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GENETIC AND ENVIRONMENTAL FACTORS OF RACCOON DOG REPRODUCTION TRAITS

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ABSTRACT

The aim of the studies was to analyse reproduction of raccoon dog females, estimation of genetic and environmental variability parameters of prolificacy and other reproduction-related traits. The material for the study was represented by data obtained from breeding documentation of a fur-animal breeding farm in the Wielkopolskie Province. The data were on raccoon dogs bred during 1997-1999. The observations covered 1165 females of the breeding stock, which had given birth and their offspring had been weaned. The results of the reproduction of the females were presented in relation to: year of an observation, age of females, litter size of their origin, colour type, date of heat appearance, gestation length, and whelping date. The restricted maximum likelihood method (REML) was applied for the estimation of genetic and phenotypic reproductive traits. The litter size was significantly influenced by: year of an observation, age of the females, litter size of their origin, colour type, and gestation period. The following factors had a significant influence on the number of weaned cubs: age of the dams, date of heat, and whelping date. The estimated heritabilities of litter size appeared to be low, with the h^2 index being 0.068 for the litter size, and 0.080 for the number of weaned cubs. The heritability coefficient for gestation period was 0.174. The repeatabilities for litter size, weaned cubs number, and gestation period were 0.153, 0.266, and 0.350, respectively. High differences between the indices of heritability vs. repeatability indicate that the level of each of the studied traits depends to much higher degree on environmental factors than on genetic ones.

Key words: raccoon dog, reproduction traits, genetic parameters

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INTRODUCTION

Profitability of fur animals farming, including raccoon dogs, depends on a high level of reproduction-related traits [16], which in turn are conditioned by both genetic and environmental factors [9]. Each breeder tends to create conditions that would enable obtaining the highest number of offspring, keeping in mind the quality of the breeding material.

The raccoon dog (*Nyctereutes procyonoides* Gray, 1834), known also as the tanuki, belongs to the order of carnivores (*Carnivora*), family *Canidae*, and subfamily *Caninae*. The species has been farmed in Poland since 1979, when 200 raccoon dogs were imported from Finland [3]. Due to a relatively short period of its farming, the literature lacks any reports related to genetic or environmental factors influencing the reproduction traits of the species.

Therefore, the studies were undertaken whose aim was to analyse the reproduction of raccoon-dog females, and to estimate genetic and environmental variability of prolificacy and other reproduction-related traits.

MATERIALS AND METHODS

The material for the study was represented by data obtained from breeding documentation of a fur-animal breeding farm in the Wielkopolskie Province. The data were on raccoon dogs bred during 1997-1999. The observations covered 1165 females of the breeding stock, which had given birth and their offspring had been weaned.

The animals were characterised by the following coat-colours: brown (310 individuals), grey-silver (169 individuals), and mixed, or grey-buff-yellow (367 animals). This number, lower than that given before for the number of the breeding-stock females, results from missing information in the farm documentation that describes the colour.

The following female traits were recorded: origin, birth date, colour type, mating dates, whelping dates, gestation periods, litter size, number of weaned cubs.

Reproduction of monestrous animals is largely controlled by photoperiod length. As the photoperiod during a given season is in each year equal, all the data expressed in dates were converted to a consecutive day of the year [8].

The effect of the age on the female performance traits was analysed separately within each of two age groups: yearlings (primiparous) and older (multiparous females). In respect to litter size of a female's origin, the following five groups were formed: 1-4 indiv., 5-6 indiv., 7-8 indiv., 9-10 indiv., and 11-15 individuals. The females were assigned to the following three groups in respect to the heat appearing date (converted to days elapsed from the beginning of the year): 29 to 50 days, 51 to 65 days, and from 66 to 88 days. In respect to gestation period length, the females were assigned to the following groups: 55 to 58, 59 to 60, and 61 to 66 days. In respect to whelping date (converted to days elapsed from the beginning of the year), three groups were created: whelping between 84 and 110 days, 111 to 125, and 125 to 149 days.

The animals were housed in frame-houses, fed according to current feeding standards for carnivorous fur animals [10], and remained under prophylactic veterinary care.

The significance of differences were tested using ANOVA according to a constant-model, which included the following effects: year of birth, age of dam, date of birth, original litter size at birth, colour type, heat appearing date, gestation period, whelping date, with use of the GLM procedure of a statistical package [15].

The computer programme VCE 4.2.5 by Eildert Groneveld [2] was applied for an estimation of genetic parameters of the reproductive traits, i.e. the coefficients of heritability (h^2), repeatability (r'), and genetic (r_G) and phenotypic (r_P) correlation. The programme uses the REML (Restricted maximum likelihood) method, according to a multitrait animal model which includes constant effects (dam's year of birth, dam's whelping date, litter size of dam's origin, dam's subsequent litter) and random effects (specific dam's environment, genetic effect of the animal). So estimated genetic parameters for selected reproduction traits were converted from the discrete (zero-one) scale to a continuous scale, through probit function [20].

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RESULTS AND DISCUSSION

The statistical characteristics referring to reproduction results of the raccoon females in respect to their age and year of observation are presented in Table 1, and are based on the mean values ($\bar{x}$) and coefficient of variability (V). Significances of differences (at $p \leq 0.05$) between mean values of the studied traits are marked with different letters (Table 1, Figs 1-5). If the means did not differ significantly from each other, no letters were placed by the mentioned values for the clarity of tables and figures.

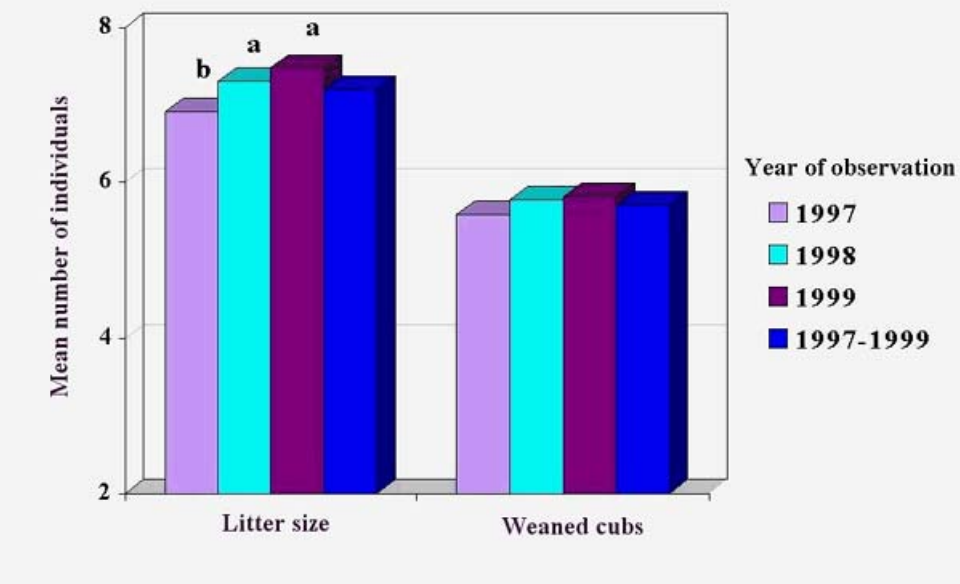
In all, the average litter size slightly exceeded 7 over the studied period. Nearly 6 young were weaned per one female (Table 1, Fig. 1). The values obtained in this study go far beyond the results of the females which had been reared in the early years of raccoon dog farming in Poland [11]. Variability both in litter size and weaned cubs was high in individual years (Table 1). High levels of variability coefficients indicate that there is still space for improvement in the reproduction results of the studied herd of raccoon dogs.

Table 1. Means ($\bar{x}$) and variability coefficients (V) of raccoon dog females reproduction results with regard to their age and observation year*

Year	Age of females	Number of females	Litter size		Weaned cubs size	
			$\bar{x}$	V(%)	$\bar{x}$	V(%)
1997	yearlings	109	6.08	35.31	4.87	40.97
	older	336	7.16	34.04	5.82	40.90
	total	445	6.90	34.99	5.59	41.63
1998	yearlings	99	7.18	31.54	5.13	47.38
	older	333	7.34	32.27	5.96	38.42
	total	432	7.30	32.08	5.77	40.66
1999	yearlings	33	8.03	33.74	5.61	41.34
	older	255	7.39	33.14	5.84	38.72
	total	288	7.47	33.28	5.81	38.96
total	yearlings	241	6.80^{b}	34.96	5.08^{b}	43.94
	older	924	7.29^{a}	33.14	5.88^{a}	39.37
Total		1165	7.19	33.60	5.71	40.60

*** Means in the columns marked with different letters differ significantly at $p \leq 0.05$.**

Fig. 1. Mean litter size and weaned cubs number with regard to the year of observation*



One-year-old females yielded much lower litter sizes and fewer weaned cubs as compared with multiparous females (Table 1). The statistically significant differences in average litter size and weaned cubs between the yearlings and the older females may result from less-developed maternal care abilities in the previous group of

females. The result presented by Jeżewska *et al*. [3] also indicated that the sizes of first litters were lower compared with the subsequent litters.

The females derived from the smallest litters (1-4 cubs) gave birth to significantly smallest number of the young, however the litter size of the female's origin did not significantly influence the number of weaned cubs (Fig. 2).

Fig. 2. Mean litter size and weaned cubs number with regard to the litter size of dam's origin*

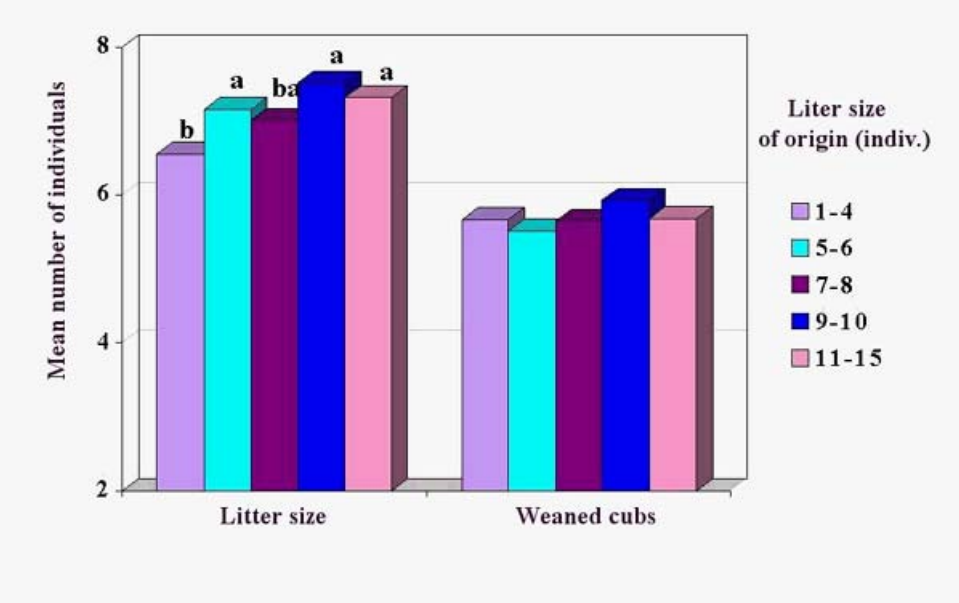
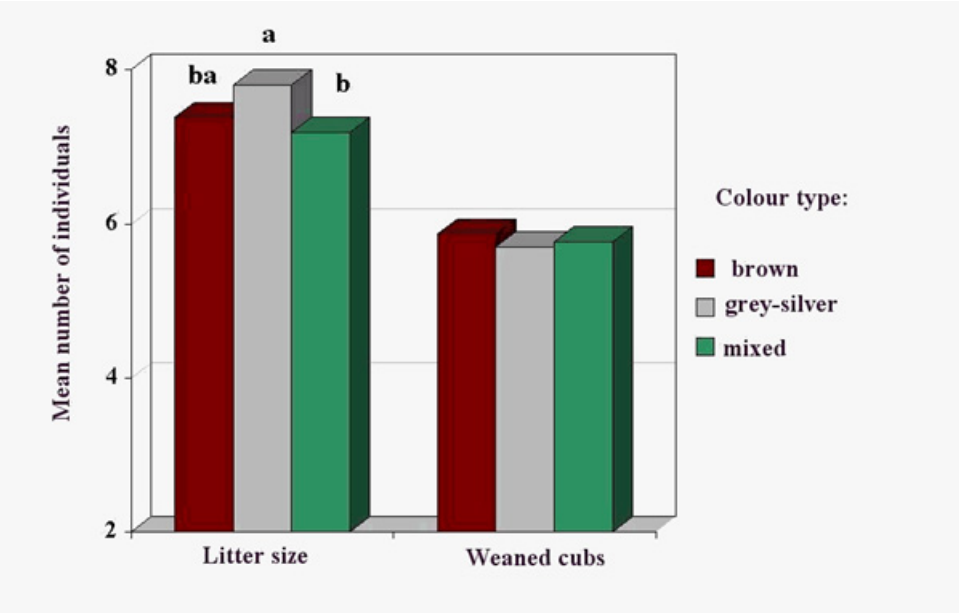


Fig. 3 presents the reproduction results of differently coloured raccoon dog females. The animals of a grey-silver colour type were characterised by the significantly highest litter size, while the animals of the mixed colour yielded the lowest litter size. The highest number of weaned cubs was obtained from brown females. The females of the remaining colour types demonstrated slightly worse reproduction performance, however the differences were statistically non-significant.

Fig. 3. Mean litter size and weaned cubs number with regard to colour type of the female*



Over the studied period, the heat was observed between the 28th and 88th day (Fig. 4). Both litter size and weaned cubs number were the lowest in the group of females whose heat appeared the soonest (before the 50th day of a year). Thus, a too early begun mating season adversely influenced both the prolificacy of the females and the weaned cubs number.

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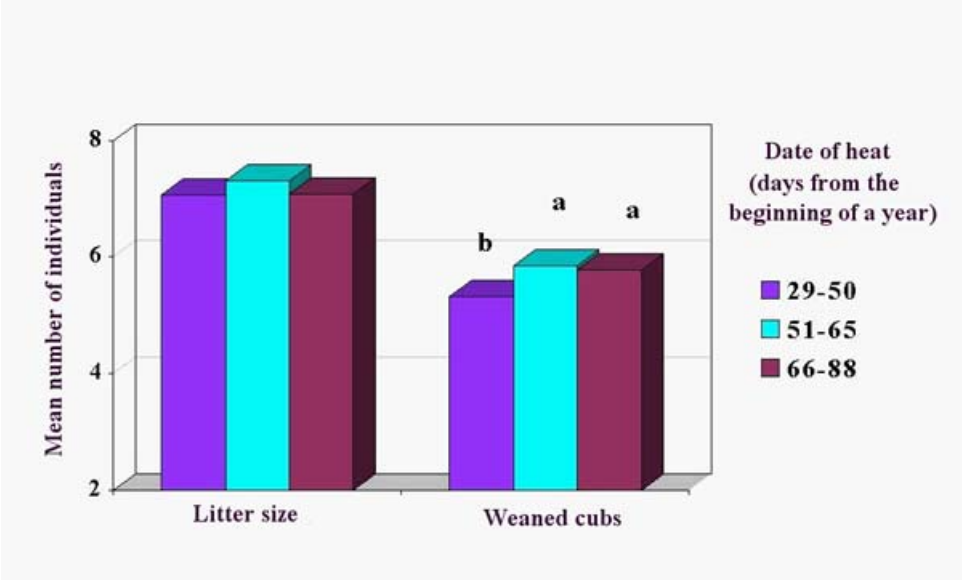
Fig. 4. Mean litter size and weaned cubs number with regard to date of heat appearing in females*



Over the studied years, gestation period of the raccoon dogs ranged between 55 and 60 days (Fig. 5). The highest average litter size and weaned cubs were recorded after a gestation which took 59-60 days. Significantly the lowest prolificacy was demonstrated by the females whose pregnancy lasted more than 60 days (Fig. 5).

Fig. 5. Mean litter size and weaned cubs number with regard to gestation length *

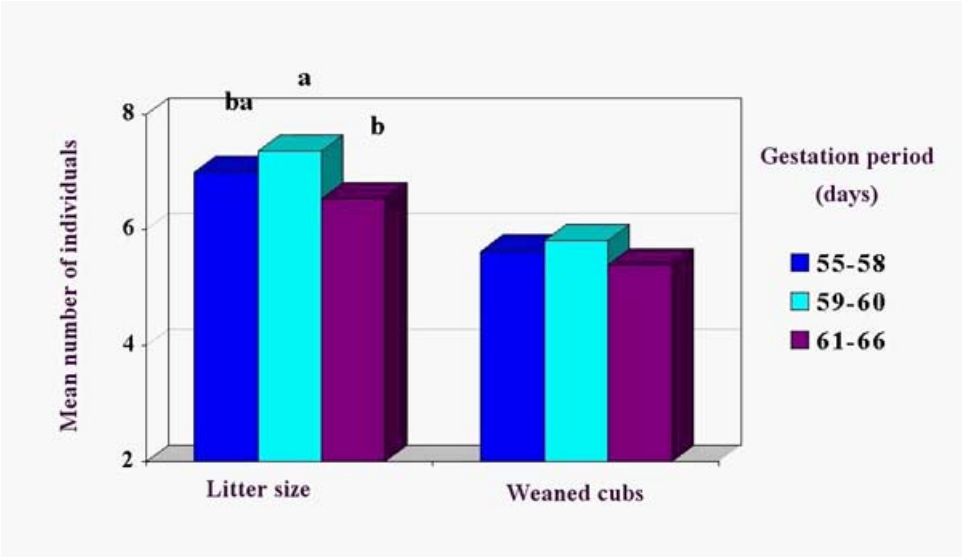


Figure 6 presents an effect of whelping date on reproduction performance of the females. The whelping took place between the 84th and 140th day from the beginning of a year. The average number of weaned cubs was significantly the lowest un the group of females whose parturition took place before the 111th day of a year, while the highest was found in the group of females that whelped between the 111th and 125th day, so the whelping date had a clear effect on the number of weaned cubs. It is possible that the young that are born in the early litters are more difficult to wean.

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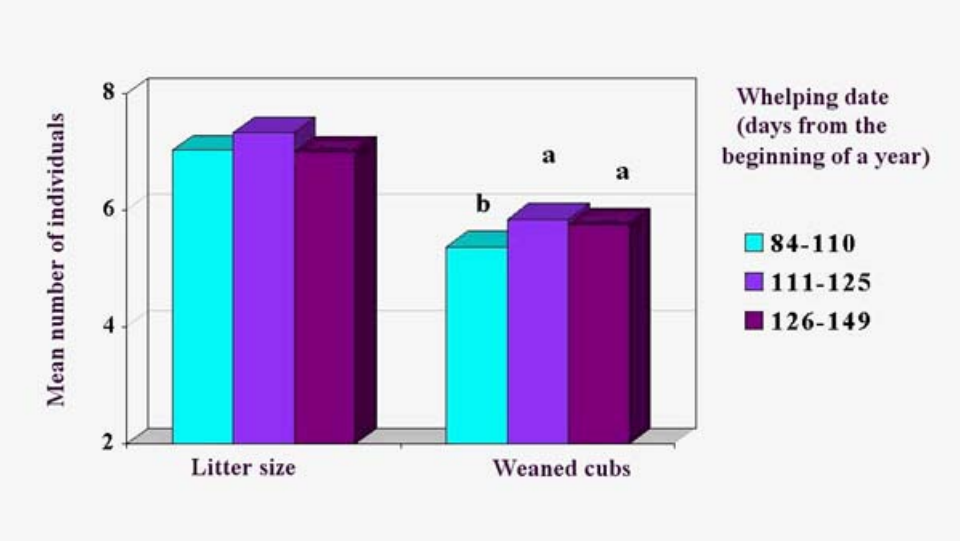
Fig. 6. Mean litter size and weaned cubs number with regard to date of whelping*



Genetic and phenotypic parameters of the analysed reproduction traits of the raccoon dog population are presented in Table 2. The coefficients of heritability of litter size, estimated using numerical data, turned out to be low. The index h^2 was 0.065 for litter size, and 0.074 for the weaned cubs number. These results indicate that an additive genetic value of an animal has a weak effect on the discussed traits.

Table 2. Coefficients of heritability (h^2, along the diagonal), genetic correlation (r_G, above the diagonal), phenotypic correlation (r_P, below the diagonal), and repeatability (r') of selected reproduction traits in raccoon dogs

Trait	Litter size	Weaned cubs number	Gestation period	r'
Litter size *SE*	**0.068** *0.007*	0.607 *0.059*	-0.038 *0.040*	**0.153**
Weaned cubs number *SE*	0.642 *0.001*	**0.080** *0.005*	0.058 *0.040*	**0.266**
Gestation period *SE*	0.509 *0.001*	0.787 *0.001*	**0.174** *0.013*	**0.350**

***SE* – standard error.**

In the available literature, no report have been found that would present coefficients of heritability or repeatability for litter size or weaned rate of raccoon dogs. However, the results the studies that have been so far carried out on various species of fur animals demonstrate low heritabilities of reproduction traits. Kenttämies [6] found that populations of silver and polar blue foxes demonstrated the coefficients of heritability for litter size: 0.12 and 0.03 respectively, while for the weaned number: 0.15 and 0.05. Coefficients of heritability of litter size or weaned number in various species of fur-bearing animals were of similar values: polar foxes – 0.15 and 0.31 [5] as well as 0.202 and 0.181 [17], common silver foxes – 0.152 and 0.105 [12], polecats – 0.11 and 0.12 [4]. Heritability of prolificacy in minks was 0.09 [7], while in polar blue foxes, it ranged between 0.16 and 0.22 [14], and, depending on estimation method, reached 0.16 or 0.17 [13].

Heritability coefficient for gestation period, and other reproduction-related traits likewise, was relatively low, i.e. 0.174 (Table 2). Such value of the coefficient of heritability for gestation period, estimated for by Przysiecki *et al*. [12] for silver foxes, was slightly higher, 0.244.

Basing on the estimated values of the coefficient of heritability for the analysed reproduction-related traits (Table 2), one may conclude that genetic assumptions have little effect on these traits. Despite this, the average litter size and weaned cubs is much higher among the raccoon dogs bred at present, compared with the early tears of this species farming in Poland [11]. This means that the systematic selection, carried out towards increasing litter size and weaned rate, is efficient despite the low heritability.

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Repeatabilities of litter size, weaned cubs number, and gestation period, were respectively: 0.153, 0.266, and 0.350 (Table 2). Socha and Adamska [18], as well as Socha and Markiewicz [19] reported similar values of repeatability coefficients for litter size and weaned cubs respectively in polar foxes and minks. Large differences between the coefficients of heritability and repeatability (Table 2) indicate that the level of each of the discussed traits depends on environmental factors much more than on genetic factors. In repeatability estimation, environmental variability factor is difficult to be distinguished from genetic variability and may significantly increase r' compared to h^2.

Genetic correlation between litter size and weaned cubs number was 0.607 (Table 2). Similar results were found by Jeżewska *et al*. [4], who studied a population of polecats. The value of the coefficient of correlation between litter size and weaned cubs estimated by those authors was 0.61. Also Filistowicz *et al*. [1] and Socha and Adamska [18] recorded a high, respectively 0.77 and 0.81, genetic correlation between litter size and weaned cubs number of polar foxes. Socha and Markiewicz [19] found the correlation between the discussed traits to be slightly higher, 0.894, in minks.

The very low values of the estimated genetic correlations between litter size/weaned cubs and gestation length demonstrate little dependence between these traits.

Phenotypic correlation between litter size and weaned cubs was high, 0.642 (Table 2). In a population of polar foxes, this correlation between the discussed traits was 0.76 [1] and 0.674 [18]. A slightly higher value of this phenotypic correlation between the discussed traits in minks, i.e. 0.86, was found by Socha and Markiewicz [19]. Phenotypic correlations between prolificacy and gestation period, as well as between weaned cubs and gestation period (Table 2), were relatively high, respectively 0.509 and 0.787.

Similar values of genetic and phenotypic correlations for litter size and weaned cubs number (Table 2) indicates that selection aimed at increased litter size will also lead to an increased number of weaned cubs. High differences between the values of genetic and phenotypic correlations between gestation length and prolificacy of females, as well as between gestation length and weaned cubs, demonstrate that selection aimed at increasing gestation period will not yield any genetic progress in litter size or weaned offspring number, due to the genetic correlations which are close to zero.

CONCLUSIONS

1. Litter size was significantly influenced by year of observation, age of dams, litter size of dam's origin, colour type, and gestation period length, whereas the number of weaned cubs was statistically significantly influenced by the following factors: age of dams, heat appearing date, and whelping date.
2. The estimated heritabilities of litter sizes turned out to be low, with the h^2 index being 0.068 for the litter size, and 0.080 for the number of weaned cubs. The heritability coefficient for gestation period was 0.174. The repeatabilities for litter size, weaned cubes, and gestation period were 0.153, 0.266, and 0.350 respectively.
3. The values of heritability coefficients for the analysed reproduction-related traits demonstrate that genetic assumptions have little effect on these traits. However, systematic selection towards increased litter sizes and weaned offspring numbers is efficient. This is demonstrated by the differences between the prolificacy of raccoon dogs in the early years of cage farming and the reproduction results presented in this work.

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