of litter at birth	Size of litter reared	Body size and conformation	Colour type	Colour purity	Coat quality
Year of whelping (F)	x	x				
Sex (F)			x		x	x
Age of dam (F)	x	x				
Length of pregnancy (F)	x	x				
Year of birth (F)			x	x	x	x
Animal's additive effect (A)	x	x	x	x	x	x
Animal's specific environment (R)	x	x				
Additive effect of animal's dam (M)[a]	x	x	x	x	x	x

F – constant factor; A and M – random factors related to the relationships matrix; R – random factor.
[a]Factor included calculation model II.

and Jensen 2000]. Factors taken into consideration for individual traits are presented in Table 3. The pedigree covered 8440 animals.

The variance and covariance components, estimated according to the models described, were used to determine the breeding value of animals by the BLUP method [Madsen and Jensen 2000]. Rank correlations were calculated determining the ranking of animals according to their breeding value as estimated by different models [SAS 2000].

As the traits analysed were characterized by a stepwise variation the probit transformations were used for the parametres obtained, according to the method described by Żuk [1989].

Results and discussion

The values of the genetic parametres estimated according to two models are presented in Table 4. The variation observed in reproduction traits, and principally the number of pups reared, was to a considerable degree affected by environmental factors. The heritability coefficient (h^2) ranged from 0.08 to 0.1 for litter size at birth and from 0.0.5 to 0.06 for the size of litter reared. Similar results were presented by Ślaska [2001] who reported the h^2 of the number of raccoon pups born and reared to reach the value of 0.065 and 0.074, respectively. The h^2 of the parametres obtained in

Table 4. Heritability (h^2, h^2_m) and maternal effect (m^2) for reproduction and conformation traits in raccoon dogs

Traits	Model I*	Model II**	
	h^2	h_m^2	m^2
Litter size at birth	0.111	0.082	0.045
Size of litters reared	0.053	0.066	0.01
Colour purity	0.519	0.278	0.168
Colour type	0.355	0.253	0.187
Coat quality	0.310	0.254	0.172
Body size and conformation	0.444	0.280	0.234

*Additive maternal effect not included.
**Additive maternal effect included.

the current study do not differ significantly from those reported for other fur animals [Lagerkvist 1992, Lagerkvist *et al*. 1994, Kenttamies 1996, Rozempolska-Rucińska 2004]. The differences in the values reported for genetic parametres result principally from the estimation method, mathematical models used, and animal species.

The results obtained in the present study indicate a considerable effect of dam on the number of pups born, as it comprised half the variation arising from the additive effect of the animal. The effect of dam on the level of reproductive traits was determined also in animals of other species. In chinchilla and mink the value of the maternal effect variation for these parametres exceeded that arising from the additive individual value [Jeżewska *et al*. 2003, Rozempolska-Rucińska 2004]. Rastogi *et al*. [2000] reported the additive effect of dam to be most marked for litter size at birth (0.09-0.12). The h^2 coefficients reported in the present study for conformation traits of raccoon dogs ranged from 0.310 to 0.519 (according to model I) and from 0.253 to 0.280 (according to model II) – Table 4. The highest values were obtained for colour purity as well as for body size and conformation. According to numerous authors [Berg 1993, Lagerkvist *et al*. 1994, Socha 1995, Socha and Olechno 2000, Wierzbicki and Filistowicz 2002] traits related to the conformation of fur animals are of a medium and high heritability, the reported respective figures being not markedly different from those obtained in the present work. In the case of the conformation traits reported here for raccoon dogs the maternal effect was clearly marked (Tab. 4), the value of this parametre (h^2m) ranging from 0.16 to 0.23. The genetic variation arising from the maternal effect comprised over half of that arising from the animal's additive effect. This was especially clear for body size and conformation (m^2 = 0.234). Similar studies, conducted by the authors on a populations of mink and chinchilla, also demonstrated that the pre- and post-natal effect of a dam was a source of significant variation, principally for the animal's body size and conformation, and fur quality [Jeżewska *et al*. 2004, Rozempolska-Rucińska 2004].

Analysing the results presented in Table 4 one should emphasise the differences between the h^2 values estimated according to different models. The parametre values obtained according to the model in which the additive effect of the dam was not considered were clearly higher, and this was most pronounced for conformation traits. In situations, when the model does not consider the maternal effect, the value of h^2 is increased by this part of variation. Considering the variation arising from the additive maternal effect it seems that this factor should be included in the model, especially for litter size and traits linked to the conformation of raccoon dogs. The model including, beside the additive effect of the animal, also the maternal effect should, in such cases, supply a more precise information on the breeding value of the progeny [Roehe and Kennedy 1993].

Table 5. Rank correlations between the animals' breeding value estimated according to model I and II

Trait	Correlation***	Model I* mean breeding value	Model II** mean breeding value
Size of litters born	0.92	3.30	4.12
Size of litters reared	0.84	4.15	2.33
Colour type	0.80	2.27	1.65
Colour purity	0.79	2.54	-1.07
Coat quality	0.80	18.00	15.26
Body size and conformation	0.81	9.95	7.46

*No additive maternal effect.
**Additive maternal effect included.
***All correlations significant at P≤0.0001.

The study presented here included also the determination of rank correlations between the breeding values estimated according to two different models (Tab. 5). The correlations indicate that the model used affected the ranking of animals. The estimated values depended both on the number of information sources used and their value [Laloë *et al*. 1992]. The highest ranking concordance was observed for the litter size at birth. In the case of traits measured objectively and thus more precisely, the use of different models had a smaller effect on the estimates obtained and as result also on the breeding rank of the raccoon dogs. Conformation-related traits are evaluated subjectively and thus one could observe clear differences in the ranking of animals. The estimated breeding values (except for litter size at birth) proved higher when calculated with the model which did not include the additive maternal effect (Tab. 5). Considerable differences were recorded principally for the mean breeding value of animals as regards colour purity. Moreover, in this case was also observed the lowest concordance in the animals' ranking (0.79).

The results presented here can be summarized as follows. Among the variation sources for the reproductive traits in raccoon dogs the animal's additive effect proved to be of small importance. The values of the genetic parametres obtained depended to a considerable degree on the calculation model used, marked inter-model differences occurring principally in case of conformation traits. In situations when the model did not include the additive maternal effect, the heritability coefficients appeared markedly higher than those obtained for the same parametres but calculated on the basis of a model including this factor. The additive maternal effect proved to be a significant source of variation for a majority of the performance traits analysed. It seems, therefore, that it should be considered when estimating the breeding value of animals. The effect of the model used on the estimates of breeding value was confirmed by the rank correlations between models – the highest differentiation in rank was observed for the conformation traits.

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Zmienność szacunków cech użytkowych i oceny wartości hodowlanej jenotów zależnie od zastosowanego modelu szacowania

S t r e s z c z e n i e

Celem pracy była ocena wpływu szacowania parametrów genetycznych dwoma modelami oraz dokładne określenie wpływu matki na zmienność cech użytkowych i reprodukcyjnych oraz na szacunki wartości hodowlanej jenotów. Badaniami objęto 17 pokoleń zwierząt. Wpływ czynników warunkujących poziom badanych cech reprodukcyjnych oraz pokrojowych weryfikowano wieloczynnikową analizą wariancji, metodą najmniejszych kwadratów. Komponenty kowariancji cech użytkowych oszacowano metodą REML, stosując wielocechowy model osobniczy. Zastosowano dwa modele, różniące się czynnikami losowymi. Pierwszy uwzględniał wyłącznie losowy addytywny wpływ osobnika i losowy wpływ specyficznego środowiska zwierzęcia. W drugim wyodrębniono dodatkowo losowy addytywny wpływ matki. Stwierdzono znaczną zależność wartości oszacowanych parametrów genetycznych od zastosowanego modelu. Znaczące różnice między oszacowaniami wystąpiły przede wszystkim w przypadku cech pokrojowych. Addytywny wpływ matki okazał się istotnym źródłem zmienności większości analizowanych cech użytkowych.