Comparison of Non-Linear Growth Models to Describe The Growth Curves in Fattening Friesian Crossbred and Buffalo Male Calves

Salem,M.M.I.; EL-Hedainy, Dalia, K.A.; Latif, M.G.A and Mahdy, A.E.
Department of Animal Production, Faculty of Agriculture, Alexandria University, Egypt

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ABSTRACT

The Brody, Gompertz, Logistic and Bertalanffy models were used to estimate growth curves of Friesian crossbred and Buffalo male calves during fattening period. The data consisted of 2583 and 847 weight performances of 405 Friesian crossbred and 122 buffalo male calves, respectively. Comparisons between these functions were based on coefficients of determination and absolute mean residual deviations. The estimated A-parameters were 450&420, 450&420, 574&581 and 450&420 for Friesian crossbred and buffalo calves in the four models, respectively. The respective estimated b-parameters were 146&150, 150&150, 99.91&99.99 and 100&100 while, the estimated k-parameters were 0.196&0.249, 0.848&0.864, 1.086&1.09 and 1.086&1.00. Brody model was more appropriate in describing growth curves of both Friesian crossbred and Buffalo calves.

Key words: buffal

INTRODUCTION

Growth, or 'gain in weight', has a crucial effect on the commercial value of livestock. The value of animals which are to be sent for slaughter depends mainly on: 1) the amount of muscles on the carcasses, 2) the quantity, in broad meaning; the body weight which is strongly associated with other economic characters including production and reproduction traits. Therefore, selection programs designed to alter growth in cattle will ultimately cause permanent changes in the associated traits. Knowledge of growth curve specifications is important to animal scientists in various specializations, especially those who are dealing with the effects and making recommendations on lifetime production efficiency (Fitzhugh, 1976).Animal growth can be predicted by observing the change in body weight at certain ages like birth weight, weaning weight, yearling weight and slaughter weight or by plotting body weights against age using mathematical growth models (Bathaei and Leroy, 1996). Growth models describe the patterns of growth of animals and summarize the information needed to understand the biological phenomenon of growth into few meaningful biological parameters, which is consequently, an important component in beef production systems (Menchaca et al. 1996). Comparison of these models is important to assist the choice of the most appropriate to describe a set of data.

The model objective of this work was to compare different non-linear models to describe the growth curves for crossbred cattle and buffalo male calves during the fattening period.

MATERIALS AND METHODS

Animals and management

The present investigation was conducted on male buffalo (BU) and Friesian crossbred (FC) calves which belong to the Feeds and Fattening Unit, Faculty of Agriculture, Alexandria University. Before the commencement of the work, calves were subjected to vaccination, then to a treatment program throughout the period of fattening. Calves were housed free in open semi shaded yards and were group fed on concentrates and roughages. Their feed requirements were calculated according to NRC (2001) on basis of the average body weight of each group. The allowances were altered every 15 days to match with the increase in weight. The concentrate ration was fed either as pelleted commercial mixture or as a mixture of crushed yellow corn, wheat bran, un-decorticated cotton seed cake, molasses, limestone, salt and mineral mixture. Either concentrate rations were equal in their nutritive value which was around 14.3% TP and 65.7% TDN. Chopped wheat straw was offered with the concentrate diet at the rate of 1% of average body weight. Berseem (*Trifolium alexandrinum*) was also offered daily from November to April. While, sorghum was offered from May to September. These green fodders were fed at the rate of 5 kg/ head /day. Fresh clean water was freely available all the time. The calves were weighed monthly throughout the fattening period which lasted for 6 months. Weighing was done at 9 a.m. after about 15-16 hours fasting period.

Data and statistical analysis

The Data set which consisted of 2583 and 847 weight performances of 405 FC and 122 BU male calves, respectively, were recorded monthly during the fattening period which lasted for 7 months. The animals were around 12 months of age at the beginning of fattening period. The growth curves were fitted using four non-linear models (Fitzhugh, 1976) using NLIN procedure (SAS 9.2, 2008). These models were described as follow:

1) Brody model: $W_t = A (1-be^{-kt})$,
2) Gompertz model: $W_t = A \exp(-be^{-kt})$,
3) Logistic model: $W_t = A / (1+be^{-kt})$,
4) Von Bertalanffy: $W_t = A (1-be^{-kt})^3$

Where W_t is the observed weight at age t expressed in months, and A is the asymptotic limit of the weight when age approaches infinity mature weight, and b indicates the proportion of the asymptotic (mature weight) to be gained after birth, established by the initial values of W and t (initial weight) and k is a function of the ratio of maximum growth rate to mature weight, normally referred to as maturing rate.

Selection the criteria used for assessing select on of the best non-linear model that describe the growth curve were coefficient determination (R^2)and absolute mean residual deviation (MAD), as proposed by Sarmento et al. (2006):

$$MAD = \frac{\Sigma_{i=1}^{n} |Y_i - \hat{Y}_i|}{n}$$

Where Y_i is the observed value, $\hat{Y}_i$ is the estimated value and n is the sample size. The higher R^2 and the lower MAD values determine the best model.

RESULTS AND DISCUSSION

The estimated parameters of growth curves from the four non-linear models, R^2 and MAD are shown in Table (1) for FC male calves and in Table (2) for BU male calves. Growth curves for observed and predicted data are shown in Figure (1) for FC male calves and in Figure (2) for BU male calves. A-parameters were similar for all studied models (450 kg) except logistic which was higher (574 kg) for FC. The same tend was observed for BU. A-parameter was 420 kg for all models but was higher for logistic model (581 kg). For b- parameter, Gompertz and Brody models showed quite similar values around 150 kg for FC and BU. Logistic and Bertalanffy models had smaller but similar values ranging between 99 – 100 kg. For FC and BU. K-parameter was similar within model for FC and BU. High and similar values were found for logistic and Bertalanffy models followed by Gompertz model and the lowest value was found for Brody model. Coefficient of determination (R^2) and MAD were used to evaluate the models and to select the best describe the growth of these particular groups of animals. Brody model recorded the highest R^2 which was similar for FC and BU (97.76 and 97.40, respectively). The logistic model had the second highest R^2 for both species (66.19 and 65.23, respectively). Bertalanffy model was inadequate to describe this type of data. R^2 were entirely zero for FC and BU. Gompertz model recorded mild R^2 of 32.66 for BU and almost zero for FC indicating a weak response of this data to Gompertz and Bertalanffy models. MAD criteria, though accounted for different values for FC and BU, produced trends similar to those of R^2 . Brody model was the best fitted for FC and BU data followed by logistic then Gompertz models. Bertalanffy model was inappropriate to describe this data.

Brown et al. (1976) studied the growth curves of crossbred beef females from Angus-Hereford-Brahman using non-linear models and found that the Brody model was the best breeds to describe this data followed by Bertalanffy model then Gompertz model but the logistic model was less adequate. Forni et al. (2009) compared several nonlinear functions for describing the growth curves of females cattle Nelore and found that Brody model was the most adequate in describing the growth curve as compared with Gompertz, Logistic and Bertalanffy models. Similar results were found by Gbangboche et al. (2008) who reported that the Brody model was the best to describe the growth curves from birth up to 180 days of age in West African Dwarf lambs followed by Bertalanffy then Gompertz and finally the Logistic model. On the other hand, Malhado et al. (2009) utilized Brody, Bertalanffy, Logistic and Gompertz functions to describe the growth of Dorper X Morada Nova, Dorper X Rabo Largo and Dorper X Santa crossbred sheep from birth up to 210 days of age and found that both Gompertz and Logistic models presented the best. Also, Ben Hamouda and Atti (2011) fitted the growth curve for Babarine lambs from birth till 120 days of age and found that the Bertalanffy function provided more accurate estimation than Brody, Gompertz and Logistic functions.

Similarly,the Brody model was suggested to be the most appropriate to describe beef cattle growth, because of its goodness of fit, computational simplicity, interpretability of parameters (Bullock et al., 1993; Kaps et al., 2000; Arango and Van Vleck, 2002).

CONCLUSIONS

Comparing non-linear models to describe the growth curve during fatting period of FC and BU male calves showed the same appropriate trends of results and confirmed that the Brody model was the best to describe the growth curve when fattening cattle.

Table 1: Growth curve parameters, coefficients of determination (R^2), and absolute mean residual deviations (MAD) of growth models in Frisian crossbred calves

Model	Parameter			R^2	MAD
	A	b	K		
Brody	450±13.4	146±2.1	0.196±0.0	97.8	0.8
Gompertz	450±408.6	150±349.3	0.848±0.5	0.0	467.7
Logistic	574±23.5	99.91±22.4	1.086±0.1	66.2	3.3
Bertalanffy	450±134257	100±9845	1.086±0.1	0.0	-

Table 2: Growth curve parameters, coefficients of determination (R^2), and absolute mean residual deviations (MAD) of growth models in buffalo calves.

Model	Parameter			R^2	DMA
	A	b	K		
Brody	420±16.4	150±4.0	0.249±0.0	97.4	1.6
Gompertz	420±506.4	150±515.8	0.864±0.8	32.7	8.3
Logistic	581±41.5	99.90±40.3	1.09±0.1	65.2	5.9
Bertalanffy	420±221251	100±17384	1.0±3.0	0.0	-

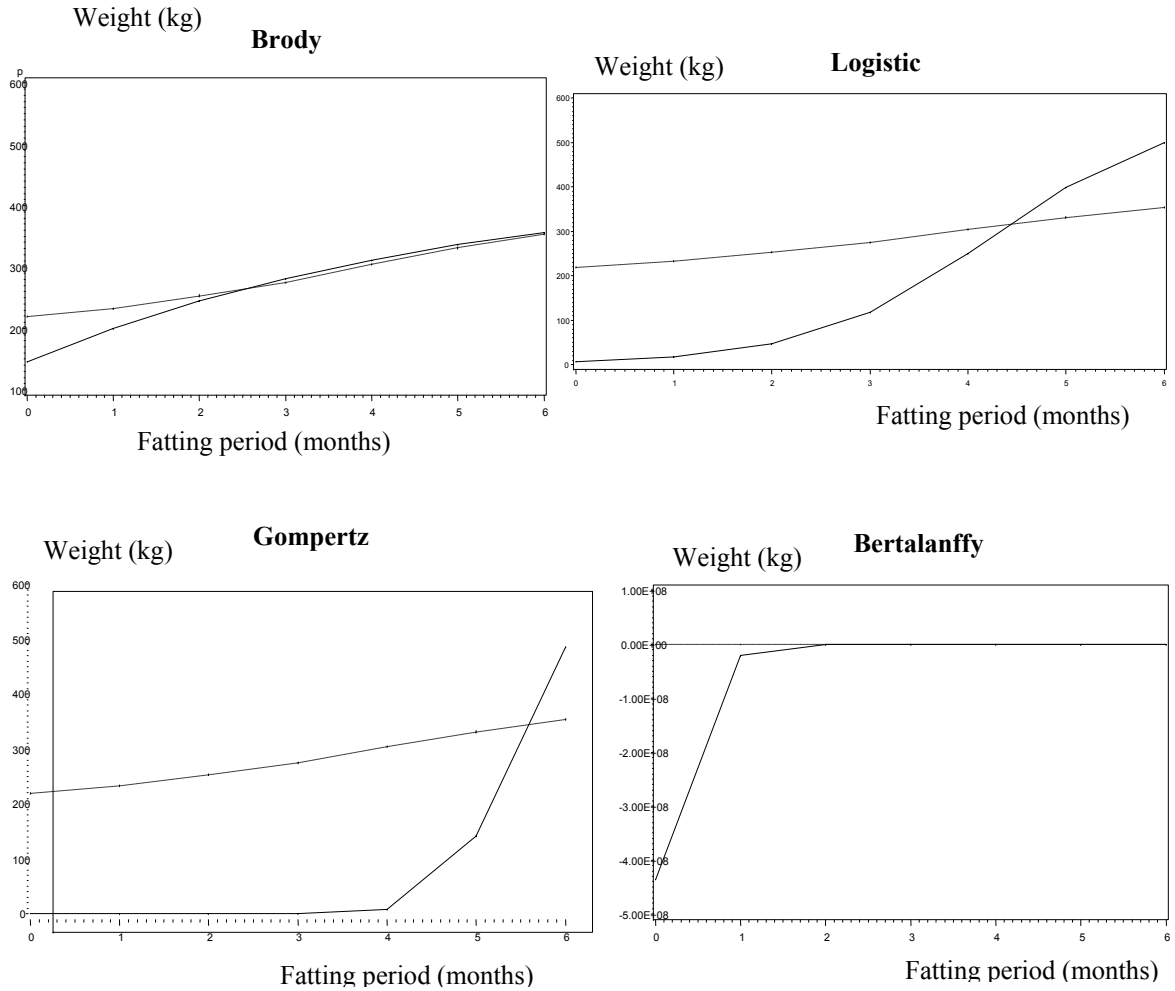

Figure 1: observed (---) and predicted (—) growth curves in Frisian crossbred during fatting period.

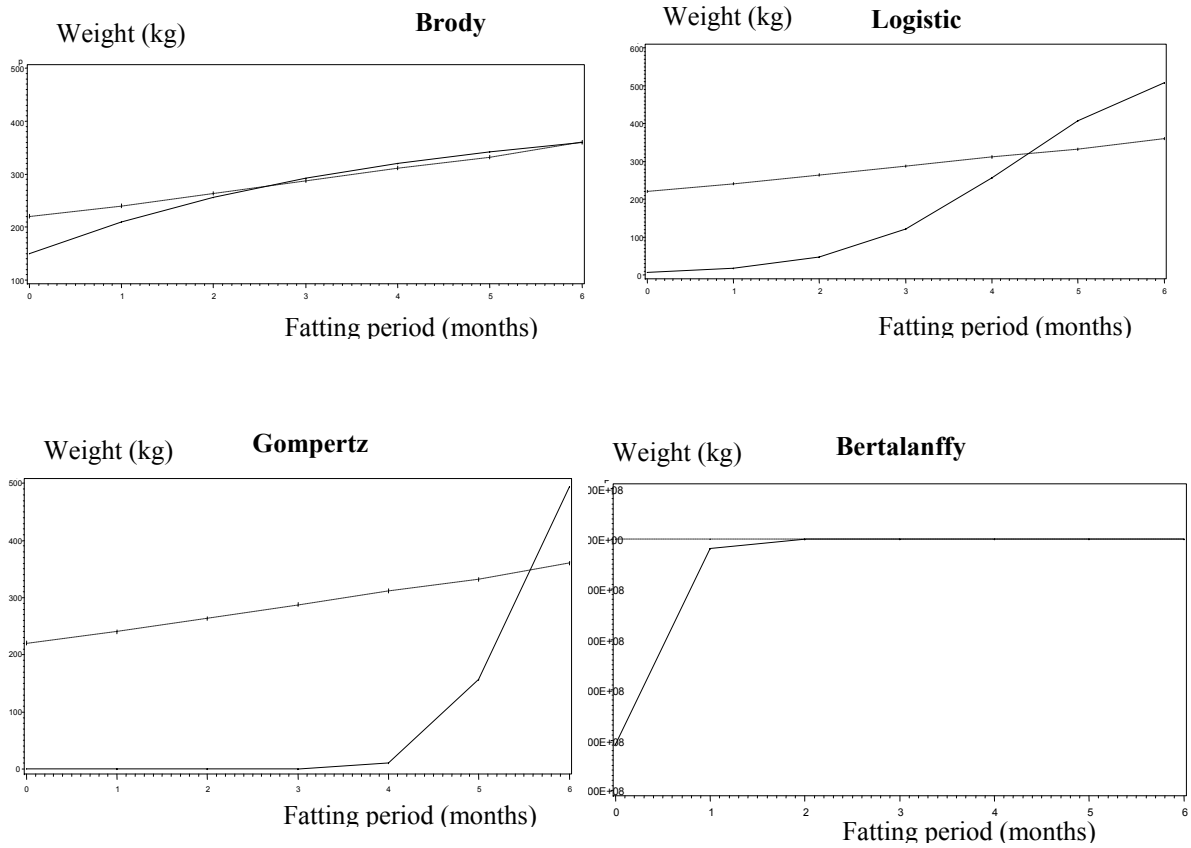

Figure 2: observed (---) and predicted (—) growth curves in buffalo calves during fatting period.

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الملخص العربى

مقارنة بين نماذج المعادلات الغير خطية لوصف منحنيات النموواثناء التسمين في عجول الفريزيان الخليطة والجاموس

محمد محمود سالم، داليا قاسم عبد المنعم الحديني، محمد جمال الدين عبد اللاطيف واحمد الطاهر مهدي

قسم الانتاج الحيواني- كلية الزراعة الشاطبي- جامعة الاسكندرية

اجريت هذه الدراسة بهدف مقارنة نماذج المعادلات الغير خطية (Brody, Gompertz, Logistic and Bertalanffy) لوصف منحني النمو في عجول الفريزيان الخليطة والجاموس اثناء التسمين. شملت البيانات المستخدمة في هذه الدراسة ٢٥٨٣ سجل لعجول الفريزيان الخليطة و٨٤٧ سجل لعجول الجاموس. كانت تقديرات المعيار A ٤٢٠&٤٥٠، ٤٢٠&٤٥٠، ٥٨١&٥٧٤، ٤٢٠&٤٥٠ لعجول الفريزيان الخليطة والجاموس في نماذج النمو الاربعة المدروسة علي الترتيب.

وكانت تقديرات المعيار b ١٥٠&١٤٦، ١٥٠&١٥٠، ٩٩.٩٩&٩٩.٩١، ١٠٠&١٠٠ لعجول الفريزيان الخليطلة والجاموس في نماذج النمو الاربعة المدروسة علي الترتيب. اما المعيار k فكانت تقديراته ٠.٢٤٩&٠.١٩٦، ٠.٨٦٤&٠,٨٤٨، ١.٠٨٦& ١.٠٩، ١.٠٠&١.٠٨٦ لنفس العجول، علي الترتيب. اكدت المقارنة بين النماذج الاربعة المدروسة باستخدام معامل التقدير ومتوسط انحراف الخطأ المطلق ان نموذج Brody هو افضل النماذج لوصف منحني النمو في عجول الفريزيان الخليطة والجاموس خلال فترة التسمين حيث انه سجل اعلي قيمة معامل تقدير واقل قيمة لمتوسط انحراف الخطأ المطلق.