

ASSESSMENT OF FACTORS INFLUENCING LONGEVITY OF DANUBIA ALBA RABBIT DOES

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Abstract: The aim of this study was to investigate the total number of kindlings in Danubia Alba rabbit does, identify key risk factors influencing their reproductive performance and assess the potential of this trait as a selection criterion. The pedigree and production information were provided by the Hungarian breeding organisation (Danubia Alba Nyúltenyésztő Egyesület) responsible for the Danubia Alba breed. The analysis included kindling records from 93 638 does born from 2012 onwards. Year-season effects and the number of kits born alive were incorporated into the model as time-dependent variables, both showing significant effects ($P < 0.001$). As the number of kits born alive increased, the corresponding culling risk declined, with the most favourable outcome observed when 10 kits were born per kindling. After adjusting for the fixed effects, the heritability of total kindling number was estimated at $h^2 = 0.14$ (standard error = 0.0033). A comparison between the progeny of the top ten and worst ten bucks provided clear evidence that selection for this trait could effectively enhance reproductive success in the Danubia Alba population.

Key Words: rabbit, Danubia Alba, longevity, genetic parameters.

INTRODUCTION

The Danubia Alba rabbit breed is among the economically important breeds in the Hungarian rabbit sector, with a base breeding population of 100 males and 4100 females in 2023 (Juráskó, 2024). Danubia Alba rabbit breed is a synthetic composite breed with three different lines. Line “D” is maternal, whereas lines “C” and “X” are used as the paternal lines. In intensive rabbit production systems, high doe replacement rates represent a major economic and welfare concern. Annual replacement rates typically range between 80 and 150%, depending on management intensity and culling strategies (Castellini *et al.*, 2010). Higher productive lifetime (longevity) could reduce the replacement cost of does and, along with some changes in the rearing and housing conditions, could improve the chance to express natural behavioural patterns (Trocino and Xiccato, 2006), which can be considered as a component of animal welfare-oriented production. The main economically important traits were highlighted in the study by Krupová *et al.* (2020), along with the importance of the number of kits born alive and productive lifetime of does. Sánchez (2025) emphasised the importance of prolificacy in addition to resilience and robustness related traits in the sustainability of rabbit production.

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Theilgaard *et al.* (2009) demonstrated that selection for reproductive lifetime is feasible and may offer advantages over selection for reproduction intensity, particularly by improving overall doe performance and reducing the risk of early culling. Reproductive longevity is typically described using indicators such as length of productive life, number of parities or lifetime reproductive performance (Piles *et al.*, 2006), which can be incorporated into breeding objectives. Selection for increasing longevity has been suggested as a viable strategy in rabbit breeding, especially in intensive production systems where early culling represents a major limitation (Larzul *et al.*, 2014). Although most evidence originates from rabbit populations, improving reproductive or productive longevity is a common objective across livestock species, as it contributes to enhanced lifetime efficiency and sustainability.

The aim of the current research was to provide a comprehensive evaluation of the productive lifetime of Danubia Alba rabbit does in the maternal line based on a large-scale, long-term dataset, to identify risk factors affecting their reproductive performance and assess their potential for routine selection within breeding programmes.

MATERIALS AND METHODS

Reproduction performance data on 93,638 rabbit does born from 2012 onwards were used in the analysis, as both reliable and sufficiently large datasets have been available only since that time following breed establishment. The production results and pedigree information were supplied by the Hungarian breeding organisation (Danubia Alba Nyúltenyésztő Egyesület), which is responsible for the breed. The dataset contained 6.97% right-censored records. The pedigree contained the ancestors of the does up to the founder rabbits, and finally the pedigree contains 112 601 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 collected as:

- Year-season: (YS): time-dependent variable with 23 levels. The level changes every six months (1st of January and 1st of July each year). Year-season was included in the model to account for contemporary environmental and management conditions within the herd over time. Given the long-term nature of the dataset, this factor allows the capture of temporal non-genetic variation. The use of similar temporal structures has been widely applied in previous studies on reproductive traits in rabbits.
- Number born alive (BA), a time-dependent variable with seven levels. The first level included does that had zero or one live-born; does with two or three born alive were included in the second 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 association between the productive life and fixed factors was analysed using a Prentice and Gloeckler discrete time model (Prentice and Gloeckler, 1978), which is suitable for time-to-event data recorded in discrete intervals. The effects of these factors on longevity were estimated using the Survival Kit program (Mészáros *et al.*, 2013a), allowing the analysis of hazard functions within a parametric survival framework. Information on the reasons for culling was not available; therefore, it was not possible to distinguish between voluntary and involuntary culling. Consequently, all removals were considered as events in the survival analysis, which may influence the interpretation of longevity estimates. 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 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 = additive 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.*, 2013b).

In the applied animal model, the individual random effect of each rabbit was estimated on the log-hazard scale. These estimates were interpreted as breeding values (EBVs) for longevity. Bucks were evaluated based on their individual EBVs obtained from the animal model. Animals were ranked according to their estimated risk ratios, and following similar studies (Vollema and Groen, 1998, Caraviello *et al.*, 2004, Posta *et al.*, 2014), the 10 bucks with the lowest and highest values were selected to represent extreme groups. This selection was intended to illustrate phenotypic contrast between extreme genetic merit groups for longevity rather than to provide population-wide inference. The variances of the risk ratios of bucks having the lowest and highest risk ratios were compared with F-test and were significantly different ($P < 0.05$). Due to this difference, the group means were compared with Welch-test using the R software package.

RESULTS

The distribution of number of kindlings is shown in Figure 1. The number of the first three kindling was almost similar; afterwards, the distribution was quite close to exponential distribution. Close to 50% of the does had no more than three kindlings, while around 10% had more than 10 kindlings.

All time-dependent effects were significant ($P < 0.001$). Figure 2 presents the relative risk ratios of the year-season time-dependent effect on productive lifetime of Danubia Alba does. The highest risk ratios were estimated for the time period from 2020 onwards for the current breeding animals, which were significantly higher than the reference category, based on non-overlapping 95% confidence intervals. The lowest risk ratios were observed for rabbits in production up to 2019.

Figure 3 shows the effect of the number of kits born alive on the relative culling risk. As was expected, the highest risk ratio was estimated for the group having 0 or 1 kid born alive and decreased continuously thereafter. The relative culling risk for does in the reference class (8 or 9 kits born alive) was lower than for those having fewer than seven kids born alive. The lowest risk ratios were estimated for does having 10 or more kits born alive per kindling.

The animal variance was estimated to 0.17471 (standard error: 0.00485) with our model, which resulted into the heritability of $h^2 = 0.14$ (standard error: 0.0033) taking into account the 6.97% censoring rate ($p = 0.9303$ was the proportion of uncensored records). There were 667 rabbits, for which the reliability of the breeding value was greater than 0.70, while it was higher than 0.30 for 77 513 animals within the total pedigree. To show the possibility for selection on this trait, we selected the ten best and ten worst bucks based on their estimated risk of culling, while extracting their offsprings with production data compared their length of productive life. Table 1 shows the detailed results of the two extreme categories. The estimated risk ratio for worst bucks was 2.665 and it was 0.537 for best bucks, while 1.752 and 0.667 were estimated for their offspring. The calculated risk ratios of the two offspring groups were compared and found to be significantly different ($P < 0.05$).

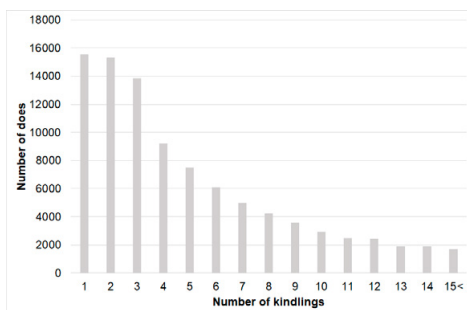


Figure 1: Distribution of the kindlings in the Danubia Alba population.

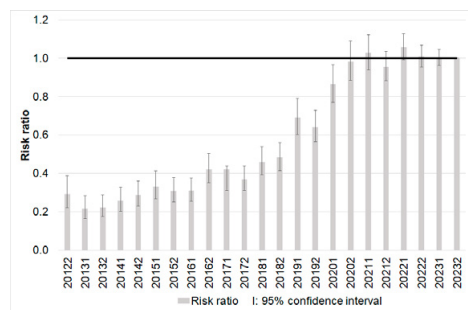


Figure 2: Effect of year-season on the relative culling risk.

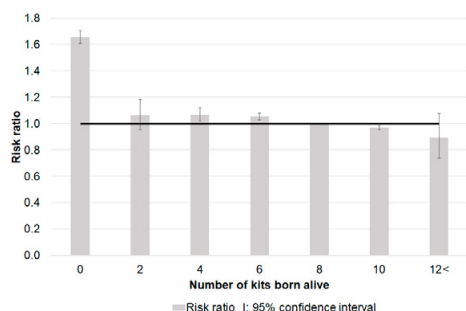


Figure 3: Effect of number of kits born alive on the relative culling risk.

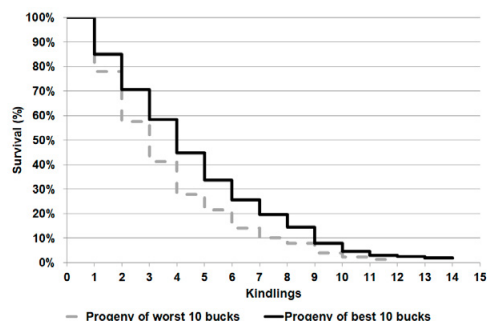


Figure 4: Survival function for the progeny from the ten best and worst bucks based on their breeding value for number of kindlings.

Figure 4 clearly shows the huge differences ($P < 0.05$) between the two extreme groups. Close to 60% of the offspring of the ten best bucks were still in production after four kindlings, while that figure was around 40% offspring left for the worst bucks after the same age. The highest number of kindlings was 12 for the worst bucks' offspring, while there were does in production after 14 kindling within the best bucks' group.

DISCUSSION

The year-season effect observed in our study was mostly consistent with the findings of Sánchez *et al.* (2004) and Piles *et al.* (2006). They also reported temporal variation in this effect. In our data, a more or less gradual change in risk ratios over time was observed, although some fluctuations between periods were also present. For the earliest combinations, lower risk ratios were obtained, whereas higher values were estimated for the middle combination categories. The changing of risk ratios over time might be the result of breeding decisions. The breeding population increased in the early part of the evaluated time period, whereas stronger selection pressure could be applied after 2020 due to a lower replacement rate, as fewer replacement does were needed and thus selection among candidates became more stringent without increasing herd size.

The higher risk ratios for litters with fewer live-born kits were expected and may reflect simultaneous selection for reproductive performance alongside selection for meat production traits. Differences in culling risk were mainly observed between the extreme categories, whereas intermediate levels showed similar risk estimates. The tendency was quite similar to the results of Piles *et al.* (2006) for rabbit lines selected for litter size. It should be noted that litter size (number born alive) was included in the survival model as a time-dependent covariate (risk factor). Therefore, the objective of the study was not to evaluate temporal trends in litter size, but to assess its effect on reproductive longevity.

Table 1: Descriptive statistics of the two extreme categories.

	Worst		Best	
	Buck	Offspring	Buck	Offspring
N	10	390	10	398
Risk ratio mean	2.665	1.752	0.537	0.667
Risk ratio standard deviation	0.097	0.256	0.034	0.315
Reliability mean	0.640	0.365	0.569	0.315
Reliability standard deviation	0.096	0.097	0.082	0.059

The estimated additive genetic variance indicates the presence of genetic differences among does in production performance. Although the estimated heritability was low, in agreement with Sánchez *et al.* (2004), Piles *et al.* (2006), Lenoir and Garreau (2016) and El Nagar *et al.* (2020), it was lower compared to the findings of Sánchez *et al.* (2006). This suggests that genetic improvement through selection may be possible, although the expected response to selection is likely to be slow. In practice, the accuracy of selection may also be limited by the relatively low reliability of breeding values for young candidates with limited performance information, and by the need to consider genetic correlations with other economically important traits in a multi-trait selection context.

The risk ratio of bucks with the highest and lowest estimated breeding values, together with their progeny, were compared descriptively. In both cases, significant differences were observed, confirming the contrast between extreme genetic merit groups. Figure 4 illustrates that the estimated risk of culling reflects differences in productive lifetime, and may serve as a useful indicator for illustrating genetic differences in longevity within the Danubia Alba maternal line. However, this comparison should be interpreted as illustrative rather than as a direct estimate of expected selection response. It should also be noted that although selection for longevity may be beneficial, it may increase the generation interval in breeding programmes, potentially slowing overall genetic progress.

A limitation of the present study is that information on the reasons for culling was not available in the dataset. Therefore, it was not possible to distinguish between voluntary and involuntary culling events, and all removals were treated uniformly in the survival analyses. This may affect the interpretation of longevity estimates, as the inclusion of both types of culling could bias hazard estimates and lead to a slight underestimation of true productive lifetime. Nevertheless, this approach is common in large-scale field data studies where detailed culling records are often incomplete.

CONCLUSIONS

The genetic background of length of productive life of Danubia Alba rabbit does was evaluated using survival analysis. The culling risk of does decreased as the number of kits born alive increased. The estimated heritability ($h^2=0.14$) indicates that genetic improvement of this trait is feasible. Further research may focus on a more detailed characterisation of the genetic architecture of longevity to support more efficient selection strategies in rabbit breeding programmes.

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Conflict of interest: Cargill Feed Ltd (employer of Csongor Demeter) and S&K-Lap Ltd (employer of Zoltán Németh and Máté Sándor) as well as Tetrabbit Ltd (employer of Zoltán Németh and Máté Sándor) were involved in the provision of data for the study. They did not interfere with co-authors' access to all of the study's data, analysing and interpreting the data, preparing and publishing manuscripts independently. The authors declare no conflicts of interest. The funder had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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