Iranian Journal of Applied Animal Science

Comparison of Growth of Male and Female Kids of Nondescript Goats in a Semi Arid Region of Nigeria

Research Article

A.O. Raji[1*], L.G. Asheikh[1] and I.D. Mohammed[1]

[1] Department of Animal Science, University of Maiduguri, Maiduguri, Nigeria

Received on: 26 Jan 2014
Revised on: 20 Apr 2014
Accepted on: 30 Apr 2014
Online Published on: Mar 2015

*Correspondence E-mail: razrajpearl@yahoo.com

Online version is available on: www.ijas.ir

ABSTRACT

This study compared the use of five different models to describe the growth from birth to 20 weeks of age of kids from both genders of nondescript goats. Fifty nine (59) nondescript kids were weighed weekly at the university of Maiduguri livestock teaching and research farm, Nigeria and the live weights were modeled. Biologically relevant variables were estimated for each kid from the Logistic, Gompertz, Richards, Monomolecular and Weibull models. Models were compared using the following goodness of fit criteria: coefficient of determination (R^2), mean square error (MSE), standard deviation (SD) and Akaike information criteria (AIC). In both genders, all nonlinear models fitted the data well, with high R^2 ranging from 0.911 to 0.943 and 0.923 to 0.95 for male and female, respectively. In addition, the males had higher asymptotic weight than females while the reverse was observed with regards to maturing rate. Male kids had heavier inflexion weight and higher age than females for all the models. These values were however higher for Logistic than Gompertz model. The monomolecular model had higher R^2 and lower MSE, SD and AIC in both male and female kids. It can be concluded that the nonlinear growth models were suitable for estimating live weight as a function of age for both male and female of nondescript kids in Nigeria. However, the best model was the monomolecular based on model parameters and goodness of fit criteria.

KEY WORDS body weight, monomolecular model, non-linear models, Richards model.

INTRODUCTION

The world population of sheep and goats increased from 1.35 billion in 1961 to 1.94 billion in 2006 (FAOSTAT, 2008). According to the federal department of livestock, the sheep and goat population estimates in Nigeria at 2009 were 34.69 million and 55.15 million, respectively (FDL, 2010). Goats occupy a strategic position in the socio economic life of the people of the semiarid region of Nigeria with approximately 0.5 goat per head of the human populace. They are kept primarily for meat and contribute substantially to income and food security in most households in rural areas. Growth is defined as an increase in body size of animals per unit time (Kucuk, 2004). Growth, also known as the relation between lifetime weight and age is explained mathematically by functions that have parameters with biological meaning. Growth curves provide sets of parameters that are used to describe growth pattern over time, and to estimate the expected weight of animals at specific ages (Yakupoglu and Atil, 2001).

In addition, the parameters obtained from growth curve functions are highly heritable and have been used in selection studies (Mignon-Grasteau *et al.* 2000). Animal growth models are used to identify alternative strategies to improve the efficiency of livestock production and to estimate daily nutrient requirements for animals of various ages and genetic groups (Schinckel and de Lange, 1996). They have also been used to estimate adult body weight and increase in live weight (Nasholm, 1991; Jenkins and Leymaster, 1993). Animal growth generally follows a sigmoidal pattern (S-shape) and shape and several nonlinear functions have been used to ight as a function of age (Bridges *et al.* 1986). These include Brody, Richards, Gompertz, Logistic, Von Bertalanffy, Weibull, and Morgan-Mercer-Flodin growth models.

Akbas *et al.* (1999) observed that interpretation of growth based on model parameters varied depending on breed and model used. Brisbin *et al.* (1987) suggested that the shape of a growth curve has a greater propensity to change in response to environmental changes more than the asymptotic weight or growth rate and thus it may be used to study the effects of environmental stress on growth. Aggrey (2002) further suggested that the shape of the growth curve may reflect the architecture of body composition and couion and could therefore be used to manipulate the desired body composition at a given age. Therefore, selection for change in the shape of a growth curve may be useful in improving the efficiency of lean meat production. Many authors have reported the Gompertz as the model of choice for poultry, but results in goats have not been consistent. The best model for modeling growth in Alpine a goats was reported to be Gompertz (Kume and Hajno, 2011; Gaddour *et al.* 2012), Weibull in Akecci goats (Kor *et al.* 2006), Brody and Gompertz in Beetal goats (Waheed *et al.* 2011) and Logistic in Cuban Creole goats (Arias *et al.* 2013). In the semiarid region of Nigeria, little information is available on growth modeling of goats. Therefore, the aim of this study was to compare the use of different models to describe growth in kids of indigenous nondescript goats in a semi-arid region of Nigeria.

MATERIALS AND METHODS

Experimental site

The study was performed at the university of Maiduguri livestock teaching and research farm, Maiduguri, Borno State, Nigeria. Maiduguri is located within the Sahelian-West Africa on Longitude 11.38˚ north and Latitude 32.77˚ east and 354 m above sea level (Alade *et al.* 2008).

Climate of the experimental site

Maiduguri experiences a short rainy season (2-4 months) usually between June and September. The rest of the year is too dry. Average annual rainfall is approximately 645 mm with monthly estimates of 138.12 mm, 198.6 mm and 157.4 mm, for July, August and September, respectively. Based on the temperature of this area, the months are grouped into three distinct seasons; dry hot (February-May), wet (June-September) and dry cold (October-January). Relative humidity varies from 5 to 45% and increases from dry to wet season. Temperature range during the dry hot season varies from 39.8 ˚C to 40.7 ˚C. During the wet season temperature can fall to 31.0 ˚C.

Management system

The management system was semi-intensive. The animals were allowed to graze twice daily (morning and evening) in an area up to 86 hectares, although; local farmers cultivated annual crops in some areas. Species of plants found in the area included *Acacia obtusifolia, Strigal asiatical, Ziziphus macronatal* and other plants.

Few days to kidding, pregnant does are isolated and housed in a well-littered lambing pen. After parturition, all necessary cleaning and identification processes were observed. New born animals were housed together with their does under close observation for 24 hours to ensure they receive colostrums. Does were allowed to graze leaving behind their kids after two weeks.

Data collection and analysis

Weekly body weights records from 59 nondescript kids (male 23; female 36) that were collected for three years at the university of Maiduguri livestock teaching and research farm were used for the study. The data were analyzed using non-linear regression in Statistix 9.0. The estimates of Coefficient of determination (R^2), mean square error (MSE), standard deviation (SD) and Akaike information criteria (AIC), in addition to evaluation of model parameters were used for comparing the goodness of fit of the models. The growth curve functions were fitted individually to the observed data by using Levenberg-Marquardt nonlinear least-squares algorithm in Statistix 9.0. During the iteration procedure, when any parameter value at a current iteration did not change in the successive iteration, the procedure stopped. The convergence criterion of 1.0E-05 was used.

The models fitted are as follows:

Gompertz:
$W(t)= A \times \exp(-B\times\exp(-k\times t))$

Logistic:
$W(t)= A \times (1+B\times\exp(-k\times t))^{-1}$

Monomolecular:
$W(t)= A \times (1-B\times\exp(-k\times t))^{-1}$

Richard:
$W(t)= A / (1+\exp(B-k\times t))^{(1/m)}$

Weibull:
$W(t)= A - B \times \exp(-k\times t^{m})$

Where:
W_t: body weight (kg) of goat at t weeks of age (t=1, 2,…, 20).

A, B, k and m: model parameters:
A: asymptotic weight when time goes to infinity.
B: scaling parameter (constant of integration), which is related with initial values of W.
k: maturing rate and m is shape parameter.

Weight and age at the point of inflection (POI) were calculated as W= A / e and t= ln(B) / k, respectively for Gompertz and W= A / 2 and t= ln(B) / k for Logistic, where e is base of natural logarithm or Eulerian number (2.71828).

RESULTS AND DISCUSSION

Estimated parameters from the different models for male and female kids are presented in Table 1. All the models fitted the observed body weight data very well based on their high R^2 (>0.911). The monomolecular model recorded the highest R^2 (0.9461 and 0.9500 for males and females, respectively). In contrast, the monomolecular had the least value for MSE, SD and AIC for both gender. The high R^2 observed in this studhe models have previously been reported for goats. Some studies (Topal *et al.* 2004; Kor *et al.* 2006; Karakus *et al.* 2008; Malhado *et al.* 2009) reported R^2 values ranging from 97.8 to 99.7 which were higher than those reported in this study but Tsukahara *et al.* (2008) reported a value (93.7%) close to that obtained for the Gompertz model of this study. The R^2 have been used to evaluate the goodness of fit of models in most studies (Lewis *et al.* 2002; Topal *et al.* 2004; Kor *et al.* 2006). Models with the highest R^2 and lowest MSE values have been accepted as best fitting (Tedeschi, 2006). Based on these statistics, the monomolecular model fitted the data better than other models. Bilgin *et al.* (2004), Kor *et al.* (2006) and Kucuk and Eyduran (2009) also made similar observation based on MSE for Morkaraman lambs, Akkeci kids and Akkaraman lambs, respectively spectively. The asymptotic weight for males ranged from 7.66 to 71.22 kg while for females it was 6.23 to 44.39 kg. The highest value was for the Weibull model, while the lowest was for the Logistic. The asymptotic weights reported in this study t obtained from the Weibull model) were generally lower than those reported earlier (Kor *et al.* 2006; Ozdemir and Dellal, 2009).

Generally, asymptotic body weights for males seemed higher compared to females for all the models. Gaddour and Najari (2013) and Arias *et al.* (2013) also made similar observation in goats of Tunisia and Cuban Creole goats, respectively. According to Aggrey *et al.* (2003), this indicates that individuals with higher adult weight will grow faster throughout the growing period and may require a dit from the slower growing kids. Similarly, Kume and Hajno (2011) observed that lower asymptotic weight means that females will reach maturity faster than males. This is not surprising as sexual dimorphism is usually in favour of males in Nigerian goats. Maturing rate seemed higher for femher for females compared to males for all models while shape parameter was higher for males.

The growth rate was maximum for the Gompertz model at 2.18 weeks with a weight of 3.09 kg for males while for females it was at 1.56 weeks with 2.36 kg. Similarly, for the logistic model, it was at 5.61 weeks with 3.63 kg for males and 1.62 weeks with 3.11 kg for females. Male kids had heavier inflexion weight and higher age than females for all the models. These values were higher for the logistic than Gompertz model.

This could be due to fixing of the inflexion p of the asymptotic weight in the logistic while it is about 30% for the Gompertz model. Barbato (1996) related the inflexion age with the value of the corresponding weight which can affect the maturing age of animals. Gaddour and Najari (2013) also reported higher inflexion points for males than females. Thus, the age at which males reac males reached maximum growth rate was higher than that of females. From the viewpoint of management, this period when the animals express their maximum biological potential of growth is very important since it indicatnt when the rearing system must be perfected to achieve higher productivity. Ricklefs (1985) suggested that early growth may be the key response to selection for later body mass, as growth rate is evidently more flexible when it is highest. In the current study, the four parameter models (Richards and Weibull) had lower R^2 and higher MSE, SD and AIC than those with three (Gompertz, logistic and monomolecular), which is similar to Aggrey *et al.* (2003) observation. The authors attributed this to difficulty in fittity in fitting four parameter models as they require more iteration to attain the convergence criterion. As seen in Figures 1 and 2, observed and predicted curves matched very well.

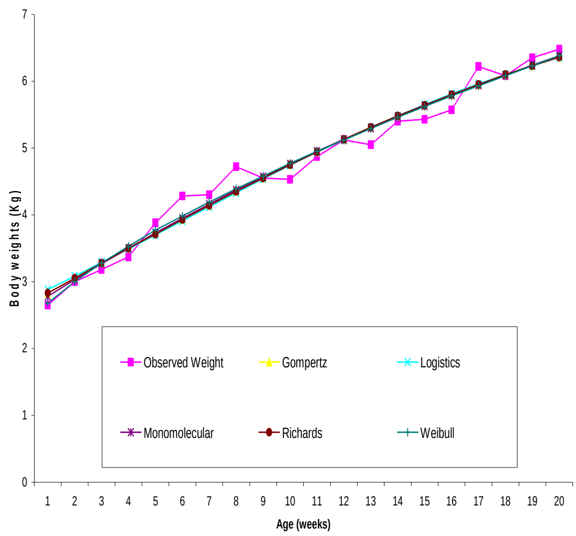

Figure 1 Observed and predicted body weights of male kids

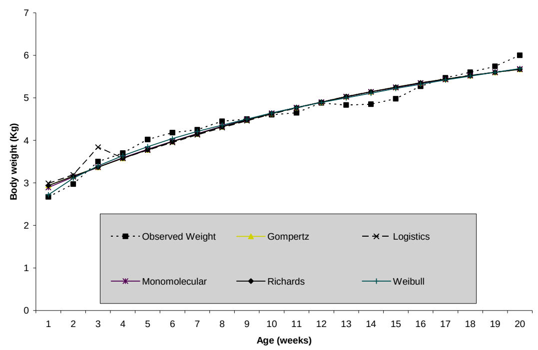

Figure 2 Observed and predicted body weights of female kids

In addition, growth curves for male kids in the differwere almost linear at the early period of growth but this linearity changed after a few weeks. Ozdemir and Dellal (2009) and Forni *et al.* (2009) made a similar observation in Angora goats and cattle, respectively.

All growth models presented similar prediction patterns at the same stages of growth. They under or overestimated body weight to a greater or lesser extent. However, they all provided less accurate predictions at the beginning of the growth curve. The observed, predicted and residual weights for the different growth models of nondescript female kids are presented in Table 2. The range of residuals for the Gompertz, logistic, monomolecular, Richards and Weibull from 2-20 weeks was 0.02-0.33, 0.02-0.34, 0.01-0.32, 0.02-0.33 and 0.00-0.31, respectively. The corresponding values for percentage deviations were 0.41-6.55, 0.36-9.60, 0.24-5.68, 0.40-6.54 and 0.10-4.88, respectively. The observed, predicted and residual weights for the different growth models of nondescript male kids are presented in Table 3. The range of residuals for the Gompertz, logistic, monomolecular, Richards and Weibull from 2-20 weeks was 0.00-0.37, 0.01-0.38, 0.01-0.35, 0.00-0.37 and 0.00-0.32, respectively.

Table 1 Parameter estimates from the various growth models for male and female kids of nondescript goats of Nigeria

Parametr	Gompertz		Logistic		Monomolecular		Richards		Weibull	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
A	8.40	6.4237	7.66	6.2294	10.55	6.7849	8.388	6.4214	71.22	44.39
B	0.156	-0.1508	0.6161	0.2043	0.0327	0.0662	-3.8743	-4.668	69.05	42.763
C	0.0717	0.0965	0.1099	0.1258	-8.338	-7.3654	0.0724	0.0968	0.0074	0.0259
D	-	-	-	-	-	-	0.0176	0.0109	0.7137	0.4512
MSE	2.0316	1.6765	2.0348	1.68	2.0285	1.6729	2.040	1.6913	2.0425	1.6789
SD	1.4254	1.2948	1.4265	1.2962	1.4242	1.2934	1.4315	1.3005	1.4292	1.2957
AIC	90.37	66.289	90.56	66.534	90.18	66.033	92.55	68.474	92.16	67.608
R^2	0.9431	0.946	0.9373	0.9414	0.9506	0.95	0.9218	0.9298	0.9109	0.9226
Age	2.18	1.56	5.61	1.62	-	-	-	-	-	-
Weight	3.09	2.36	3.83	3.11	-	-	-	-	-	-

A: asymptotic weight; B is a scaling parameter (constant of integration); C: relative growth rate; D: shape parameter and AIC: Akaike information criteria
R^2: coefficient of determination; MSE: mean square error and SD: standard deviation.

Table 2 The observed, predicted and residual weights for the different growth models of female kids of nondescript goats of Nigeria

Age (weeks)	Observed weight	Gompertz			Logistics			Monomolecular			Richards			Weibull		
		P	R	D	P	R	D	P	R	D	P	R	D	P	R	D
1	2.67	2.94	0.28	10.31	2.99	0.33	12.20	2.89	0.22	8.19	2.94	0.28	10.31	2.72	0.05	1.92
2	2.97	3.16	0.19	6.55	3.19	0.22	7.46	3.14	0.17	5.68	3.16	0.19	6.54	3.11	0.14	4.88
3	3.50	3.37	-0.13	-3.59	3.84	0.34	9.60	3.37	-0.13	-3.73	3.37	-0.13	-3.61	3.40	-0.10	-2.75
4	3.70	3.58	-0.12	-3.24	3.58	-0.12	-3.33	3.59	-0.11	-3.02	3.58	-0.12	-3.25	3.64	-0.06	-1.51
5	4.02	3.78	-0.24	-5.94	3.77	-0.25	-6.23	3.79	-0.22	-5.57	3.78	-0.24	-5.96	3.85	-0.16	-4.10
6	4.18	3.97	-0.22	-5.17	3.95	-0.23	-5.56	3.98	-0.20	-4.75	3.97	-0.22	-5.18	4.04	-0.15	-3.49
7	4.25	4.15	-0.10	-2.42	4.13	-0.12	-2.84	4.16	-0.09	-2.02	4.15	-0.10	-2.44	4.21	-0.04	-1.04
8	4.45	4.32	-0.13	-2.98	4.30	-0.15	-3.35	4.33	-0.12	-2.65	4.32	-0.13	-3.00	4.36	-0.09	-2.01
9	4.50	4.48	-0.02	-0.49	4.46	-0.04	-0.80	4.49	-0.01	-0.24	4.48	-0.02	-0.50	4.50	0.00	0.11
10	4.60	4.63	0.03	0.64	4.62	0.02	0.41	4.64	0.04	0.79	4.63	0.03	0.62	4.64	0.04	0.87
11	4.65	4.77	0.12	2.60	4.76	0.11	2.46	4.77	0.12	2.67	4.77	0.12	2.59	4.77	0.12	2.52
12	4.88	4.90	0.02	0.41	4.90	0.02	0.36	4.90	0.02	0.40	4.90	0.02	0.40	4.89	0.00	0.10
13	4.83	5.03	0.19	4.00	5.03	0.19	4.02	5.02	0.19	3.94	5.03	0.19	3.99	5.00	0.17	3.52
14	4.85	5.14	0.29	6.01	5.14	0.29	6.08	5.14	0.29	5.90	5.14	0.29	6.00	5.11	0.26	5.43
15	4.98	5.25	0.26	5.31	5.25	0.27	5.41	5.24	0.26	5.19	5.25	0.26	5.30	5.22	0.24	4.72
16	5.27	5.35	0.08	1.51	5.35	0.09	1.62	5.34	0.07	1.41	5.35	0.08	1.51	5.32	0.05	1.02
17	5.47	5.44	-0.03	-0.54	5.44	-0.02	-0.44	5.43	-0.03	-0.61	5.44	-0.03	-0.54	5.42	-0.05	-0.89
18	5.60	5.52	-0.08	-1.40	5.53	-0.07	-1.34	5.52	-0.08	-1.43	5.52	-0.08	-1.41	5.51	-0.09	-1.57
19	5.74	5.60	-0.14	-2.46	5.60	-0.14	-2.44	5.60	-0.14	-2.42	5.60	-0.14	-2.46	5.60	-0.14	-2.37
20	6.00	5.67	-0.33	-5.50	5.67	-0.33	-5.54	5.68	-0.32	-5.39	5.67	-0.33	-5.50	5.69	-0.31	-5.13

P: predicted weight; R: residuals (P-observed weight) and D: percentage deviation of predicted from observed weight.

Table 3 The observed, predicted and residual weights for the different growth models of male kids of nondescript goats of Nigeria

Age (weeks)	Observed weight	Gompertz			Logistic			Monomolecular			Richards			Weibull		
		P	R	D	P	R	D	P	R	D	P	R	D	P	R	D
1	2.65	2.83	0.18	6.87	2.88	0.23	8.75	2.78	0.13	4.80	2.83	0.18	6.90	2.68	0.03	1.10
2	3.00	3.05	0.05	1.79	3.08	0.08	2.74	3.03	0.03	0.91	3.05	0.05	1.80	3.00	0.00	0.13
3	3.18	3.28	0.09	2.89	3.29	0.10	3.25	3.27	0.09	2.71	3.28	0.09	2.89	3.28	0.10	3.10
4	3.37	3.50	0.13	3.84	3.49	0.13	3.79	3.50	0.14	4.08	3.50	0.13	3.83	3.53	0.17	4.94
5	3.88	3.72	-0.17	-4.33	3.70	-0.18	-4.62	3.73	-0.15	-3.93	3.71	-0.17	-4.35	3.77	-0.12	-3.03
6	4.28	3.93	-0.35	-8.22	3.91	-0.37	-8.61	3.95	-0.33	-7.78	3.93	-0.35	-8.24	3.98	-0.30	-6.97
7	4.30	4.14	-0.16	-3.64	4.12	-0.18	-4.08	4.16	-0.14	-3.20	4.14	-0.16	-3.66	4.19	-0.11	-2.49
8	4.72	4.35	-0.37	-7.75	4.33	-0.38	-8.14	4.37	-0.35	-7.39	4.35	-0.37	-7.76	4.39	-0.32	-6.88
9	4.55	4.55	0.00	0.09	4.54	-0.01	-0.27	4.57	0.02	0.38	4.55	0.00	0.08	4.58	0.03	0.74
10	4.53	4.75	0.22	4.82	4.74	0.21	4.54	4.76	0.23	5.00	4.75	0.22	4.81	4.77	0.24	5.20
11	4.87	4.94	0.08	1.56	4.94	0.07	1.40	4.95	0.08	1.63	4.94	0.08	1.56	4.95	0.08	1.67
12	5.12	5.13	0.01	0.22	5.12	0.01	0.16	5.13	0.01	0.19	5.13	0.01	0.21	5.12	0.01	0.10
13	5.05	5.31	0.26	5.08	5.31	0.26	5.10	5.30	0.25	4.97	5.31	0.26	5.07	5.29	0.24	4.78
14	5.40	5.48	0.08	1.44	5.48	0.08	1.54	5.47	0.07	1.29	5.48	0.08	1.44	5.46	0.06	1.06
15	5.43	5.64	0.21	3.86	5.65	0.22	4.00	5.63	0.20	3.68	5.64	0.21	3.86	5.62	0.19	3.42
16	5.57	5.80	0.23	4.20	5.81	0.24	4.36	5.79	0.22	4.04	5.80	0.23	4.20	5.78	0.21	3.78
17	6.22	5.95	-0.27	-4.26	5.96	-0.26	-4.14	5.94	-0.27	-4.38	5.95	-0.27	-4.27	5.93	-0.28	-4.57
18	6.08	6.10	0.01	0.20	6.10	0.02	0.28	6.09	0.01	0.16	6.10	0.01	0.20	6.08	0.00	0.02
19	6.35	6.23	-0.12	-1.85	6.23	-0.12	-1.85	6.24	-0.11	-1.79	6.23	-0.12	-1.85	6.23	-0.12	-1.83
20	6.48	6.36	-0.12	-1.85	6.36	-0.13	-1.96	6.38	-0.11	-1.67	6.36	-0.12	-1.86	6.38	-0.10	-1.58

P: predicted weight; R: residuals (P- observed weight) and D: percentage deviation of predicted from observed weight.

The corresponding values for percentage deviations were 0.09-8.22, 0.16-8.61, 0.16-7.78, 0.08-8.24 and 0.02-6.97, respectively. Residuals and percentage deviations were generally low, an indication that the models fitted the weight data adequately. In addition, the models under and overestimated weights at short intervals. This observation agrees with the report of Brown *et al.* (1976) that postulated that a model which yields differences between predicted and actual weights al weights which tends to alternate in sign at short intervals is preferred to a model which yields deviations which alternate in sign at longer intervals.

When compared to the other models, the Weibull model seemed to predict weight in the first week in female kids better with percentage deviation of 1.92 compared to 10.31, 12.20, 8.19 and 10.31 for the Gompertz, logistic, monomolecular and Richards models, respectively. Similar observation was made for males with corresponding values of 1.10 compared to 6.87, 8.75, 4.80 and 6.90, respectively.

CONCLUSION

Mathematical functions of the different growth models explained growth of male and female kids of nondescript goats of Nigeria very well. The parameters in the model estimated by nonlinear models provided very good fit (>91%) for the partial growth curves. Thus, the observed and predicted curves matched well. Though these models can be used for predicting live weight at later ages from early partial live weight data, the best model for male and female kids of nondescript goats in Nigeria based on R^2 and MSE appeared to be the Monomolecular growth model.

ACKNOWLEDGEMENT

I acknowledge with gratitude, the support of the Department of Animal Science, University of Maiduguri for its assistance in providing the animals and materials for the study.

REFERENCES

Aggrey S.E. (2002). Comparison of three non-linear and spline regression models for describing chicken growth curves. *Poult. Sci.* **81,** 1782-1788.

Aggrey S.E., Ankra-Badu G.A. and Marks H.L. (2003). Effect of long-term divergent selection on growth characteristics in Japanese quail. *Poult. Sci.* **82,** 538-542.

Akbas Y., Taskin T. and Demiroren E. (1999). Comparison of several models to fit growth curves of Kivircik and Daglic male lambs. *Turkish J. Vet. Anim. Sci.* **23,** 537-544.

Alade N.K., Raji A.O. and Atiku M.A. (2008). Determination of appropriate model for the estimation of body weight in goats. *ARPN J. Agric. Biol. Sci.* **3(4),** 52-57.

Barbato G.F. (1996). Genetics of the growth curve in poultry: physiological implications. Pp. 153-165 in Proc. 2nd European Poult. Breed. Roundtable. Landbrugs.

Bilgin O.C., Esenbuga N. Macit M. and Karaoglu M. (2004). Growth curves characteristics in Morkaraman and Awwasi sheep. I. Comparison of non-linear functions. *Wool Technol. Sheep Breed.* **52(1),** 1-7.

Bridges T.C., Turner U.W. Smith E.M. Stahly T.S. and Loewer O.J. (1986). A mathematical procedure or estimating animal growth and body composition. *Trans. ASAE.* **29,** 1342-1347.

Brisbin I.L., Collins C.T., White G.C. and McCallum D.A. (1987). A new paradigm for the analysis and interpretation of growth data: the shape of things to come. *Auk*. **104,** 552-554.

Brown J.E., Fitzhugh (Jr) H.A. and Cartwright T.C. (1976). A comparison of nonlinear models for describing weight-age relationships in cattle. *J. Anim. Sci*. **42,** 810-818.

FAOSTAT. (2008). Food and Agriculture Organization of the United Nations. Available: http://faostat.fao.org/site/573/default.aspx.

FDL. (2010). National Livestock Estimates. Livestock sector-disaggregated data on key development indicators. FDL, Ministry of Agriculture and Natural Resources, Nigeria.

Forni S., Piles M., Blasco A., Varona L., Oliveira H.N., Lôbo R.B. and Albuquerque L.G. (2009). Comparison of different nonlinear functions to describe Nelore cattle growth. *J. Anim. Sci*. **87,** 496-506.

Gaddour A., Ouni M. and Najari S. (2012). Growth curve estimation in pure goat breeds and crosses at first and second generation under oases. *Tunisian J. Cell Anim. Biol.* **6(6),** 99-103.

Gaddour A. and Najari S. (2013). Estimation parameters of the kid's growth curve in Tunisia goat by using Gompertz model. *J. Gen. Environ. Res. Conser*. **1(1),** 47-49.

Jenkins T.G. and Leymaster K.A. (1993). Estimating of maturing rates and masses at maturity for body components of sheep. *J. Anim. Sci*. **71,** 2952-2957.

Karakus K., Eyduran E., Kum D., Ozdemir T. and Cengiz F. (2008). Determination of the best growth curve and measurement interval in Norduz male lambs. *J. Anim. Vet. Adv*. **7,** 1464-1466.

Kor A., Baspınar E., Karaca S. and Keskin S. (2006). The determination of growth in Akkeci (White goat) female kids by various growth models. *Czech J. Anim. Sci*. **51(3),** 110-116.

Kucuk M. **(**2004). Growth characteristics of Hamdani, Karakul and Morkaraman lambs in suckling period. *Indian Vet. J.* **81,** 172-175.

Kucuk M. and Eyduran E. (2009). The determination of the best growth model for Akkaraman and German Blackheaded mutton x Akkaraman crossbreed lambs. *Bulgarian J. Agric. Sci*. **81,** 172-175.

Kume K. and Hajno L. (2011). Study of growth curve variations for kids 0-6 months old of Alpine goat breed in Albania. *Arch. Zootech.* **13(2),** 54-62.

Arias M.A., Guevara F., Fonseca N., Rodríguez L., Pinto R., Gómez H., Medina F.J. and Hernández A. (2013). Application of the logistical and Gompertz models to the analysis of live weight curves in Cuban Creole kids. *Cuban J. Agric. Sci.* **47(1),** 1-5.

Lewis R.M., Emmans G.C., Dingwall W.S. and Simm G. (2002). A description of the growth of sheep and its genetic analysis. *Anim. Sci*. **74,** 51-62.

Malhado C.H.M., Carneiro P.L.S., Affonso P.R.A.M., Souza Jr., A.A.O. Sarmento J.L.R. (2009). Growth curves in Dorper sheep crossed with the local Brazilian breeds, Morada Nova, Rabo Largo and Santa Ines. *Small Rumin. Res.* **84,** 16-21.

Mignon-Grasteau S.M. Piles L. Varona H. de Rochambeau J.P. Poivey Blasco A. and Beaumont C. (2000). Genetic analysis of growth curve parameters for male and female chickens resulting from selection on shape of curve. *J. Anim. Sci.* **78,** 2515-2524.

Nasholm A. (1991). Mature weight of ewe as a trait in sheep breeding. Pp. 88-91 in: Proc. 4th World Cong. Genet. Appl. Livest. Prod., Genet. Breed. Fiber, Fur and Meat Quality., Edinburgh.

Ozdemir H. and Dellal G. (2009). Determination of growth curves in young Angora goats. *Tarim. Bilimleri. Gergisi.* **15,** 358-362.

Ricklefs R.E. (1985). Modification of growth and development of muscles in poultry. *Poult. Sci.* **64,** 1563-1576.

Schinckel A.P. and De Lange C.F. (1996). Characterization of growth parameters needed as inputs for pig growth models. *J. Anim. Sci*. **74,** 2021-2036.

Tedeschi L.O. (2006). Assessment of the adequacy of mathematical models. *Agric. System.* **89,** 225-247.

Topal M., Ozdemir M., Aksakal V., Yildiz N. and Dogru U. (2004). Determination of the best point nonlinear function in order to estimate growth in Morkaraman and Awassi lambs. *Small Rumin. Res.* **55,** 229-232.

Tsukahara Y., Chomei Y., Oishi K., Kahi A.K., Panadam J.M., Mukherjee T.K. and Hirooka H. (2008). Analysis of growth pattern in purebred Kambing Katjang goat and its crosses with the German Fawn. *Small Rumin. Res.* **80,** 78-85.

Waheed A., Muhammad S.K., Safdar A. and Muhammad S. (2011). Estimation of growth curve parameters in Beetal goats. *Arch. Tierz.* **54(3),** 287-296.

Yakupoglu C. and Atil H. (2001). Comparison of growth curve models on broilers II. Comparison of models. *J. Biol. Sci.* **1(7),** 682-684.