Estimation of genetic parameters for age at last calving as a measure of Cow Survival in a Population of Nellore Beef cattle in Brazil

S.B. Ramos[1], S.L. Caetano[2], R.B. Lôbo[3], L.A.F. Bezerra[3], A. Bonifácio[4] and D.P. Munari[1]
[1]Departamento de Ciências Exatas, Universidade Estadual Paulista, [2]Centro Universitário de Barretos, [3]Departamento de Genética, FMRP, Universidade de São Paulo, [4]Agência Nacional de Criadores e Pesquisadores

ABSTRACT: Longevity was measured by the variable age of cow at last calving. The date of the last calving occurred in the farm was used as a reference moment. If the difference between the age of cow at last calving and this moment was greater than a predetermined criterion, the cow was considered to disposal. Otherwise, it could remain in the herd. A Weibull proportional hazards model was used to estimate heritabilities for age of cow at last calving considering three values of the criterion: 16, 26 and 36 months. The dataset used for the analysis consisted of 22312 cows born between 1967 and 2009. The heritability estimates obtained for age of cow at last calving considering criteria values of 16, 26 and 36 months, respectively: 0.1020, 0.1002 and 0.0871. The phenotypic variance was explained mostly by the non-additive genetic and environmental effects. Selection response for this trait would be low.
Keywords: Heritability, Survival analysis, Weibull model

Introduction

Longevity is an important trait in beef cattle. In a commercial farm, profit comes after a beef cow remained in the herd long enough to generate revenue sufficient to offset development and maintenance costs. In Brazil, the few studies concerning longevity in beef cattle uses threshold models to evaluate binary traits (Silva et al., 2006; Van Melis et al., 2010 and Buzanskas et al., 2010).

Caetano et al. (2012) used the age of cow at last calving (ALC) as a measurement of longevity. Since some animals had not yet definitively reached their last calving, a criterion for censoring these animals was used. This consisted of the difference between the date of the cow's last calving (up to the time of gathering data on each cow) and the date of the latest calving on each farm. If this difference was >36 months, the cow was considered to have failed. If not, this cow was censored, thus indicating that future calving was still possible for this cow. The criterion of 36 months was used because this is sufficient time for a new calving to have occurred. Nevertheless, since 36 months could be considered as an upper limit value for the censoring criterion, different values of it should be studied.

The objective of this study was to estimate the genetic parameters for ALC considering different values for the censoring criterion equal to 16, 26 and 36 months.

Materials and Methods

Data. The records of 21996 cows from 13 farms within the Nellore Breed Genetic Improvement Program ('Nellore Brazil'), which is coordinated by the 'Associação Nacional de Criadores e Pesquisadores' – ANCP ('National Breeders and Researchers Association'), were used. On these farms, the animals are reared on pasture. Weaning took place at around 6 to 8 months of age. The reproduction management consists of a mating season lasting 90 to 130 days, using artificial insemination or controlled natural breeding.

Statistical analyses. Cows from 2113 sires were studied using survival analysis and a sire model for longevity. The response variable considered in the analysis, was ALC. Three values for the censoring criterion were considered: 16, 26 and 36 months. The reference moment considered was the date of last calving occurred in the farm (LCF). If the difference between ALC and LCF was bigger than the criterion value, the record is considered complete, indicating productive life of the cow could have ended and, therefore, could be considered for disposal. Otherwise, the record was censored indicating a new calving could happen and, therefore, the cow could remain in the farm.

The following proportional hazards Weibull model was used:

$$\lambda(t) = \lambda_0(t) exp(afc + hys + s)$$

where $\lambda(t)$ is the hazard function of an individual depending on time t (age at last calving), $\lambda_0(t)$ is the baseline hazard function which is assumed to follow a Weibull distribution with shape parameter ρ, *afc* is the fixed effect of age at first calving, *hys* is the random effect of herd-year-season class, where herd was the source farm of origin, assumed to followed a gamma distribution with parameter γ, and s is the random sire effect, assumed to follow a multivariate normal distribution with variance $A\sigma^2$, where A is the additive relationship matrix between sires and σ_s^2 is the sire variance. The Survival Kit software Version 6.1 (Mészáros et al., 2013) was used for the survival analysis.

Heritability was approximated as in Ducrocq and Casella (1996):

$$h^2 = \sigma_s^2 / \sigma_s^2 + \psi^{(1)}(\gamma) + \frac{\pi^2}{6}$$

where $\psi^{(1)}(\gamma)$ is the trigamma function evaluated at γ and $\frac{\pi^2}{6}$ is the variance of an extreme value distribution.

Spearman correlation coefficients were used to assess the similarity (or lack thereof) between sire rankings, based on ALC breeding values, for the three censoring criterion values. Only the top 1% (approximately 50 animals) of sires that had ≥25 daughters were considered in the analysis.

Results and Discussion

Table 1 contains the total number of observations, number and percentage of censored and complete observations and mean of ALC for both censored and complete observations. The proportion of censored cows was greater for the criterion value of 36 months and smaller for the criterion value of 16 months. The mean of ALC calculated from the dataset was approximately equal for the censored observations and for the complete observations.

Table 1. Descriptive statistics for the three censoring criteria.

Item	Censoring criterion value, months		
	16	26	36
Total number of observations	21996	21996	21996
Number of censored observations(%)	5864(26.66)	7198(32.72)	8527(38.77)
ALC mean for censored observations, months	83.22	82.67	83.60
Number of complete observations(%)	16132(73.34)	14798(67.28)	13469(61.23)
ALC mean for complete observations, months	85.89	86.40	86.19

Table 2 contains the estimates of the shape parameter of the Weibull distribution (ρ), the parameter of the gamma distribution of random effect of herd-year-season (γ), the trigamma function ($\psi^{(1)}(\gamma)$), the sire variance (σ^2) and heritability (h^2) of ALC considering the three criteria. The Weibull shape parameters were bigger than 1 for all criterion values, indicating the risk of disposal increased as time increased. The gamma parameter estimate for the criterion value of 36 was the smaller among the estimates of the other criterion values. This might be due differences in the number of censored animals between the criterion values. The trigamma function measured the variance of the herd-year-season random effect. Since this variance is calculated in function of the gamma parameter, the differences between the estimates can be explained by the differences between the gamma parameter estimates. The estimates of sire variance were equal for all criterion values. This result leads to believe that changes in the criterion value do not lead to changes in the sire variance. The estimates of heritability were approximately equal for all the three criterion values. Forabosco et al. (2006) and Van Melis et al. (2010) found similar estimates of heritability for longevity (0.112 and 0.1, respectively). But Caetano (2010), found an estimate equal to 0.25 using ALC and a criterion of 36 months. But this author considered the effect of herd-year-season to be fixed and the heritability estimate was calculated only in function of the sire variance.

Table 2. Parameters estimates for the three censoring criterion values.

Item	Censoring criterion value		
	16	26	36
ρ	3.2466	3.1772	3.1241
γ	0.8329	0.8155	0.7011
$\psi^{(1)}(\gamma)$	2.1616	2.2326	2.8270
σ^2	0.0996	0.0996	0.0996
h^2	0.1020	0.1002	0.0871

ρ: shape parameter of the Weibull distribution
γ: parameter of the gamma distribution
$\psi^{(1)}(\gamma)$: trigamma function
σ^2: sire variance
h^2: heritability

The Spearman correlation estimates based on ALC breeding values for the censoring criteria of 16 and 26, 16 and 36 and 26 and 36 months were equal to -0.2124, 0.1348 and 0.1211, respectively ($P>0.05$). The correlation estimates are not significantly different from zero, which lead us to suggest that sires rank differently for daughter longevity between censoring criteria. One possible explanation for this result is that prediction of sire effect takes in consideration only information of non-censored individuals. Since this number varies between censoring criteria, the predicted sire values between censoring criteria also varies.

Conclusion

The heritability estimates for ALC considering the three values of censoring criterion were similar. Although the response of selection for this trait considering ALC as a measurement of longevity can be low, the use of different censoring criterion values can lead to selection of different sires.

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