

HETEROSIS AND BREED TRANSMITTED EFFECTS IN GROWTH CURVE PARAMETERS IN ANGUS, CRIOLLO AND RECIPROCAL CROSSBRED COWS.

C.A. Mezzadra and M.C. Miquel
INTA, Estación Experimental Agropecuaria Balcarce, and Facultad de Ciencias Veterinarias, UBA, Buenos Aires, Argentina.

SUMMARY

Five linear models: Brody, Von Bertalanffy, Gompertz, Logistic and Richards, were fitted to weight-age data from a diallel experiment between Angus and Criollo breeds. A total of 216 Angus (AA), 53 Criollo (C), 20 CxAA and 113 AAxC cows were used. The results were similar for all models, although Richards' function was selected. Individual additive effects favoured Criollo for A (22.2 kg, $P < 0.01$) and Angus for k (.0029, $P < 0.001$). Heterosis effects were significant only for A and k parameters, having values of 4.4% ($P < 0.05$) and 10.5% ($P < 0.01$) respectively.

INTRODUCTION

Under pastoral conditions it is relevant to produce more meat with no extra costs. The use of crossbreeding increases productivity of the systems, specially when combining the advantages of heterosis and complementarity. The analysis of lifetime growth through non linear models allows the evaluation of traits such as mature weight and maturing rate, which are related to efficiency of production. The objectives of this study were to fit five non linear models to weight-age data from a diallel experiment between Angus and a hardy breed, the Criollo, and to obtain estimates of individual heterosis and additive effects for the curve parameters.

MATERIALS AND METHODS

The experiment was carried out at the INTA Balcarce Experiment Station in Argentina (38°SL , 130 m above sea level). Mean annual rainfall and temperatures in the region are 900 mm and 13.7°C respectively. A total of 216 Angus (AA), 53 Criollo (C), 20 CxAA (CAA) and 113 AAxC (AAC) cows, born between 1962 and 1988 were used. The animals belonged to a complete diallel experiment designated to evaluate pre- and postweaning growth, as well as fertility and productivity traits. Details of the experimental design and general management were reported by Miquel (1986). The cows were managed to have their first calving at the age of 36 months. Cows were kept on improved pastures (*Festuca arundinacea*, *Lolium multiflorum*, *Trifolium repens* and *Thinopyron ponticum*) all the year round with no housing in winter months. Before calving, from May to August, cows were fed with supplemental pasture hay (0.55 digestibility). Weights were taken at birth and from that moment every 28 days up to the animal was culled from the herd or died. The animals that did not reach the age of 48 months were excluded from the analysis.

Weight-age data were used to fit five nonlinear functions: Brody, Von Bertalanffy, Gompertz, Logistic and Richards. As described by Fitzhugh (1976), the equations were as follows:

Brody	$W = A (1 - be^{-kt})$
Von Bertalanffy	$W = A (1 - be^{-kt})^3$
Gompertz	$W = A \exp(-be^{-kt})$
Logistic	$W = A (1 + be^{-kt})^{-1}$
Richards	$W = A (1 - be^{-kt})^M$

where: W represents the observed weight at the age t; A the asymptotic value as age t approaches infinity, usually taken as an indicator of the mature weight; b a constant of integration established by the initial values of W_0 and t; k a function of the ratio of maximum growth rate to mature size, and interpreted as a maturing index; M an inflection parameter for Richards' function which establishes degree of maturity at inflection point, and determines the shape of the curve.

Each of the five functions was fitted to each animal to obtain the corresponding growth curve parameters. This procedure was performed using the NLIN procedure from SAS (SAS, 1988), utilizing the Marquardt's iterative method. The convergence criterion followed was as follows:

$$(SSE_{i+1} - SSE_i)/(SSE_i + 10^{-6}) < 10^{-8}$$

where SSE_i is the residual sum of squares of the i th iteration. The maximum number of iterations was established in 50. To assess the goodness of fit of the different functions, the following criteria were used: the residual sum of squares of each function, the bias of the A parameter taken as the difference between A parameter and the average weight from day of age 1800 onward, and the difference between the predicted and observed birth weight. The coefficient of variation of each parameter from every function was also taken into account.

The parameters obtained were then analysed by least-squares (GLM procedure, SAS, 1988) through a fixed model containing year and month of birth, and genetic group of the cow as main effects, and all possible two-way interactions. In a preliminar analysis all interactions resulted non significant ($P > 0.05$), so that they were not included in the final analysis. Orthogonal contrasts among least-squares means were used to estimate heterosis and breed transmitted effects of Criollo and Angus breeds according to Dickerson (1969).

RESULTS

The average residual sum of squares of the functions (RSS), the difference between the A parameter and average adult weight, and the difference between predicted and observed birth weight are presented in Table 1.

Von Bertalanffy's function presented the lowest RSS followed closely by Brody's and Richards'. However, these two last functions showed the greatest deviations of A, Logistic model fitting better at weights late in the life of the animal. This was not consistent when considered the bias in BW, where Logistic had the highest values and Brody's function the lowest. The coefficients of variation of the curve parameters showed similarity across functions; A ranged from 10.1% for Richards' and Logistic to 16.4% for Brody's, b did from 4.3% for Brody's to 30.1% for Logistic, and k ranged from 21.6% for Von Bertalanffy's to 27.9% for Logistic; M had a coefficient of 29.2%. In this situation it is very difficult the election of a

Table 1: Goodness of fit characteristics of the growth curves.

Function	Residual SS	Bias A (kg)	Bias BW (kg)
Brody	72759.75	22.38	0.41
Von Bertalanffy	72093.62	10.41	23.18
Gompertz	73330.42	7.12	31.11
Logistic	78938.72	0.99	46.92
Richards	72786.76	12.90	9.09

specific function. However, the RSS of Richards' model was very similar to Von Bertalanffy's, both biases being intermediate. Thus, the selected function was Richards'.

Birth year affected ($P < 0.01$) all curve parameters, whereas genetic group had significant ($P < 0.01$) effect on A and k. Birth month was a non significant ($P > 0.10$) source of variation.

Least-squares means of the curve parameters by genetic groups are showed in Table 2, and the corresponding figures for breed transmitted (additive) and heterotic effects are in Table 3.

Table 2: Least-squares means and their standard errors of the growth curves parameters by genetic group.^a

Genetic Group	A (kg)	b	k x 10 ⁻³ (kg/kg.d ⁻¹)	M
Angus	410.6 ± 10.4	.834 ± .027	2.23 ± .12	1.69 ± .11
Criollo	432.8 ± 10.9	.793 ± .028	1.94 ± .13	1.84 ± .12
AAC	447.5 ± 14.8	.807 ± .038	2.31 ± .17	1.78 ± .16
CAA	432.9 ± 11.9	.799 ± .031	2.31 ± .14	1.84 ± .13

^a Standard errors could be biased due to repeated measures taken on the same individuals.

Table 3: Estimated additive individual and heterotic effects and their standard errors for growth curve parameters.^a

Component ^b	A (kg)	b	k x 10 ⁻³ (kg/kg.d ⁻¹)	M
g _{AA} ¹ g _C ¹	-22.2 ± 8.5**	.041 ± .022	.29 ± .10**	-.15 ± .09 ⁺
h _{AA,C}	18.5 ± 7.3 [*] (4.4)	-.01 ± .019 (-1.3)	.22 ± .08** (10.5)	.05 ± .08 (2.8)

^a ** P<0.01, * P<0.05, + P<0.10. Figures between parentheses represent heterosis as percentage.

^b g_{AA}¹g_C¹ breed transmitted effect; h_{AA,C} individual heterosis.

AA: Angus, C: Criollo.

In general terms, it was observed an inverse relationship between A and k parameters for AA and C. This was not the case for AAC and CAA, where k values approached Angus'.

DISCUSSION

The means of the b, k and M parameters were similar to those reported in other studies (DeNise and Brinks, 1985; Beltrán et al, 1992), although the values of A for Angus were lower, indicating that this is a small framed line of Angus. In previous studies (Slobodzian et al, 1992 a b) Angus and Criollo breeds did not differ in any pre- nor postweaning growth trait (weights and absolute and relative average daily gains). However, the individual additive effects in this study favoured Criollo by more than 20 kg. On the other hand, k value from Angus were 20% higher than that of Criollo. The relationships exhibited by both pure breeds in A and k are coherent with the negative genetic correlation (-.84) between these parameters found by DeNise and Brinks (1985) for Richards' function. These relationships indicate that smaller animals tend to mature earlier than larger ones. This seems to be the trend in the present study, particularly taking into account that Criollo has not been selected for maturing rate. Brown et al (1976) suggested that crossbreeding could be one method to overcome, at least partially, the antagonism between mature weight and rate of maturing. The average A of both F₁ was 7% higher than that of Angus, and their k was 3.5% higher. The significant value of 10.5% of heterosis indicates that nonadditive genetic effects on the shape of the curve were present. This is important in systems where the breeding and fattening activities are both run under pastoral conditions, and an increase of maturing rate would be desirable, but keeping invariant the adult size, due the increase in energy maintenance requirements.

M parameter represents the point of inflection (POI) of the curve, Richards' function being the only model having a variable POI. As Perotto et al (1992) have pointed out, the most critical aspect of the data affecting the estimate of this parameter is the number of points between birth and 300 days of age, since POI lay within this interval. In our case, this fact did not pose a serious problem since animals were weighed every 28 days, and then they had at least 10 points in that interval. Our estimation of M had lower variation coefficient than that reported by López de Torre et al (1992) for Retinta breed, who informed a coefficient of variation of 253% for that parameter.

Although no sources of variation affected this trait, it seems relevant to consider it as a means to alter the shape of the curve, having exhibited additive variation and positive genetic correlation with k parameter (DeNise and Brinks, 1985).

REFERENCES

- BELTRAN, J.J.; BUTTS, W.T.; OLSON, T.A. and KOGER, M. (1992) *J. Anim. Sci.* 70(3):734-741.
- BROWN, J.E.; FITZHUGH, H.A. and CARTWRIGHT, T.C. (1976) *J. Anim. Sci.* 42(4):810-818.
- DeNISE, R.S.E. and BRINKS, J.S. (1985) *J. Anim. Sci.* 61(6):1431-1440.
- DICKERSON, G. (1969) *Anim. Breed. Abstr.* 37:191-202.
- FITZHUGH, H.A. (1976) *J. Anim. Sci.* 42(4):1036-1051.
- LOPEZ DE TORRE, D.; CANDOTTI, J.J.; REVERTER, A.; BELLIDO, M.M.; VASCO, P.; GARCIA, L.J. and BRINKS, J.S. (1992) *J. Anim. Sci.* 70:2668-2672.
- MIQUEL, M.C. (1986) *Proc. 3rd. World Congr. Gen. Appl. Livestock Prod.*:342-347.
- PEROTTO, D.; CUE, R.I. and LEE, A.J. (1992) *Canad. J. Anim. Sci.* 72:773-782.
- SAS Institute Inc. (1988) Release 6.03 Ed. Cary, NC.
- SLOBODZIAN, A.; MEZZADRA, C.A.; MELUCCI, L.M. and VILLARREAL, E.L. (1992 a) *Revista Arg. Prod. Animal* 12(Supl 1):90.
- SLOBODZIAN, A.; MEZZADRA, C.A.; MELUCCI, L.M. and VILLARREAL, E.L. (1992 b) *Revista Arg. Prod. Animal* 12(Supl 1):91.