Genetic Parameters and Inbreeding Depression of Litter Weight in Pannon White Rabbits

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Summary

Genetic parameters and inbreeding depression were estimated for litter weight at day 21 of a synthetic Pannon White rabbit population selected as a closed population since 1992. The data file consisted of 15652 kindling records of 3711 rabbit does (mated to 933 bucks) collected between 1992 and 2009. The total number of animals in the pedigree file was 4804. REML and BLUP procedures were applied using repeatability animal model (VCE and PEST software). The estimated narrow sense heritability for litter weight was low (0.08±0.01). The estimated permanent environmental effects showed higher relative importance compared to the additive genetic effects (0.13±0.01). Analyzing the inbreeding depression simultaneously for all parities, increasing the inbreeding coefficient by 10% had small positive effect on litter weight (0.028 kg) but the estimate was not significant (p=0.30). When the inbreeding depression was estimated by parities small depressions (-0.023, -0.045 and -0.021 kg) were found for the 2-4th parity groups but the estimates were not significant (p=0.59, 0.23 and 0.61, respectively). On the contrary a significant positive effect was observed for the 1st parity (0.198 kg; p=0.01). The small positive estimate estimated at the 5th parity (0.033 kg) was not significant (p=0.39).

Key words

rabbit, genetic parameter, inbreeding depression, litter weight

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Aim

The Pannon White rabbit population was developed at the Kaposvár University by reciprocal crossing of New Zealand White and Californian rabbits. The progeny of the crosses showing the best weight gain and dressing out percentage served as the basis for a new synthetic line. Selection for dressing out percentage was possible through progeny test (Szendrő et al., 1988). Few years later application of Computer Tomography (CT) made the selection possible for slaughter traits using the live animals (Szendrő et al., 1992). CT-aided selection is exclusively applied at Kaposvár ever since to improve the slaughter value of Pannon White rabbits (Nagy et al., 2006; Szendrő et al., 2010). Between 1992 and 2003 the average cross-sectional area of the muscle Longissimus dorsi was determined by CT measurements together with the average daily gain between the ages of five and 10 weeks and these traits were the selection criteria used in Pannon White rabbit breed. From 2004 the average cross-sectional area of the muscle Longissimus dorsi was changed to thigh muscle volume. Average daily gain remained as a selection criterion until 2010 when this trait was replaced by litter weight at day 21. As the Pannon White rabbit breed kept as a closed population since 1992 inbreeding may have an effect on this new selection criterion. Thus the objective of the present study was to estimate the genetic parameters and inbreeding depression of litter weight at 21 days of age (LW21) using REML and BLUP procedures.

Material and methods

The analysis was based on the kindling records of the Pannon White rabbit breed collected at the Experimental Rabbit Farm of the Kaposvár University between 1992 and 2009. The dataset consisted of 15652 kindling records of 3711 does mated to 933 bucks. The total number of rabbits in the pedigree file was 4804. The analyzed trait was litter weight 21 days after kindling. Because of the large number (and unbalanced structure) of parities they were combined to 5 groups (1, 2, 3-4, 5-7, 8-). In the model the effects of inbreeding arising from individual rabbit weight was not tested due to the un-known cross-fostering information. The mean inbreeding coefficient (Fd) of the 3711 does was 1.91% with a standard deviation of 2.62%. Due the long evaluated period the complete pedigree equivalents of the does were also calculated (CGEd) and the mean and standard deviation of this parameter were 4.95 and 3.39, respectively. Descriptive statistics of the litter weight, litter size (number of reared rabbits at day 21) are presented in Table 1.

Litter weight was evaluated with the REML and BLUP procedures in order to estimate genetic parameters and inbreeding depression. Repeatability animal model was used. The applied softwares were VCE 6 (Groeneveld et al., 2008) and PEST (Groeneveld, 1990). Significance of the estimated inbreeding depression was evaluated by the hypothesis section of PEST software.

The repeatability model was:

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Za} + \mathbf{Wpe} + \mathbf{e}$$

where:

y = vector of observations, **b** = vector of fixed effects, **a** = vector of random animal effects, **pe** = random vector of permanent environmental effects, **e** = vector of random residual effects, **X**, **Z** and **W** incidence matrices relating records to fixed, animal and random permanent environmental effects, respectively.

Table 1. Descriptive statistics for litter size and influencing factors

Trait	No. of records	Mean	Standard deviation
Litter weight	15652	2.62	0.67
Litter size	15652	7.38	1.59

Table 2. Structure of the applied animal model

Factor	Type	Level
Parity	F	5
Year-month	F	196
Animal	A	4804
Permanent environment	R	3711
Fd	C	1
CGEd	C	1
Litter size	C	1

Fd: inbreeding coefficient of the does; CGEd: pedigree completeness of the does; Litter size: number of reared kits at day 21; F: effect; A: additive genetic effect; R: random effect; C: covariate

Expected values of **a**, **pe** and **e** were E(**a**)=E(**pe**)=E(**e**) = 0. The variance–covariance structure was assumed to be V(**a**) $=A\sigma^2_a$ V(**pe**) = $I\sigma^2_{pe}$, V(**e**) = $I\sigma^2_e$, and cov(**a**,**e**) = cov(**e**,**a**) = 0, where **A** is the numerator relationship matrix. Also $cov(y,a)=ZAI\sigma^2_a$. Regarding the model, the distribution of y was assumed normal, the trait was determined by many additive genes of infinitesimal effects at infinitely many unlinked loci. The structure of the used model is given in Table 2.

Results and discussion

The inbreeding coefficient and pedigree completeness of the population is presented as the average values of the period 1992-2009. Taking the last two years (2008, 2009) the average inbreeding level of the population was 6.3% with a complete generation equivalent of 12.1. This latter number is exceptionally large and can only be compared to some horse pedigrees (Curik et al., 2003; Poncet et al., 2006).

The estimated narrow sense heritability for litter weight was low (0.08±0.01). The received value was similar to that of Gyovai et al. (2010) who estimated the heritability of the same trait for the Pannon White rabbit breed. However, in their case the heritability of litter weight was estimated for the first four parities separately (0.14±0.02; 0.10±0.02; 0.08±0.02; 0.16±0.03) together with average daily gain and thigh muscle value. Comparing the results with that of other authors (Lukefahr and Hamilton, 1997; Krogmeier et al., 1994; Moura et al., 2001; Rastogi et al., 2000) it can be concluded that all estimates (0.02±0.11; 0.13; 0.08; 0.08±0.06, respectively) were low in accordance with our results. The estimated permanent environmental effects showed higher relative importance (0.13±0.01) compared to the additive genetic effects similarly to Lukefahr and Hamilton (1997) (0.29±0.13).

The inbreeding depression of litter weight was obtained as a BLUE estimate of the inbreeding coefficient of the dam (covariate). Increasing the inbreeding coefficient the dam by 10% had small positive effect on litter weight (0.028 kg) but the estimate was not significant (p=0.30). Obviously inbreeding does not have a positive effect therefore this result suggests that inbreeding had no effect on litter weight. This result is unusual for reproductive traits that are generally affected by inbreeding contrary to morphological traits (Curik et al., 2003). On the other hand when the dams inbreeding coefficient was nested to parity partly different results were obtained. For the 2nd, 3rd and 4th parity groups the direction of the effect became negative (-0.023, -0.045 and -0.021 kg) but the estimates were not significant (p=0.59, 0.23 and 0.61, respectively). On the contrary a significant positive effect were observed for the 1st parity (0.198 kg; p=0.01). The small positive estimate estimated at the 5th parity (0.033 kg) was not significant (p=0.39). It has to be noted however that the magnitude of the effect remained small. The relevant literature about the inbreeding depression of this trait is scarce. Eisen et al. (1970) found 2.2 g decrease in 12 day litter weight per 10% increase of inbreeding coefficient in mice. In purebred Yorkshire pigs Culbertson et al. (1998) reported a 0.52 kg decrease of litter weight per 10% increase of inbreeding. Considering the mean litter weight of the pigs (56 kg) (Culbertson et al., 1998) this estimate was similar to our results for the 2-4th parity groups. In Botucatu rabbits Moura et al. (2000) reported a large decrease of litter weight (0.21 kg) per 10% increase of inbreeding. It has to be noted that the average inbreeding level of the Botucatu rabbits was 7% that was more than double comparing to that of the Pannon White rabbit population (3.24%). In the related trait of litter size it could also be observed that the magnitude of inbreeding depression was connected to the level of inbreeding of the population (Belic et al., 2002; Farkas et al., 2007; Rodriganez et al., 1998).

Conclusions

As the inbreeding level of the Pannon White rabbit population is small no serious effect of inbreeding can be expected in the future.

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