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A Computing System for Adjustment and Simulation of Growth Models to Estimate Nutrient Requirements for Cattle

[1]Martin E. Pereda-Solis, [2]Sergio S. Gonzalez-Munoz, [3]Enrique Arjona-Suarez,
[3]Graciela Bueno-Aguilar, [2,4]German D. Mendoza-Martinez,
[1]Jose Toca Ramirez and [1]Jose Hugo Martinez Guerrero
[1]Facultad de Medicina Veterinaria y Zootecnia, Universidad Juarez del Estado de Durango,
Apartado Postal 291 Durango, 34000 Dgo, Mexico
[2]Ganaderia, [3]Estadistica, Montecillo Campus, Colegio de Postgraduados, Mexico
[4]Facultad de Medicina Veterinaria y Zootecnia, UAM-Xochimilco, Mexico

Abstract: The system (SIMAC) presented in this study allows simulation and adjustment of 24 growth models as well as to estimate nutrient requirements for beef cattle. To adjust linear and non-linear models, the LeastSqX (Newcastle Scientific) software was incorporated within a routine in the programming language Microsoft visual basic 6.0. To check the operation of the SIMAC, the Curve expert 1.4 and Number Cruncher Statistical Software (NCSS), 2007 programs were used to adjust the growth models to data from weight records (CDP; AMCC). From the verification and comparison of SIMAC with other systems, results were highly satisfactory, obtaining similar results. The SIMAC differs from other model adjustment systems in a posteriori handling of the estimated results. This system can be used to analyze factors that affect the productive efficiency of cattle growth and carry out an analysis of sensibility of required nutrients for estimated growth.

Key words: Mathematical models, equations, growth, cattle, systems, Mexico

INTRODUCTION

The relationship between age and growth in an animal is represented by models using the general equation; W = f (t) where, W is Weight, t is time, f is a functional relationship with one or more parameters.

There are several mathematical models available to analyze and predict growth patterns (Brody, 1945; Richard, 1959; Cartwright, 1970; Lopez *et al*., 2000). Growth models have been also proposed for Belgian blue (De Behr *et al*., 2001), Hereford, Charolais, Angus, Galloway, Charolais x Angus and Holstein Angus (Goonewardene *et al*., 1981; Nadarajah *et al*., 1984), Brahman (Menchaca *et al*., 1996) and Brahman x Hereford (Joandet and Cartwright, 1969).

There are several computing programs that allows the adjustment of growth models: Curve expert, NCSS, 2007. However, there is little information on computing systems that allows adjustment of growth models for cattle which is the objective of this study.

MATERIALS AND METHODS

In the system, developed for the adjustment of linear and nonlinear models an object (control), LeastSqX was incorporated within a visual basic routine, using some parameter such as the number of observations, degrees of freedom for the adjustment, the matrix of independent (time) and dependent (body weights) data as well as the initial values of the parameters. LeastSqX uses the Levenberg-Marquardt method (Press *et al*., 1986) which is common in several systems used for the adjustment of nonlinear models and which use the least squares (Math-Works Inc., 1995; SAS, 1985).

To verify the results, models were adjusted using the NCSS, 2007 program with two series of data obtained from the Control de Desarrollo Ponderal Ponder Development Center (PDC) with body weights at birth, 120, 205 and 365 days of age of 100 Brahman females and 68 males born between 1994 and 1998; age and weight data of Holstein cattle were taken from Brody (1945).

RESULTS AND DISCUSSION

The SIMAC is organized into processes and modules. The main processes are database management, model adjustment, requirement estimation and help. The system is managed by menus; the system is manipulated through its menu also, there is available online help which can be execute by selecting the

Corresponding Author: Jose Hugo Martinez Guerrero, Facultad de Medicina Veterinaria y Zootecnia, Universidad Juarez del Estado de Durango, Apartado Postal 291 Durango, 34000 Dgo, Mexico

Table 1: Average weights

Birth season/age	Birth weights	Days 120	Days 205	Days 365	n	Models
Males born at dry season	32	112	154	225	11	Aldama 1
Males born at rainy season	31	125	175	232	57	Aldama 2
Females born at dry season	31	110	163	206	31	Aldama 3
Females born at rainy season	31	113	160	208	69	Aldama 4

Table 2: Obtained parameters

Parameters	Initial value	Final value	SD
Aldama 1			
A	100.00	261.790	8.8800
B	1.00	-1.180	1.6200
C	0.01	0.007	0.0010
D	0.10	0.130	0.1880
			X^2 = 76.1400
Aldama 2			
A	100.00	246.500	3.3100
B	1.00	-0.572	0.7700
C	0.01	0.010	0.0008
D	0.10	0.221	0.1400
			X^2 = 40.4200
Aldama 3			
A	100.00	217.9100	2.8700
B	1.00	-0.1990	0.6790
C	0.01	0.0106	0.0009
D	0.10	0.3031	0.1585
			X^2 = 0.3900
Aldama 4			
A	100.00	222.2700	3.5500
B	1.00	-1.0700	1.2400
C	0.01	0.0095	0.0009
D	0.10	0.1500	0.1642
			X^2 = 12.3800

corresponding icon on each menu and have an internet connection. In SIMAC, database files are managed in mdb format (Microsoft access). For the model adjustment, the system suggests the initial values for parameters which are helpful to find a solution and a better adjustment (Fig. 1). For each model of adjusted growth, the system calculates and plots an analysis of residuals, a report of adjustment, estimated daily weight gains, percentage of weight in relation to adult weight and estimated live weight. These adjusted models are also used to estimate dry matter intake, EN, Ca and P considering the breed, sex, physiological stage and size of cattle. The relations of average weights were obtained from the CDP data as shown in Table 1.

Once the data capture of ages and weights was done, the adjustment of models was carried out using the Richards model whose equation is:

$$y = a(1+(b - 1)\,Exp(-c(x - d)))^{\wedge}(1/(1 - b))$$

The parameters obtained from the adjustment of data are shown in Table 2. After the adjustment of the growth model for each group, the calculated weights were obtained from the day of birth to 365 days of age, representing with this model the relationship between the animal's age and body weight. The obtained growth curves (Fig. 2) appear as relatively straight slopes and their sigmoid shape would be more noticeable if cattle are kept and their weight recorded after reaching typical market weight. After 120 days of age, it is observed that the growth curves are modified according to sex of the animal and season of birth.

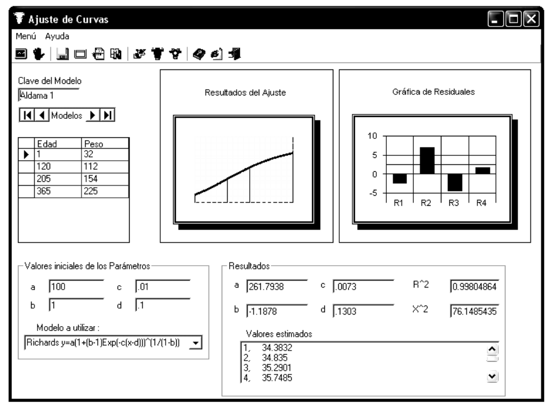

Fig. 1: Screen for adjustment of models

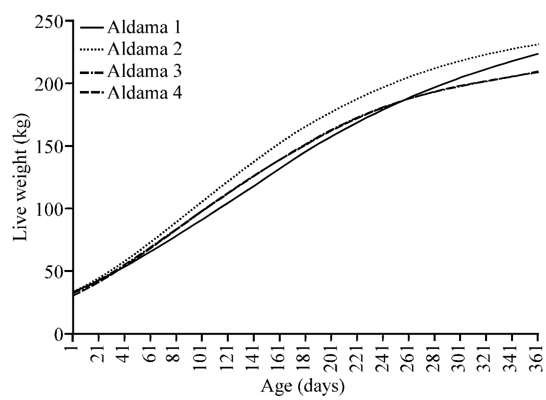

Fig. 2: Estimated weights with the Richards' model

To estimate the requirements of Dry Matter Intake (DMI) and net energy gain, the estimation module of the system requirements was used which is based on prediction equations for beef cattle published by NRC (1988, 2000) that are characterized by the emphasis between the nutrient contribution to the diet and the bovine requirements. As shown in Fig. 3, requirements take the sigmoid shape to be calculated in function of live weight. Under this approach, it is possible to know in a

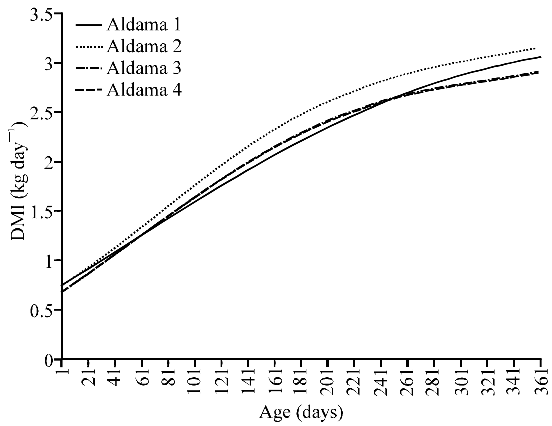

Fig. 3: Dry matter intake requirement

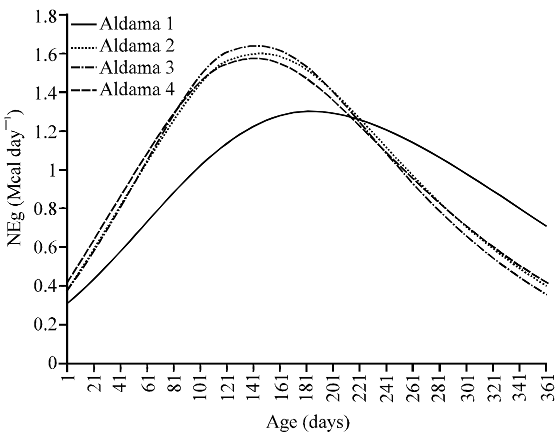

Fig. 4: Requirement of net energy gain (Mcal day^{-1})

dynamic way the requirements and the relationships among them. Figure 4 shows the net energy requirement for gain where it reaches its maximal value at about 5 months to then diminish since, this is calculated on the basis of live weight and daily weight gain. To know the DMI for a given period (1 year in the cases under study) allows producers to calculate the forage amount needed to feed cattle amount of concentrate feed, surface to produce the forage, amount of fertilizer, necessary agricultural inputs, doses of veterinary medicine, etc. It is possible that starting from the information generated by this system a future scenario will be formed as well as to organize needs and future activities for cattle raising and exploitation.

To verify the results generated by the adjustment module, comparative adjustments of the same data were carried out using the statistical packages Curve expert 1.4 and Number Cruncher Statistical Software (NCSS), 2007. In the Curve expert program, the same initial values for the Richards model parameters were used (Table 2). In the NCSS, it was not possible to consider these values

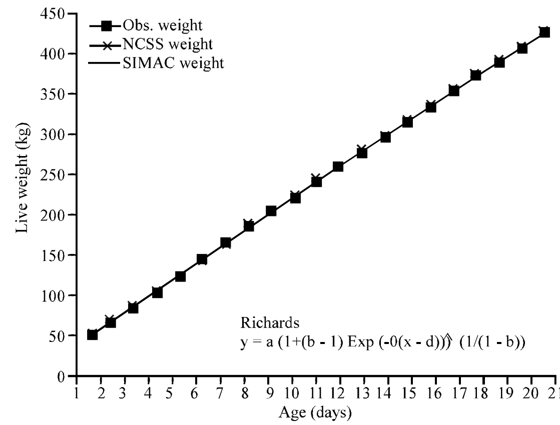

Fig. 5: Estimated and observed weights for Holstein cattle

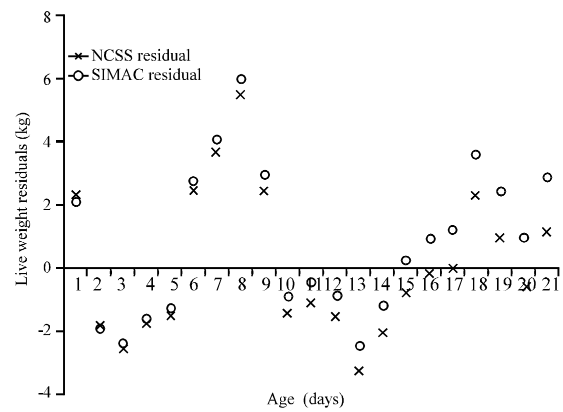

Fig. 6: Residuals of the estimated weights through SIMAC and NCSS

Table 3: Obtained values of X^2

Models	SIMAC	Curve expert	NCSS
Aldama 1	76.14	346.56	2.53
Aldama 2	40.42	1491.60	0.00
Aldama 3	0.39	220.99	0.00
Aldama 4	12.38	245.34	0.00

since, it generated an overflow error and the option of automatic generation of initial values of the parameters was selected. To quantify the differences between the estimated and observed weights table of residuals is shown in Table 3. From Table 3, the best adjustment was obtained by the NCSS, 2007 followed by the SIMAC and finally, the program Curve expert. The following exercise (Fig. 5) considers ages and weights of Holstein cattle taken from Brody (1945). From these data, his growth model is adjusted. Some comparisons between SIMAC and NCSS are analyzed and established. Figure 5 shows the behavior of observed and estimated values for the two systems. Both models provide a good degree of adjustment (Fig. 6), it is observed that the growth rate increases until, it reaches the inflexion point and then decline if this behavior is extrapolated, the growth rate would approach the x-axis with increasing age of cattle.

CONCLUSION

The SIMAC differs from other systems for the adjustment of models in the a. posteriori management of the obtained results. Once the model is adjusted, results allow calculate and plot the dependent variables as well as to estimate the nutrition requirements of cattle. The SIMAC can be used as a tool for the analysis of factors affecting production efficiency in cattle growth and do sensibility analysis of the amount of nutrients required for the growth estimated.

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