Assessment of growth curve parameters of Santa Gertrudis cattle

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Introduction

The adult weight of beef cattle in relation to productivity has been a source of preoccupation as far back as the 70ies. Dickerson (1978) advocated that any productive approach to the subject would have to include questions such as correct adaptation of mature weight to the production system, environmental and market conditions, production per area and, principally, the relation of these factors with improvements of production indices such as reproduction efficiency, relative growth and carcass composition.

According to Arango & Van Vleck (2002), the efficiency of growth is more important for beef cattle than for other species, due to low reproduction rate and high maternal cost of maintenance.

Adaptation to the environment represents another important component of biological efficiency. Animals with a high adult weight benefit from colder climates and respond more favourably to temperature-related stress in such a situation, provided feed resources are not limited. On the other hand, animals with low adult weight are more efficient in a grazing environment, principally due to the seasonal growth of forage resources; they are therefore better adapted to tropical climates.

The expression of the body size can be represented by a set of points which change gradually, attaining a plateau at maturity (Arango & Van Vleck, 2002). According to Rorato et al. (2007), cattle growth is not linear and hinders the standardization of the body weights at certain stages of life; yet, this procedure is important for comparison of the animals' production performance. The growth functions permit to study the changes of the growth curve shape, providing solutions to questions related to quick and efficient growth of the progeny until slaughter, presenting smaller body size and low cost of upkeep of the parents. Thus, the purpose of this paper is to evaluate the growth curve parameters of Santa Gertrudis cattle raised in a tropical environment.

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Material and methods

Formation of data records. The work was carried out at the Laboratory for Animal Improvement of the Zootechnical Information Nucleus of the Department for Animal Sciences at Universidade Federal Rural do Semi- Árido (UFERSA). The data for weight increase stemmed from the Associação Brasileira de Santa Gertrudis (ABSG). The animals were generally weighed every four months, from 1990 through 2001. The data archive contained weighing records of animals aged up to 5,000 days. After achieving archive consistency, weight specifications above or below three standard deviations as compared to the age average, were excluded. Weight specifications referring to animals of more than 5,000 days of age were also excluded. Thus, 67,774 weight specifications stemming from 12,863 animals were used for evaluation of the growth curve parameters.

Statistical analyses. The data was analysed according to the Methodology of Least Squares, by using the computer program SAS® (SAS 9.1, Institute, Cary, North Carolina, USA). The quality of fit of the models Brody, von Bertalanffy, Logístico and Gompertz was tested by means of procedure NLIN of said program, using the modified method of Gauss-Newton as summarized by Silveira Jr. et al (1992). The equations of the growth curve models are shown below.

Model Logístico: $Y= a*(1+b*exp(-k*x))^{-1}$

Model Brody: $Y= a*(1-b*exp(-k*x))$

Model von Bertalanffy: $Y= a*(1-b*exp(-k*x))^3$

Model Gompertz: $Y=a*exp(-b*exp(-k*x))$ where:

Y is the estimated weight, a is the asymptotic weight, b is the scale parameter, k is the maturity index and x is the animal's age at weighing date.

For verification of goodness of fit of the growth curve models, the criterions of the determination coefficient (R^2) and the mean prediction error (MPE) were used. After verification of the models' goodness of fit, the individual evaluations of the curve parameters and analysis for obtainment of genetic parameters thereof were performed. The analysis of the a and k parameters of the growth curve was performed by the method of Least Squares.

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} + \begin{bmatrix} Z_1 & 0 \\ 0 & Z_2 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix}$$

where:

y_1 e y_2 = vector of the measurement registers of parameters a and k;

b_1 e b_2 = vector of fixed effects for parameters a and k;

$u1$ e $u2$= vector of random effects of genetic value for parameters a and k;

X_1 e X_2 = Incidence matrix of elements of b_1, b_2 and y_1, y_2;

Z_1 e Z_2 = Incidence matrix of elements of u_1, u_2 and y_1, y_2;

e_1 e e_2 = vector of residual effects.

The fixed effects of the model were constituted by contemporaneous group formed by concatenation of the variables farm, year and season of birth and sex of the animal, in addition to the quadratic effect of parameters k and b on the asymptotic weight and quadratic effect of parameter a and linear effect of parameter b on the maturity index, as co-variables. The animal's additive genetic effect was considered random.

The evaluations of variance components for parameters *a* and *k* were obtained by two-trait analyses according to the method of derivative-free restricted maximum likelihood, utilizing the program MTDFREML developed by Boldman et al. (1995), as an animal model. The animals' genetic values regarding the traits analysed were obtained by equations of mixed models, using the model described above.

Results and discussion

The mean values of asymptotic weight as obtained by the models varied from 539.1 to 559.2 kg and are shown in Table 1.

Table 1: Evaluated mean values and standard errors of parameters of Santa Gertrudis cattle growth curve models

Models	a	B	k	R^2	MPE
von Bertalanffy	549.1	0.5238	0.00283	0.99	-0.0062
Gompertz	545.8	2.0410	0,00325	0.99	-0.0058
Logístic	539.1	4.7872	0.00463	0.99	-0.0059
Brody	559.2	0.9570	0.00198	0.99	-0.0064

a = asymptotic weight; b = scale parameter; k = rate of maturity; R^2 = Determination coefficient; MPE = Mean Prediction Error.

The four models presented similar results (Table 1) and the models overestimated the weight values observed; however, the function presenting the smallest prediction error was that of Gompertz. Figure 1 shows the means of the animals' weight increase performance, weights evaluated and the prediction errors of each age studied, using the Gompertz function.

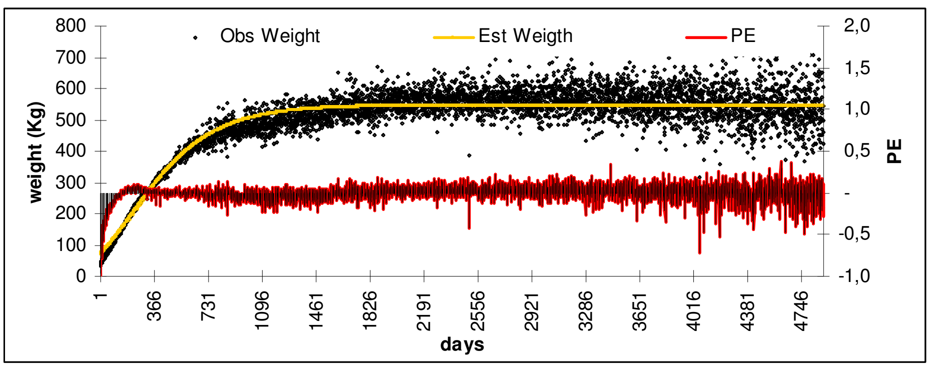

Figure 1: Mean weight observed (Obs Weight) and fitted (Est Weight) and prediction errors, obtained by the Gompertz function, referring to Santa Gertrudis cattle.

In accordance with the variance analysis, the effects of contemporaneous group (CG), parameters *a*, *b* and *k*, were significant in respect to the asymptotic weight and maturity rate parameters, as shown in Table 2

Table 2 – Summary of variance analysis of parameters asymptotic weight (*a*) and rate of maturity (*k*) of the Gompertz function, regarding Santa Gertrudis cattle raised in tropical environment.

SV	DF (*a*)	MS (*a*)	DF (*k*)	MS (*k*)
CG	3296	25549.77**	3296	0.00000214**
a	-	-	1	0.00030772**
a*a	-	-	1	0.00008614**
b	1	16567620.19**	1	0.00288717**
b*b	1	208781.40**	-	-
k	1	2242552.16**	-	-
k*k	1	4278792.02**	-	-
	R^2= 0.72	CV= 14.07%	R^2= 0.78	CV= 19.62%

SV = Source of Variation; MS = mean square; DF = degree of freedom o; CG = contemporary group; R^2 = Determination Coefficient; CV = Variation Coefficient; ** = P<0,0001.

The genetic analyses revealed 66 endogamous animals resulting in a mean coefficient of endogamy of 0.11%, considered to be of low magnitude. The heritability values were 0.24±0.022 and 0.20±0.021 for parameters *a* and *k*, respectively, indicating that the selection based on these parameters may be effective. The estimated correlation between the two parameters was -0.31, indicating that the selection for the asymptotic weight increase is expected to lower the maturity rate.

Conclusion

The animals with higher adult weight present a smaller maturity rate which suggests that larger animals are maturing later, being less adapted to tropical environment. The selection using the traits analyzed (***a*** and ***k***) is likely to show effective results, considering that approximately 24% of total variation is of genetic origin and, therefore, the trait of asymptotic weight ought to be included in the programs of genetic evaluation.

References

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