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Full length Research paper

Estimation of growth curve of Horro (Zebu) and their crosses calves using Gompertz model

Habtamu Abera

Oromia Agriculture Research Institute, Bako Agricultural Research Center P.O. Box 03, Bako, Ethiopia
HMaassee@gmail.com

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The estimate growth curve of birth weight, weaning and one year weight of Horro and their crosses with Holstein Friesian-Horro (FH) and Jersey-Horro (JH) calves were investigated by using gompertz model on data collected from Bako Agricultural Research center during the year 1980-2008. Least squares means and growth curves were analysed using General Linear Model (GLM) of Statistical Analyses System (SAS). Environmental factors were the effects on mature weight (A), proportion body weight gained after birth (B) and maturing rate (k) parameters of the growth curve. The overall means of growth curve parameters were 83.7±0.93 kg, 1.4±0.012 and 0.015±0.00 for mature weight (A), proportion body weight gained after birth (B) and maturing rate (k), respectively. Coefficient of variations (CV) of A, B and K parameters were 24%, 18% and 221%, which implies there is much more variation in maturing rate (K), followed by mature weight. Degree of maturity at birth, weaning and one year were 0.25, 0.69 and 0.99, respectively, for Horro and their crossbred cattle. Therefore, development of a growth model that describes the growth pattern of a herd within a particular environment and management system may be useful to determine the relative importance of factors affecting production efficiency.

Keywords: Crosses, Gompertz model, growth curve, Horro, maturity rate

INTRODUCTION

Growth curves are used for investigating optimum feeding programmes, determining optimum slaughtering age and the effects of selection on curve parameters and on live weight at a certain age of calves. Growth to a certain age, apart from milk production, is the most common trait to be focused upon in genetic improvement programs (both selection and crossbreeding) of cattle. An optimum growth curve could be obtained by selection for the desired values of growth curve parameters (Bathaei and Leroy, 1998). Growth is not a selection trait in dairy cattle breeding, however, there is a possibility to influence the length of non-productive period, i.e. replacement heifer rearing and associated with economic efficiency of the whole herd (kratochvílová et *al*., 2002). Knowledge of growth curves is important to all animal scientists who are concerned with the effects of their research and recommendations on lifetime production efficiency (Fitzhugh, 1976). Some nonlinear models are used to describe lifetime relationships between individual's inherent impulse to grow and mature in all body parts. This relationship for growing animals, called a smooth S-shaped curve, obtained from nonlinear models such as Brody, von Bertalanffy, Gompertz, Richards or Logistic (Koops, 1986).The shape of growth curves has been reported to vary according to the species of animal, the environment and the trait (Efe, 1990; Akbaş *et al*., 1999; Topal *et al*., 2004). Growth curve significantly affected by year of birth, sex, parity and breeds reported by (DeNise and Brinks, 1985; Solomon 2002).

Comparative analyses of growth curves in cattle were reported by Brown *et al.,* (1976), Sager (1983), DeNise and Brinks (1985), Perotto *et al.,* (1992), and Matthes *et al.,* (1996). Growth patterns of cattle were described by Brody function (Marshall *et al*., 1984; Koenen and Groen, 1996) and Gompertz (Meyer, 1995; Nešetřilová *et al*., 1999). The Gompertz models generally provided the best fit and adequately describe the postnatal growth of many mammals and the growth path of chickens (Hurwitz *et al*., (1991). No previous information has been reported on growth curve characteristics of the Horro and their crossbreeds' cattle breeds. Therefore, estimation of growth curve by using gompertz model will provide information on growth parameter of in Horro (Zebu) and crosses of Holstein Friesian and Jersey cattle breeds.

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MATERIALS AND METHODS

Study site

The data was generated from Bako Agricultural Research Centre of livestock farm on Horro and their crosses breed cattle during the year 1980-2008. The Bako Agricultural Research Centre is located at about 258 km West of Addis Ababa at an altitude of 1650 m above sea level. The Bako Agricultural Research Centre lies at about 09°6'N and 37°09'E. The area has a hot and sub humid climate and receives a mean annual rainfall of about 1220 mm, of which more than 80% falls in the months of May to September. Mean monthly minimum and maximum temperatures are about 14°C and 28°C, respectively, with an average monthly temperature of 21°C. The daily mean minimum and maximum temperatures are 9.4°C and 31.3°C, respectively. Potential evapotranspiration average 60 mm per month (Abebe, 1998). The soil belongs to Alfisols series and it is clay in texture (Piccolo and Assefa, 1983), reddish brown in color with pH ranging from 5.3-6 (Dawit and Leggesse, 1987) and cation exchange capacity of 18.3 me/100g (Sahlemdhin and Ahmed, 1983). Total (Piccolo and Assefa, 1983) and available (Sahlemdhin and Ahmed, 1983) phosphorous content of the soil was estimated to be about 475 parts per million (ppm) and 2.2ppm, respectively. The vegetation cover of the area is woodland and open wood grassland type. The dominant pasture species include Hyperhenia (*Hyperhenia anamasa*) and Sporobolus (*Sporobolus prraminmidalis*) grasses and the legume Neonotonia (*Ninotonia wighti*) (Lemma *et al.*, 1993).

Management of calves at Bako Agricultural Research Center

Calves were separated from their dams at birth, weighed and fed colostrums from a bucket for the first five days of life. A total of 227 liter of milk was fed to each calf and a concentrate mix (49.5% ground maize, 49.5% noug seed cake and 1% salt) were offered until weaning (three months), then after both calves (male and female) were kept indoors (day and night) until six months of age in individual pens except for about two hours of exercise in a nearby paddock every day. After six months of age, weaned calves were maintained on natural pastures for approximately eight hours a day and supplemented with silage or hay *adlibitum* during the night and were kept as a group (male and female separately),where concentrate were supplemented to heifer calves only on availability.

Data Collection and Preparation

A total of 1090 calves' records were used in which produced from 184 sires and 710 dams, born from 1980 to 2008 years for description of growth curve from birth to one year of age . Data were extracted from birth weight (BW; weight taken within 24 hours of birth); weaning weight (WW; weight recorded at three months of age) and one year weight (YW; weight recorded at 12 month age). Daily gains were calculated by dividing the difference between the initial and final weight with the number of days.

Estimation of growth curve

The following Gompertz function that is suitable for shape of growth curve in cattle (Meyer, 1995; Kratochvilová *et al*., 2002) was chosen to estimate individual curve parameters:

$Y_t = A*exp(-B*exp(-K*t)$

where Y_t= is body weight (BW) at time t (age of animal since birth), A is asymptotic BW (final or mature BW), B is the integration constant which is time scale parameter and related to birth weight (W0) as B=ln(A/W0). The parameter K is the relative growth rate. To understand the shape of the growth curve, age (t*), weight (W*), maximum weight gain (K*) at time of inflection point where growth rate is maximum were calculated as t*=ln(B)/K; W*=A/e and k*=A*K/e, respectively. Where e is base of natural logarithm (2.71828).In addition to that degree of maturity (U_t), proportion of mature size attained at age t ($U_t = Y_t/A$) at birth, weaning and twelve months of age were considered. The functions were fitted to weight (kg)-age (days) data from each animal using the nonlinear procedure (NLIN) of Statistical Analysis System (SAS,). A fixed effect model were year of birth, sex (male and female), parity and breeds were fitted using the General Linear Model procedure of SAS (2004) in order to identify environmental effects which affect growth curve parameters. The convergence criterion to be used is as follows $(SSE_{i-1}-SSE_i)/(SSE_i + 10^{-6})<10^{-8}$ Where SSE_i is the residual sum of squares for the i^{th} iteration.

RESULTS AND DISCUSSION

Effects of breeds, parity, sex, and year of birth on growth curve parameters estimates and weights are presented in

Table 1. Effects of breeds, parity, sex, and year of birth on growth curve parameters

Effect	Level	N	Weight (kg)	A (kg)	B	K
Overall		1090	41.8±28	83.7±0.93	1.4±0.012	0.015±0.00
Year			Ns	**	Ns	Ns
	1980	45	55±4.5	92.9±3.2	1.3±0.04	0.04±0.00
	1981	37	45±4.9	79.7±3.4	1.3±0.04	0.023±0.00
	1982	44	33±4.5	67.5±3.2	1.3±0.04	0.018±0.00
	1983	12	26±8.3	73.8±5.8	1.5±0.07	0.012±0.00
	1984	16	42.4±7.2	89±5.0	1.5±0.07	0.009±0.00
	1985	19	47.3±6.6	95.8±4.7	1.5±0.06	0.011±0.000
	1986	17	37±7.0	93.2±4.9	1.5±0.06	0.023±0.000
	1987	28	41±5.5	86.8±3.8	1.6±0.05	0.009±0.00
	1988	42	51±4.5	93.6±3.2	1.5±0.04	0.011±0.00
	1989	19	48±6.6	95±4.6	1.7±0.07	0.011±0.00
	1990	16	43±7.2	87.9±5.1	1.8±0.07	0.016±0.00
	1991	16	30±7.2	77.1±5.1	1.3±0.07	0.010±0.00
	1992	35	36±4.9	67.7±3.4	1.4±0.05	0.016±0.00
	1993	19	43±6.6	86.7±4.6	1.5±0.06	0.013±0.00
	1994	34	38±5.0	81.2±3.5	1.4±0.05	0.013±0.00
	1995	44	42±4.4	88±3.0	1.5±0.04	0.013±0.00
	1996	37	44±4.6	87.2±3.3	1.5±0.05	0.012±0.00
	1997	32	37±5.1	86.9±3.6	1.4±0.05	0.014±0.00
	1998	40	24±4.6	101±3.3	1.7±0.04	0.008±0.00
	1999	38	31±4.9	88.6±3.6	1.5±0.05	0.010±0.00
	2000	65	35±4.7	83.5±3.7	1.5±0.04	0.013±0.00
	2001	45	33±4.5	78.7±3.2	1.4±0.04	0.011±0.00
	2002	54	30.±4	77.8±2.8	1.3±0.04	0.014±0.00
	2003	65	35±3.5	79.8±2.6	1.4±0.04	0.014±0.00
	2004	69	46.±3.7	92.5±2.6	1.6±0.04	0.011±0.00
	2005	41	25±4.5	94.8±3.2	1.6±0.04	0.013±0.00
	2006	63	41±3.7	78.8±2.6	1.4±0.04	0.016±0.00
	2007	64	40±3.6	58.2±2.6	1.2±0.04	0.022±0.00
	2008	34	58±3.8	59.7±3.6	1.1±0.05	0.019±0.00
Parity			Ns	*	Ns	Ns
	1	314	40±1.7	83±1.3	1.49±0.02	0.018±0.00
	2	246	42±2.1	84±1.4	1.43±0.02	0.013±0.00
	3	184	44±2.2	86.2±1.6	1.46±0.02	0.014±0.00
	4	140	43±2.7	85±1.8	1.46±0.02	0.014±0.00
	5	94	37±3.2	82±2.2	1.42±0.03	0.017±0.00
	6	59	35±3.9	81.7±2.8	1.4±0.013	0.014±0.00
	≥7	53	37±4.3	82.8±3.0	1.46±0.04	0.014±0.00
Sex			Ns	*	Ns	Ns
	Male	537	38±1.5	81.2±1.1	1.42±0.015	0.013±0.00
	Female	553	40±1.5	86±1.1	1.47±0.015	0.016±0.00
Breeds			Ns	**	Ns	Ns
	HH	546	44±1.5	74.9±1.1	1.42±0.015	0.013±0.00
	FH	369	38±1.7	91.9±1.2	1.45±0.017	0.013±0.00
	JH	175	35±2.4	83.9±1.7	1.47±0.02	0.019±0.00
CV (%)			67	24	18	221
R^2			0.095	0.32	0.26	0.047

* =P<0.05; **=P<0.01; Ns=not significant; HH= Horro; FH= Holstein Friesian-Horro; JH= Jersey-Horro

The overall means of growth parameters were 83.7±0.3 kg, 1.4±0.012 and 0.015±0.00 for A, B and K, respectively. Least squares means in the different years ranged from 58 to 101 kg for A, 1.1 to 1.8 for B and 0.8 to $4x10^{-2}$ for k, respectively. Year of birth had a significant (P<0.05) effect on weight of the growth curve. Similar significant effects of year of birth on mature weight of sheep have been reported by Stobart *et al*. 1986; Pitchford; 1993 and Bathaei and Leroy 1996 and for cattle (López de Torre and Rankin, 1978 as cited by Solo

Table 2. Parameter estimates for growth curve of Horro cattle and their crosses

Parameters	Estimate
A	83.7±0.3
B	1.4±0.012
K	0.015±0.0004
Wo	20.6
t* (day)	22.4
W* (kg)	30.79
K*(per day)	0.46
Ut(birth)	0.25
Ut (weaning)	0.69
Ut (one year)	0.99

Age (t*), weight (W*), maximum weight gain (K*)

-mon, 2002). Year of birth had a significant (P<0.05) effect on mature weight (A) and proportion body weight gained after birth (B) parameters of the growth curve. This is in agreement with DeNise and Brinks (1985) who reported year of birth had an effect on the mature weight (A), proportion body weight gained after birth (B) and maturing rate (k) parameters of Brody's curve. The coefficient of determination (R^2) for all traits indicated that the fixed model fitted, explained only less than half of the total variability.

Coefficient of variations (CV) of A, B and K parameters were 24%, 18% and 221%, which implies there is much more variation in maturing rate (K), followed by mature weight. Similar high CVs for K in cows were reported by López de Torre *et al*. (1992), but in this instance CV was lowest for mature weight. It appears that animals achieve similar mature weight though their rate of growth (maturity) varies which is in agreement with results of Solomon (2002). In this study body weight at age of point of inflection, maximum weight gain at point of inflection and age at the inflection point were found 31.79 kg, 0.46 kg/day and 22.4 day, respectively (Table 2).

Sex had a significant effect on A (P<0.01) but non-significant effect on B and K. Females have faster maturing rates than males, however, the difference is not statistically significant for both B and K, whereas, the A value of female was heaver by 4.8 kg than the male. Solomon (2002) reported that A value of males have higher than the female, but rate of maturing females are faster for Horro sheep.

Using the Gompertz function Lewis *et al.* (2002) estimated values of A for males, which is about 1.27 times that for females. As opposed to the finding in the current study Brown *et al*. (1972a) found that in Hereford and Angus cattle, males mature faster than females. Parity had a significant effect on A (P<0.01) but non-significant effect on, weight, B and K. The calves born from the second, third and fourth parity were higher A values while the calves born from fifth, six and above seven lower A values.

Similarly lambs from young and first parity ewes are born with lighter weights than lambs from older and advanced parity ewes, and a higher proportion of their mature weight is gained after birth (Solomon, 2002). Breed has a significant (P<0.01) effect on weight, parameter A of the growth curve, but non significant effects on B and K. Friesian-Horro crosses were 16.7 kg and 7 kg heavier than pure Horro and Jersey-Horro crosses, respectively. However, the maturing rate was comparable in each breed. Mean values of growth parameters for body weight in Horro, Holstein Friesian-Horro and Jersey-Horro, were: 74.9±1.1, 91.9±1.2 and 83.9±1.7kg for mature weight 1.42±0.015, 1.45±0.017 and 1.47±0.02 for integration constant 0.013±0.00, 0.013±0.00 and 0.019±0.00 for maturity rate per day, respectively. Akbas *et al*. (2006) reported that Piemontese x Limousin cattle had higher maturing rate than Friesian and Limousin x Friesian. This finding is in consistent with other findings which reported no significant differences in growth rate (López de Torre *et al*. 1992; Akbas *et al*. 2006). Degree of maturity at birth, weaning and one year were 0.25, 0.69 and 0.99, respectively, for Horro cattle and their crossbred cattle. Kratochvilová *et al.* (2002) and Akbas *et al*. (2006)) reported degree maturity at birth 0.078 and 0.053 for Holstein Friesian and their crosses, respectively.The higher degree of maturity in the present study is due to limitation of data to one year age only though growth curve under ideal condition needs weight to maturity. The average age at maturity for Horro and their crosses is 4 and 2 year reported by Mulugeta (2003). More meaningful growth curve parameters can be obtained from data extending to maturity (two to four year), however, in the current study due to distribution of crossbred heifers to farmers and culling of male animals before maturity were limited to one year weight.

CONCLUSIONS AND RECOMMENDATION

The gompertz growth model was using to estimate the growth parameters of A, B and K for birth weight, weaning and one year weight of Horro and their crosses with Holstein Friesian-Horro (FH) and Jersey-Horro (JH) calves. The growth parameters affected by year of birth, breed, parity and sex. Estimate of growth curve parameters in Horro cattle and their crosses was found to be quite different from previous report elsewhere. This is what can be expected since the growth data used were up to one year of age. The A and k parameters, represent the mature weight and the growth rate (maturing rate) respectively, thus being practically the most important components of the growth function. Therefore, development of a growth model that describes the growth pattern of a Horro and crossbred cattle within a particular environment and management system may be useful to determine the relative importance of factors affecting production efficiency. More meaningful growth curve parameters can be obtained from data extending to maturity, however, in the current study due to distribution of crossbred heifers to farmers and culling of male animals before maturity were limited to one year weight.

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REFERENCES

Akbaş Y, Alçiçek A, Önenç A, Güngör M (2006). Growth curve analysis for body weight and dry matter intake in Friesian, Limousin x Friesian and Piemontese x Friesian cattle. Arch.Tierz. Dummerstorf. 49: 329-339.

Bathaei SS, Leroy PL (1998). Genetic and phenotypic aspects of the growth curve characteristics in Mehraban Iranian fat-tailed sheep. *Small Rumin. Res. 29: 261-269.*

Brown JE, Brown JC, Butts WT (1972a). A discussion of the genetic aspects of weight, mature weight and rate of maturing in Hereford and Angus cattle. *J. Anim. Sci. 34: 525-537.*

Brown JE, Fitzhugh HAJ, Cartwright TC (1976). A comparison of nonlinear models for describing weight-age relationships in cattle. J. Anim. Sci. 42: 810-818.

DeNise-Kersey RS, Brinks JS (1985). Genetic and environmental aspects of the growth curve parameters in beef cows. J. Anim. Sci. 61: 1431-1440.

Hurwitz S, Talpaz H, Bartov I, Plavnik I (1991). Characterization of Growth and Development of Male British United Turkeys. Poultry Science, 70: 2419-2424.

Kachman SD, Gianola D (1984). A Bayesian estimator of variance and covariance components in nonlinear growth models. *J. Anim. Sci. 59: p.176*.

Kratochvilová M, Hyánková L, Knížetová H, Fiedler J, Urban F (2002). Growth curve analysis in cattle from early maturity and mature body size viewpoints. Czech J. Anim. Sci., 47:125-132.

López de Torre G, Candotti JJ, Reverter A, Bellido MM, Vasco P, García LJ,Brinks JS(1992). Effects of growth curve parameters on cow efficiency. J. Anim. Sci. 70: 2668-2672.

López de Torre G, Rankin BJ (1978). Factors affecting growth curve parameters of Hereford and Brangus cows. *J. Anim. Sci. 46: 604-613.*

Meyer K (1995). Estimates of genetic parameters and breeding values for New Zealand and Austraian Angus cattle. *Aust. J. Agric. Res.46: 1219-1229*.

Mulugeta K (2003). An Evaluation of Reproductive performance of Horro cattle in Ethiopia. 2003. Ph.D. Thesis. Free State University, Texas, South Africa. P.48.

Solomon A (2002). Genetic evaluation of production, reproduction and survival in a flock of Ethiopian Horro sheep. Ph .D. Thesis, University of Free State Bloemfontein, South Africa. Pp.10-47.

Theron HE, Scholtz MM, Roux CZ (1994). Genetic relationship between growth traits in Bonsmara heifer and bull calves on different nutritional regimes. S. Afr. J. Anim. Sci. 24: 67-70.

Webster AJF, Ahmed AAM, Frappell JP (1982). A note on growth rates and maturation rates in beef bulls. *Anim. Prod. 35: 281-284.*