

Short Communication

Longevity analysis of the Pannon White rabbit does

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HIGHLIGHTS

- Evaluating productive life of Pannon White rabbit.
- Number of born alive kits affects productive life.
- Longevity is genetically determined.

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ABSTRACT

The aim of this study was to analyse the number of kindlings of Pannon White rabbit does, to get information about the risk factors affecting their reproductive performance success and to evaluate the suitability of this trait as a possible selection criterion. The pedigree information was supplied by the experimental farm of the Hungarian University of Agriculture and Life Sciences, who is responsible for the maintenance of the Pannon White rabbit breed. Total kindling number of 3371 Pannon White rabbit does born from 2000 up to 2022 were used in the analysis. Year-season and number of kits born alive were considered as fixed time dependent effects in the model and they both were significant ($P < 0.001$). The genetic variance was estimated to calculate the heritability for longevity. To demonstrate the extent of differences within the population, the ten best and worst bucks were compared based on the estimated risk of culling to check genetic differences. As number of kits born alive increased, the culling risk for this parameter decreased. After adjusting for the fixed effects, the estimated heritability of the total kindling number was $h^2 = 0.14$ (s.e. 0.034). The offspring of ten best and ten worst bucks were compared, revealing convincing evidence of principle that selection on this trait has a potential to improve the longevity of the Pannon White rabbits.

1. Introduction

The long-lasting performance is an important trait in rabbit breeding. The intensive selection for reproduction usually decreases the functional longevity. Due to the replacement costs, it might be beneficial to keep does in the production system as long as possible. Despite this clear economic benefit of long-lasting performance, the number of studies in this field in rabbits (Theilgaard et al., 2009; El Nagar et al., 2020) are scarce. Sánchez et al (2004) used a Cox proportional hazard model with survival analysis, and found that reproductive rhythm, number of born alive kits and year-season had large effect on longevity. Piles et al (2006) evaluated two rabbit lines. They used the time in days between date of

the first pregnancy and date of culling/death and the number of artificial inseminations after the first kindling for the two lines, respectively. Overall, previous studies reported low heritability for longevity and most of them included year-season effect in the evaluation model.

The Pannon White breed has a major impact on the Hungarian rabbit sector, accounting for approximately 50% of the national breeding stock (Juráskó, 2023). Several previous studies have investigated the Pannon White rabbit, focusing on its' excellent meat production capacity (Matics et al. 2014) and the connection between the reproductive performance and inbreeding depression (Nagy et al, 2013). However, the potential for increased longevity in this breed has not yet been studied.

The primary relevance of rabbits in livestock production lies in their

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sustained production of offspring for slaughter, similarly to beef cattle and pigs, therefore the longevity and lifetime production is of utmost importance (Soltész et al., 2016). In this context, the number of parities is more relevant than the lifespan measured in days, and the survival time could be considered in discrete intervals rather than as a continuous variable. Mészáros et al (2010) suggested to rescale the time axis from continuous to parities as discrete classes, to use grouped survival data. While the resulting heritabilities between models were similarly low, they suggest using grouped data models to better reflect the needs in meat producing breeds.

The aim of this study was to assess the potential breeding value estimation for longevity in Pannon White rabbits in practice, to estimate breeding values and to assess the potential for routine selection in the future.

2. Materials and methods

Lifetime reproduction performance of 3371 Pannon White rabbit does born from 2000 up to 2022 were used in the analysis. Kindling records as well as the pedigree information was supplied by the experimental farm of the Hungarian University of Agriculture and Life Sciences, who is responsible for the maintenance of the Pannon White rabbit breed. The dataset contained 13.9% animals that were still alive, which were marked as right-censored records. The pedigree consisted of 6198 individuals.

The number of kindlings was chosen as the dependent variable. Does still in breeding after 15 kindlings were merged into one category. The model included the random effect of the does. Other factors that could affect the productive lifetime were the following:

- Year-season: (YS): time dependent variable with 45 levels. The level changes every six months (1st of January and 1st of July each year). This factor attempts to explain the group effect of does that are on the experimental farm at the same time.
- Number of kits born alive in each parity (BA), a time dependent variable with seven levels. All the does are included in the first level when they are nulliparous; the second includes does that are not nulliparous and have zero or one live born, does with two or three born alive are included in the third level and so on until the seventh level, which includes the does with 12 or more born alive. This factor could change every parturition.

The connection between the productive life and fixed factors was analysed using a Prentice and Gloeckler discrete time model (Prentice and Gloeckler, 1978). Relationships among the factors and longevity were estimated using the Survival Kit program (Mészáros et al., 2013b). The risk of culling was expressed via risk ratios, which denoted the relative risk of a rabbit in a certain class to be culled, compared to an animal in a reference class, with risk ratio set to 1. The genetic variance was estimated as the mode of its approximate posterior density after Laplace integration of the other parameters (Ducrocq and Casella, 1996). At the same time, the mean, variance and skewness of this posterior density were obtained. Knowing these three parameters, makes it possible to draw the posterior density of the variance component using a Gram-Charlier approximation. The standard deviation of the posterior density can be interpreted as a conservative estimate of the standard error. From this, the standard error of the heritability was computed using the Delta method (see e.g. Lynch and Walsh, 1998).

The heritability based on the animal model was computed as:

$$h^2 = \frac{\sigma_g^2}{1/p + \sigma_g^2}$$

where: h^2 = heritability, σ_g^2 = genetic variance, p = proportion of uncensored records

The reliability was based on the prediction error variance for each estimate as:

$$R = 1 - \frac{PEV}{\sigma_g^2}$$

where: R = reliability, PEV = prediction error variance, σ_g^2 = genetic variance

The prediction error variance was calculated as the square of the standard error for each estimate from the Survival Kit (Mészáros et al., 2013a).

In addition, following similar studies (Vollema and Groen, 1998, Caraviello et al., 2004, Posta et al., 2014), the ten best and ten worst bucks were selected based on their breeding values, i.e. the estimated risk of culling of their offspring. This comparison was used to demonstrate the extent of differences in the breeding values for longevity in the Pannon White population and the direct consequence of these breeding values for the length of life of their offspring. The offspring with available data on their length of productive life were characterized with Kaplan-Meier survival function and their difference was tested with Log-rank test (Kaplan and Meier, 1958).

3. Results

All time dependent effects were highly significant ($P < 0.001$). The distribution of number of kindlings is shown in Fig. 1a. Nearly exponential distribution of kindlings can be seen as 18.2% of the does had only one kindling, 13.9% had two kindlings, 11.6% had three kindlings etc. There were only a few rabbits having more than 10 kindlings during their breeding career, does having at least 15 kindlings were 79.

Fig. 1b presents the relative risk ratios of the year-season time-dependent effect on longevity. The highest risk ratios were estimated for the time period between 2011 and 2016 which significantly differed from the reference class. The lowest risk ratios were observed for rabbits between 2017 and 2020 as well as for the present breeding animals.

Fig. 1c shows the effect of the number of kits born alive on the relative culling risk. The highest risk ratio was observed in does with 0 or 1 kit born alive and the risk decreased continuously as the number of kits increased. Does in the reference class (10 or 11 kit born alive) showed a low relative culling risk than those with fewer than seven kits born alive. This pattern supports increased selection efficiency for the number of kits born alive in the breeding population.

After adjusting for the fixed effects mentioned above, the estimated animal variance was 0.185 (s.e. = 0.05442), resulting in a heritability estimate of $h^2 = 0.14$ (s.e. = 0.034) taking into account the censoring rate of 13.9% ($p = 0.861$ was the proportion of uncensored records). Among the 6198 animals included the total pedigree, only 44 rabbits had breeding value reliabilities greater than 0.40. The mean relative risk for these 44 rabbits was 0.75 with a standard deviation of 0.243, whereas minimum and maximum values for the risk ratio was 0.462 and 1.713, respectively. To compare the impact of buck breeding values and to assess the future potential for selection for longevity, the ten best and ten worst bucks based selected based on their estimated culling risk. Their offspring with available production records were extracted, and their length of productive life was compared. Table 1 shows the detailed results of the two extreme categories.

Fig. 1d clearly shows the huge differences ($P < 0.05$) between the two extreme groups. Following seven kindlings, over 50% of the offspring sired by the ten best bucks were still in production, compared with less than 20% for offspring from the ten worst bucks. After 14 kindlings the percentage of offspring was similar for both categories left in production.

4. Discussion

The fixed, time dependent effect of kits born alive and year-season

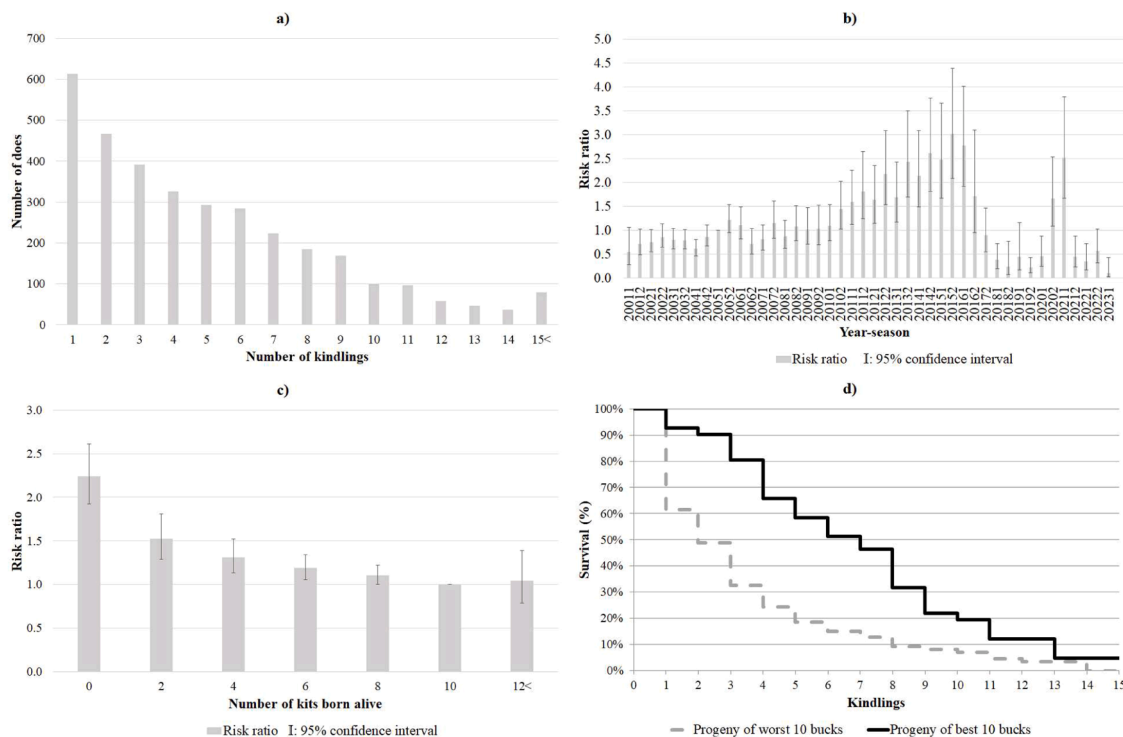


Fig. 1. Characteristics of longevity and its influencing factors in Pannon White rabbits. (1a. Distribution of the kindlings. 1b. Effect of year-season on the relative culling risk. 1c. Effect of number of kits born alive on the relative culling risk. 1d. Survival function for the progeny from the ten best and worst bucks based on their breeding value for number of kindlings).

Table 1
Descriptive statistics of the two extreme categories.

	Worst		Best	
	Buck	Offspring	Buck	Offspring
N	10	86	10	41
Risk ratio mean	1.460	1.169	0.280	0.305
Risk ratio st. dev.	0.121	0.175	0.015	0.042
Reliability mean	0.236	0.190	0.083	0.135
Reliability st. dev.	0.097	0.086	0.108	0.102

were included to correct for genetic effects. The culling risk for the categories having lower than seven born alive kits were significantly different ($P < 0.05$) from the reference class. The risk ratio was 19%–124% higher compared to the reference class and decreased with increasing number of kits born alive. Fig. 1c shows that the decrease of culling risk for the number of kits born alive is not linear. The does at the highest risk are the ones with low number of kits born alive, being subjected to artificial selection by the farmer. the increase of kits in the litter has diminishing returns, however, as the culling risk remains at approximately the same level for 10 and more kits.

The year-season effect was included to account for environment and breeding related fluctuations. Although the evaluated time interval was different, the trend in the year-season effect risk ratios was similar to the findings of Piles et al (2006). This correction was necessary in particular for the variability in breeding decisions and stronger selection (lower replacement rate) between 2011 and 2016.

The ability to distinguish bucks with low and high breeding values of bucks, as demonstrated by the differences in the reproductive longevity of their offspring show the relevance and feasibility of selection for longevity in Pannon White rabbits.

The estimated heritability in this study was similar to or higher than that reported by El Nagar et al (2020) ($h^2 = 0.02$ – 0.14), and exceeded the estimates of Lenoir and Garreau (2016) ($h^2 = 0.12$) and Piles et al

(2006) ($h^2 = 0.1$). Our estimate was lower than that reported by Sánchez et al (2006) ($h^2 = 0.3$), although their study used the interval between the first positive pregnancy test and the date of death or culling as response variable. Despite the relatively low heritability compared with some other traits, longevity can still be leveraged to increase the number of parities in rabbit does, by consistently selecting bucks with high breeding value for the trait. This was clearly demonstrated by comparison of best and worst bucks and the significant differences among their progenies. The risk ratios (Fig. 1d) for the productive lifespan can be transformed into relative breeding values and included in the genetic improvement programs for Pannon White rabbits. The identification of the best and worst animals is feasible due to the substantial differences in the cumulative survival between the two progeny groups, enabling the potential removal of worst sires and their offspring from the breeding population. However, the low reliability of the breeding values could limit the wide scale use of this procedure in small populations.

5. Conclusions

This study estimated the genetic background of length of productive life of Pannon White rabbits. The risk of culling decreased with increasing number of kits born alive, and annual and seasonal effects were accounted for by a year-season factor. After adjusting for the fixed effects, the estimated heritability of $h^2 = 0.14$ was in agreement with other studies. Although the reliability was low, the demonstrated genetic differences between the bucks indicate that selection for this trait is favourable for the improvement of the Pannon White breed. Future studies might include a larger data set spanning over a wider time interval, extended opportunities to consider fixed and random effects to further clarify the genetic basis of productive longevity in rabbits.

Author contribution

Conceptualization: JP, ZsM, ZsG, GM and IN; Methodology: JP and GM; Data curation: ZsM, ZsG; Formal analysis: JP and IN; Writing -

original draft: JP, ZsG, GM and IN; Funding acquisition: JP. All authors contributed to the article and approved the submitted version.

CRedit authorship contribution statement

János Posta: Writing – original draft, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Zs. Gerencsér:** Writing – original draft, Data curation, Conceptualization. **Zs. Matics:** Writing – original draft, Data curation, Conceptualization. **G. Mészáros:** Writing – original draft, Methodology, Conceptualization. **I. Nagy:** Writing – original draft, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Janos Posta reports financial support was provided by Hungarian Academy of Sciences. Janos Posta reports financial support was provided by The Ministry for Culture and Innovation. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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References

- Caraviello, D.Z., Weigel, K.A., Gianola, D., 2004. Prediction of longevity breeding values for US holstein sires using survival analysis methodology. *J. Dairy Sci.* 87, 3518–3525. [https://doi.org/10.3168/jds.S0022-0302\(04\)73488-8](https://doi.org/10.3168/jds.S0022-0302(04)73488-8).
- Ducrocq, V., Casella, G., 1996. A Bayesian analysis of mixed survival models. *Genet. Sel. Evol.* 28, 505–531.
- El Nagar, A.G., Sánchez, J.P., Ragab, M., Mínguez, C., Baselga, M., 2020. Genetic variability of functional longevity in five rabbit lines. *Animal* 14 (6), 1111–1119. <https://doi.org/10.1017/S1751731119003434>.
- Juráskó, R., 2023. Situation of Hungarian rabbit production in 2022. In: *Proceedings of the 34th Hungarian Conference on Rabbit Production, September 28. Kaposvár, Hungary*, pp. 7–11.
- Kaplan, E.L., Meier, P., 1958. Nonparametric-estimation from incomplete observations. *J. Am. Stat. Assoc.* 53, 457–481.
- Lenoir, G., Garreau, H., 2016. Survival analysis of longevity in breeding does. In: *Proceedings of the 11th World Rabbit Congress, June 15-18. Qingdao, China*, pp. 67–70.
- Lynch, M., Walsh, J.B., 1998. *Genetics and Analysis of Quantitative Traits* Sunderland. Sinauer Assoc., Inc, MA.
- Matics, Zs., Nagy, I., Gerencsér, Zs., Radnai, I., Gyovai, P., Donkó, T., Dalle Zotte, A., Curik, I., Szendrő, Zs., 2014. Pannon breeding program in rabbit at Kaposvár University. *World Rabbit Sci.* 22, 287–300. <https://doi.org/10.4995/wrs.2014.1511>.
- Mészáros, G., Kadlečík, O., Kasarda, R., Sölkner, J., 2013a. Analysis of longevity in the Slovak Pinzgau population—Extension to the animal model. *Czech J. Anim. Sci.* 58, 289–295. <https://doi.org/10.17221/6858-CJAS>.
- Mészáros, G., Pálos, J., Ducrocq, V., Sölkner, J., 2010. Heritability of longevity in large white and landrace sows using continuous time and grouped data models. *Genet. Sel. Evol.* 42, 13. <https://doi.org/10.1186/1297-9686-42-13>.
- Mészáros, G., Sölkner, J., Ducrocq, V., 2013b. The survival kit: software to analyze survival data including possibly correlated random effects. *Comput. Methods Programs Biomed.* 110, 503–510. <https://doi.org/10.1016/j.cmpb.2013.01.010>.
- Nagy, I., Gorjanc, G., Curik, I., Farkas, J., Kiszlinger, H., Szendrő, Zs., 2013. The contribution of dominance and inbreeding depression in estimating variance components for litter size in Pannon White rabbits. *J. Anim. Breed. Genet.* 130, 303–311. <https://doi.org/10.1111/jbg.12022>.
- Pálos, J., Garreau, H., Rafel, O., Larzul, C., Ramon, J., Ducrocq, V., 2006. Survival analysis in two lines of rabbits selected for reproductive traits. *J. Anim. Sci.* 84, 1658–1665. <https://doi.org/10.2527/jas.2005-678>.
- Posta, J., Rudiné Mezei, A., Mihók, S., Mészáros, G., 2014. Evaluation of the length of competitive life in Hungarian sport horses. *J. Anim. Breed. Genet.* 131, 529–535. <https://doi.org/10.1111/jbg.12108>.
- Prentice, R.L., Gloeckler, L.A., 1978. Regression analysis of grouped survival data with application to breast cancer data. *Biometrics* 34, 57–67. <https://doi.org/10.2307/2529588>.
- Sánchez, J.P., Baselga, M., Peiró, R., Silvestre, M.A., 2004. Analysis of factors influencing longevity of rabbit does. *Livest. Prod. Sci.* 90, 227–234. <https://doi.org/10.1016/j.livprodsci.2004.06.002>.
- Sánchez, J.P., Korsgaard, I.R., Damgaard, L.H., Baselga, M., 2006. Analysis of rabbit does longevity using a semiparametric log-normal animal frailty model with time-dependent covariates. *Genet. Sel. Evol.* 38, 281–295. <https://doi.org/10.1051/gse:2006004>.
- Soltész, A., Baginé Hunyadi, Á., Kusza, Sz., Balogh, P., 2016. Survival analysis of sow longevity and lifetime reproductive performance – review. *Acta Agrar. Debreceniensis* 70, 75–80. <https://doi.org/10.34101/actaagrar/70/1821>.
- Theilgaard, P., Baselga, M., Blas, E., Friggens, N.C., Cervera, C., Pascual, J.J., 2009. Differences in productive robustness in rabbits selected for reproductive longevity or litter size. *Animal* 3, 637–646. <https://doi.org/10.1017/S1751731109003838>.
- Vollema, A.R., Groen, A.F., 1998. A comparison of breeding value predictors for longevity using a linear model and survival analysis. *J. Dairy Sci.* 81, 3315–3320. [https://doi.org/10.3168/jds.S0022-0302\(98\)75897-7](https://doi.org/10.3168/jds.S0022-0302(98)75897-7).