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gabor.meszaros@uniag.sk

Evaluation for functional length of productive life in Slovak Pinzgau cattle

G. MÉSZÁROS[1], J. WOLF[2], O. KADLEČÍK[1], R. KASARDA[1]

[1] Slovak University of Agriculture, Nitra, Slovak Republic
[2] Institute of Animal Science, Prague Uhříněves, Czech Republic

INTRODUCTION

Length of productive life, usually measured as time from first calving until death, describes the ability of a cow to avoid culling by the farmer. If the measure is adjusted for within-herd production deviation, it is called functional longevity, and this trait describes the cow's ability to avoid involuntary culling (Ducrocq et al. 1988).

Longevity results from good health and fertility status, from which low costs of veterinary care and insemination arise (Essl 1998). Marginal economic values for length of productive life for Holstein and Czech Fleckvieh cows in the Czech Republic were calculated to be 74 and 58 € per year per cow, respectively (Wolfová et al. 2007). A similar economic value of approximately 66 € per year per cow was calculated for Slovak Pied cows in mountain areas (Krupa et al. 2006). Length of productive life has a large effect on the economic efficiency of the production system and its relative importance reaches about 25 to 30% of 305-d milk yield which is the most important trait (Wolfová et al. 2007).

The aim of the study was to analyze effects affecting the length of productive life using a Weibull model. The importance of the individual factors (milk production level, parity and stage of lactation, age at first calving and herd size change) acting on the functional length of productive life in this breed was studied.

MATERIAL AND METHODS

A data set of 44796 Slovak Pinzgau cows first calved between 1993 and 2007 was analyzed. Cows with age at first calving below 23 or above 50 months and cows with missing date of first calving were deleted. Similarly cows not alive at the date of data collection (March 2007) with missing date of culling were not considered. Herds with less than 20 evaluated cows were omitted.

The records of cows alive at the time of data collection were treated as right censored. The records were also treated as right censored at the end of the tenth lactation, when the cow reached more than 10 lactations. Also cows removed from milk recording on behalf of the breeders' decision were considered as censored, while no further data about their production and longevity were available, but the true length of their productive life was assumed to be longer than the last entry in the milk recording. The data were analyzed with a proportional hazard model following a Weibull distribution:

$\lambda(t) = \lambda_0(t)\, exp(hy_i + rp_j + pst_k + afc_l + hs_m)$

where $\lambda(t)$ is the risk of culling at time t, $\lambda_0(t)$ is the baseline hazard function which is assumed to follow a Weibull distribution, hy_i is the time dependent effect of herd × year, rp_j is the time dependent effect of the relative milk production (see below), pst_k is the time dependent effect of parity × stage of lactation, afc_l is the time independent

effect of age at first calving and hs_m is the time dependent effect of annual herd size change.

The relative milk production for lactations was computed after their adjustment to the first lactation, as the milk production of a cow compared to the herd average in the given year. The resulting difference expressed in standard deviations was subdivided into nine classes. The lower and upper bounds for these classes are given in Table 1.

Lactations were divided into four intervals with changes on day 61, 151 and 240 of lactation. These stages were combined with the effect of parity to form the factor parity × stage of lactation. The cows were grouped according to their age at first calving into 9 approximately three-month wide classes.

The relative change of herd size was computed to 1st January each year and expressed as percentage deviation from the herd size in the previous year. Five classes were formed as given in Table 2.

For basic data processing and initial text file creation SAS® 9.1 was used. The risk ratios were computed using Survival Kit 3.12 program package (Ducrocq and Sölkner 1998).

RESULTS

All factors included in the model (herd × year, relative milk production, parity × stage of lactation, age at first calving and annual herd size change) were highly significant.

Table 1. Estimates of risk ratios for classes of the relative milk yield

Class	Lower bound of lactation value	Upper bound	Risk ratio
1		< -1.5 std.	4.840
2	- 1.5 std.	< -1.0 std.	2.506
3	-1.0 std.	< -0.5 std.	1.795
4	-0.5 std.	< -0.2 std.	1.300
5	-0.2 std.	< +0.2 std.	1.000
6	+0.2 std.	< +0.5 std.	0.849
7	+0.5 std.	< +1.0 std.	0.720
8	+1.0 std.	+1.5 std.	0.569
9	> +1.5 std.		0.465

The risk ratios for classes of relative milk yield are shown in Table 1. The relative milk production expresses the milk performance relative to the performance of all cows in the same herd and year. The results indicate a clear dependency of the risk ratio on the milk performance. Cows with lower than average production had a higher risk of culling compared to average producing cows. While cows with slightly under average production (class 4) had only a 1.3 times higher risk to be culled, the risk ratio for lower classes increased reaching a value of about 4.84 in class 1 with the lowest milk performance. On the other hand, highest-yielding cows had a risk ratio of about 46% of average-yielding cows. That means, increasing the performance above average was of a relatively smaller effect on the risk ratio than decreasing milk performance.

The highest risk for culling was estimated for the first stage of the first lactation (until 60 days), and decreased with days in milk (not shown). The culling risk decreased from the first to the fourth or fifth lactation and stayed then more or less equal, except of a slight increase at the end of the ninth and tenth lactation. Cows

had the lowest risk of culling in the first stage and the highest risk of culling in the last stage of lactation from the second lactation onwards.

The risk ratios for the factor age at first calving (not shown) showed a considerably lower variability than the factors considered above. They were in the range from 0.941 to 1.185 whereby their values increased with age at first calving. Though the effect of the factor age at first calving was statistically significant, it had only a moderate impact on the risk to be culled.

Table 2. Estimates of risk ratios for classes of the relative change of the herd size

Class	Lower bound for relative change in herd size	Upper bound	Risk ratio
1		< -50%	7.511
2	-50%	< -20%	1.804
3	-20%	< +20%	1.000
4	+20%	< +50%	0.373
5	+50%		0.266

The risk ratios for the time dependent effect of relative annual herd size change are shown in Table 2. The risk ratio was set to 1.0 for cows from stable herds with no or only slight changes in the herd size and the other classes were compared to this class. The change of the herd size had a clear impact on the culling risk of cows. The risk increased in shrinking herds and decreased in expanding herds compared with herds stable in size.

DISCUSSION

The present investigation analyses the impact of different factors on the length of productive life of Slovak Pinzgau cows using methods of the survival analysis. This breed is considered to be endangered because of decreasing numbers of young Pinzgau sires, their low utilization in insemination (Kadlečík et al. 2006) and the increase of the inbreeding coefficient (Kadlečík et al. 2004, Kasarda and Kadlečík 2007). In contrary many bulls of other breeds (mainly Red Holstein) are used, which leads to a decrease of the purebred Pinzgau population in Slovakia.

The relative milk yield represents mainly the effect of voluntary culling. The milk production level has been shown to be the most important or one of the most important factors on the length of productive life in many studies (Vollema et al. 2000, Sewalem et al. 2005, Bielfeldt et al. 2006) what is in agreement with our results.

The asymmetric (non-linear) behaviour of the culling risk in dependence on the relative milk production where high risk ratios were observed for the classes with very low milk production and moderately low risk ratios were estimated for the highest yielding cows was confirmed by Fuerst and Egger-Danner (2002) and Chirinos et al. (2007). It seems that the nonlinear character of the relationship between risk ratio and milk production class is amplified when increasing the number of classes.

The selection of cows is very intensive at the beginning of the first lactation as documented by the highest risk of culling in stage 1 of lactation 1. The risk ratio decreases in the subsequent stages of the 1st lactation. This result is in agreement with the findings of Fuerst and Egger-Danner (2002) and Egger-Danner et al. (2005) who also detected a similar pattern of the course of the risk ratio during the first lactation.

As Dürr et al. (1999) stated producers would always be tempted to get rid of low producing cows in time for economic reasons.

Most authors (Dürr et al. 1999, Fuerst and Egger-Danner, 2002, Egger-Danner et al. 2005, Páchová et al. 2005) agree that from the second lactation onwards the hazard rate follows a different pattern than in the first lactation: the hazard is low at the beginning of the lactation immediately after calving, then increases with advancing lactation and reaches its maximum at the end of the lactation, when most non-pregnant cows are culled. It seems that culling in the course of the lactation is restricted mainly to involuntary culling and the main selection is realized at the end of the lactation. The farmers possibly let even non-pregnant cows finish their lactations not to lose returns from milk.

There is a general agreement in the literature confirming our results that age at first calving has only a small influence on the length of productive life, although a certain trend of increasing culling risk with higher age at first calving is observed (Páchová et al. 2005, Sewalem et al. 2005, Bielfeldt et al. 2006). No significant effect of age at first calving on the length of productive life was reported by Ojango et al. (2005).

In case the farmer is forced to lower the number of animals in his herd, cows could be culled which otherwise would remain. Also if the herd expands, more cows will be left in the herd than in a stable situation. This change of the number of animals in the herd consequently causes a corresponding change of risk of culling, as observed in this study. Vollema et al. (2000) reported similar results for decreasing herd size, but for herds with increasing numbers our results indicated a sharper decrease in the culling risk. Mostly the change in the herd size caused smaller responses in the risk ratio than in our investigation. Dürr et al. (1999) came to the surprising result that cows in herds from both extremes (accretion or reduction in herd size of more than 25% from one year to another) were at a greater risk of being culled than were cows in herds with a stable number of cows. Chirinos et al. (2007) who also found a small effect of herd size change on the length of productive life suggested that the time dependent herd-year-season effect might be accounting for changes in risk of culling due to increases or reductions in herd size.

CONCLUSIONS

Proportional hazard models are an efficient means to identify factors acting on the length of productive life. The relative milk production level within herd, year and parity has the greatest impact on the culling policy. Cows with extremely low milk production have a culling risk 4.84 times higher than cows with average milk production. Change of the herd size is a second factor with great importance. In herds decreasing by more than 50% the culling risk is about 7.5 times higher than in stable herds. The selection pressure expressed as risk ratios is greatest at the beginning of the first lactation and at the end of the subsequent lactations. Age at first calving is a factor of minor importance for the length of productive life.

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Corresponding author:
Ing. Gábor Mészáros
Department of Genetics and Breeding Biology
Slovak University of Agriculture in Nitra
Tr. A. Hlinku 2, 949 76 Nitra
Slovak Republic

Email: gabor.meszaros@uniag.sk