Research Journal of Animal Sciences 5 (2): 17-24, 2011
ISSN: 1993-5269

Growth Curves for Different Body Traits of Lagune Cattle

[1]A.B. Gbangboche, [2]T.I. Alkoiret, [2]Y. Toukourou, [3]A. Kagbo and [4]G.A. Mensah
[1]Department of Animals Production, Faculty of Agronomy,
University of Abomey Calavi, 01 P.O. Box 526 Cotonou, Republic of Benin
[2]Department of Animals Productions, Faculty of Agronomy,
University of Parakou, 01 P.O. Box 123 Parakou, Benin
[3]National Livestock Office Farm of Samiondji, P.O. Box 50, Cove, Republic of Benin
[4]National Agricultural Research Center of Agonkanmey (CRA-Agonkanmey) of the Benin,
National Institute Agricultural Research (INRAB), 01 P.O. Box 884 RP-Cotonou, Republic of Benin

Abstract: This study was carried out at Samiondji breeding farm in Benin. A total of 1, 414 age-data sets of Height at Withers (HW), Heart Girth (HG), Scapulo-Ischial Length (SIL) and Live Body Weight (LBW) from 707 Lagune cattle (373 males and 334 females) were individually fitted to Brody, Gompertz and Logistic Growth Models using the NLIN procedure of SAS. The growth parameters consist of mature weight or body size (A), the constant of integration (B) and the maturity rate (k). The most appropriate model through the goodness of fit was determined by higher adjusted determination coefficient (R^2), lower Mean Squares Errors (MSE) and Bayesian's Information Criteria (BIC). Among the competing models and within sexes, the Brody show the best adjustment of data followed by Gompertz and Logistic. According to the range of the parameters A (81.36-137.07), B (0.46-2.94) and k (0.0019-0.102), the value of A derived from the Brody model (82.41-137.07) was higher ($p<0.05$) whereas B (0.46-0.95) and k (0.0019-0.0065) lower ($p<0.05$) than in Gompertz and Logistic. The plot from birth up to 1, 320 days of age of LBW, HW, HG and SIL using Brody model provide the higher growth profiles of males than females ($p<0.05$). Polynomial regressions to predict LBW from HW, HG and SIL showed that HG alone or with the inclusion of HW and SIL was the reasonable fit according to R^2 (between 68 and 81%). The degree of maturity show that except for LBW both sexes are fully developed (≥90%) at 720 days of age. Under field condition where farmers do not usually have weighing facilities this study present several applications such as management purposes, selling animals for slaughter and medicine dosage. Among the fitting equations to predict LBW, the simplest possible indication for male and female was respectively, LBW = - 92.39+0.86HG and LBW = -49.72+1.26HG.

Key words: Cattle, body measurements, nonlinear models, female, farmers, medicine

INTRODUCTION

Indigenous cattle breeds of Benin (1, 391.755 heads) are classified in two majors subgroups: *Bos indicus* (7.7%) and *Bos taurus* (92.3%). The *Bos taurus* consists of Borgu (34%), Lagune (3.7%), Somba (0.3%) and different crossed breeds (55%). The Lagune cattle named Muturu (Nigeria), Mayombe or Dahomey (Democratic Republic of Congo) and Lagoon (Ghana) are of the smallest cattle breeds, usually black or black with white spots, black mucosa, eyelids and hoofs, described as the Dwarf Shorthorn breeds. Their adaptive features such as trypanosomosis resistant, parasitic disease and feeding behaviour enable them to cope with the savannah and humid tsetse-infested areas (Epstein, 1971). The limited knowledge of Lagune breeds cattle has hampered the development of technology to improve their productivity. Since the last decade, the drastic regression of Lagune cattle has been reported in Benin due to indiscriminate slaughter inappropriate husbandry techniques, lack of improvement and continuous interbreeding with Zebu breeds. Without sustainable management, the Lagune cattle may become one of the threatened breeds in the next future. Morphological characterisations are of interest not only in the organization and conservation of genetic resources but for the design of genetic improvement programmes. They have been used to rank animal population (Gatesy and Arctander, 2000;

Corresponding Author: Alkoiret Traore Ibrahim, Department of Animals Production, Faculty of Agronomy, University of Parakou, 01 P.O. Box 123 Parakou, Benin

Mwacharo *et al.*, 2006), to determine feeding and management plans, breeding goals and strategies (Brotherstone and Hill, 1991; Fernandez *et al.*, 1997; Luo *et al.*, 1997; Alderson, 1999, Zechner *et al.*, 2001). The growth models such as Logistic and Gompertz (Renne *et al.*, 2003; Lambe *et al.*, 2006) and Brody functions (Brody, 1945) have been used to summarize important growth characteristics (growth rate, earliness, daily gain, food conversion, mature body size and weight, length of the time interval between birth and maturity) and they goodness of fit was access taken in to account some criteria such as the coefficient of determination (R^2), the Mean Squares Errors (MSE), the log-likelihood (lnL) values, the Akaike's Information Criteria (AIC), the least Average Prediction Error (APE) (Akaike, 1974; Brown *et al.*, 1976; Schwarz, 1978; Goonewardene *et al.*, 1981; Beltran *et al.*, 1992). The aim of this study was to establish the morphological and growth description of Lagune cattle using three models (Logistic, Gompertz and Brody), to select the model given the goodness of fit and to predict the live body weight from body measurements using polynomial regression.

MATERIALS AND METHODS

The study was carried out at the Samiondji farm (2°22 and 2°25 long. E, 7°25 and 7°30 lat. N) in the Sudano-Guinean zone of Benin. This farm is focused on the breeding of registered purebreed Lagune cattle where animals grazed on cultivated and natural pastures and received various quantities of supplements. Water was provided *ad libitum* to animals. A routine inoculation, drenching and tick control program was followed.

Data were recorded from 707 Lagune cattle (373 male and 334 female) ranging from calves to mature adult animals, providing 3,535 sets of Live Body Weight (LBW), Height at Withers (HW), Heart Girth (HG) and the Scapulo-Ischial Length (SIL). Each animal had 5 records with the first HW, HG, SIL and LBW recorded within 24 h at birth and the others between 50 and 1, 320 days of age. The HW, HG and SIL were measured with cloth tape (cm) and the LBW with scaled balance (kg) by one person in order to minimize between-individual variations (Buvanendran *et al.*, 1980). All measurements were taken early in the morning before grazing and to avoid upward biases following feeding. Visibly pregnant females were excluded from the study. Three competing growth curves (Brody, Gompertz and Logistic) were fitted to the data to model the relationship between LBW, HW, CC and SIL with age. These functions can be specified as:

$$\text{Brody, } W_t = A\ (1\text{-}Be^{-Kt})$$

$$\text{Gompertz, } W_t = A \exp(\text{-}Be^{-Kt})$$

$$\text{Logistic, } W_t = A/(1\text{+}Be^{-Kt})$$

Where:

W	=	The observed weight or size at age t expressed in day
t and A	=	The asymptotic limit of the weight when age (t) approaches infinity

This does not imply that A is the heaviest size or weight attained by the individual but it indicates the average size or weight of the mature cattle independent of short-term fluctuation in size or weight due to temporary environmental effects. B indicates the proportion of the asymptotic mature size or weight to be gained after birth, established by the initial values of W and t. The k is a function of the ratio of maximum growth rate to mature size or weight, normally referred to maturing rate. It is related to postnatal rate of maturing and serves both as a measure of growth rate and rate of change in growth rate. Large k values indicate early maturing animals and vice versa; e is Napier's base for natural logarithms; t is age expressed in day. The analysis of growth curves was carried out using the NLIN procedure of SAS (2006). The comparison between models and sex for growth parameter estimated was performed using the pairwise differences between means. The goodness of fit was determined by the maximum adjusted determination coefficient (R^2), minimum of the Mean Squares Errors (MSE) and of the Bayesian's Information Criteria (BIC) (Brown *et al.*, 1976; Schwarz, 1978; Akbas *et al.*, 1999). The selected model was used to provide the plot of the predicted LBW, HW, HG and SIL. The degree of maturity at time t as the value of the function W_t relative to the asymptotic value at maturity A was calculated. Multiple polynomial regressions using REG procedure of SAS (2006) were used to predict LBW from HW, HG and SIL and the reasonable fit was determined by higher adjusted R^2.

RESULTS AND DISCUSSION

The least-squares estimates parameters (A, B and k), the adjusted R^2, BIC and MSE of the three growth models were shown in Table 1 and within sexes in Table 2 and 3. The overall growth performance was plotted for HG (Fig. 1), HW (Fig. 2), SIL (Fig. 3) and LBW (Fig. 4). The degree of maturity and the predicting LBW from HG, HW and SIL were shown in Table 4 and 5, respectively.

Goodness of fit: The BIC and MSE values obtained ranged from 8752.9-10850.7 and 26.6-88.4, respectively (Table 1) and within sexes, from 4105.7-5351.8 and 16.8-161.3, respectively (Table 2 and 3). Lower BIC and MSE values were found in Brody (4053.5-10843.0 and 16.8-153.2) when comparing, respectively to

Table 1: Parameter A, B and k estimates (±standard errors) and the selection criteria (R^2, MSE and BIC) of growth model fitted to the data of the Live Body Weight (LBW, kg), Height at Withers (HW, cm), Heart Girth (HG, cm) and Scapulo-Ischial Length (SIL, cm) of Lagune cattle breeds

		Parameters				Selection criteria	
Measurements	Models	A	B	k	R^2	MSE	BIC
LBW	Brody	88.28±0.78	0.88±0.0041	0.0065±0.0003	0.94	84.95	10843.0
	Gompertz	87.40±0.63	2.05±0.0317	0.0091±0.0003	0.94	87.51	10843.5
	Logistic	87.10±0.59	2.94±0.0457	0.0102±0.0004	0.93	88.41	10850.7
HW	Brody	82.91±0.35	0.47±0.0052	0.0046±0.0001	0.84	26.60	8725.9
	Gompertz	82.38±0.32	0.61±0.0089	0.0055±0.0002	0.84	26.73	8768.3
	Logistic	81.90±0.29	0.85±0.0122	0.0066±0.0002	0.84	26.62	8807.2
HG	Brody	115.27±0.58	0.56±0.0043	0.0036±0.0001	0.89	45.21	9741.3
	Gompertz	113.69±0.45	0.78±0.0086	0.0046±0.0001	0.89	45.63	9794.2
	Logistic	112.66±0.47	1.07±0.0119	0.0055±0.0001	0.89	46.43	9835.8
SIL	Brody	100.65±0.51	0.54±0.0044	0.0036±0.0001	0.89	35.47	9327.6
	Gompertz	99.35±0.44	0.74±0.0086	0.0046±0.0001	0.88	36.00	9379.1
	Logistic	98.44±0.41	1.03±0.0119	0.0056±0.0001	0.93	36.77	9424.4

A: The asymptotic limit of the weight when age (t) approaches infinity; B: The proportion of the asymptotic mature size; k, the growth rate; R^2: The adjusted coefficient of determination; MSE: Mean Square Error and BIC: Bayesian Information Criterion

Table 2: Parameter A, B and k estimates (±standard errors) and the selection criteria (R^2, MSE and BIC) of growth model fitted to the data of the Live Body Weight (LBW, kg), Height at Withers (HW, cm) of male (n = 373) and female (n = 334) Lagune cattle breeds

	LBW			HW		
Model	Male	Female	Significance level	Male	Female	Significance level
Brody						
A	137.07±2.80	127.19±3.83	*	86.20±0.54	82.41±0.42	*
B	0.95±0.01	0.96±0.01	*	0.46±0.00	0.49±0.00	*
k	0.0019±0.0001	0.0023±0.0001	*	0.0035±0.0002	0.0037±0.0001	*
R^2	0.90	0.87	-	0.91	0.89	-
MSE	153.2	139.6	-	16.8	16.8	-
BIC	5254.6	4806.6	-	4053.5	4382.9	-
Gompertz						
A	124.21±1.62	110.15±1.98	*	85.30±0.46	81.82±0.38	*
B	2.19±0.05	2.22±0.05	*	0.48±0.04	0.65±0.01	*
k	0.0036±0.0001	0.0049±0.0002	*	0.0055±0.0002	0.0045±0.0001	*
R^2	0.90	0.87	-	0.89	0.89	-
MSE	158.8	140.5	-	20.8	18.9	-
BIC	5330.2	4929.2	-	4079.2	4400.5	-
Logistic						
A	122.18±1.46	107.60±1.77	*	84.52±0.41	81.36±0.35	*
B	2.99±0.07	2.95±0.07	*	0.46±0.00	0.91±0.01	*
k	0.0043±0.0001	0.0058±0.0002	*	0.0068±0.0002	0.0054±0.0001	*
R^2	0.90	0.87	-	0.89	0.89	-
MSE	161.3	141.6	-	22.8	18.8	-
BIC	5351.8	4961.6	-	4105.7	4416.0	-

A: The asymptotic limit of the weight when age (t) approaches infinity; B: The proportion of the asymptotic mature size; k, the growth rate; R^2: The adjusted coefficient of determination; MSE: The Mean Square Error and BIC: The Bayesian Information Criterion. *Significantly different between male and female using pairwise differences between means ($p<0.05$)

Table 3: Parameter A, B and k estimates (±standard errors) and the selection criteria (R^2, MSE and BIC) of growth model fitted to the data of the Heart Girth (HG, cm) and Scapulo-Ischial Length (SIL, cm) of male (n = 373) and female (n = 334) of Lagune cattle breeds

	HG			SIL		
Models	Male	Female	Significance level	Male	Female	Significance level
Brody						
A	117.20±1.04	116.05±0.74	*	102.47±0.70	100.11±0.77	*
B	0.55±0.00	0.58±0.00	*	0.56±0.00	0.53±0.00	*
k	0.0037±0.0001	0.0031±0.0001	*	0.0029±0.0001	0.0042±0.0001	*
R^2	0.91	0.92	-	0.91	0.89	-
MSE	38.8	38.8	-	31.9	29.4	-
BIC	4532.3	4897.1	-	4656.7	4399.5	-
Gompertz						
A	114.76±0.85	114.51±0.64	*	101.12±0.61	98.52±0.64	*
B	0.76±0.01	0.81±0.01	*	0.77±0.01	0.72±0.01	*
k	0.0049±0.0001	0.0039±0.0001	*	0.0037±0.0001	0.0054±0.0002	*
R^2	0.90	0.91	-	0.90	0.89	-
MSE	39.0	39.6	-	32.8	29.4	-
BIC	4566.4	4915.8	-	4671.6	4430.9	-

Table 3: Continue

	HG			SIL		
Models	Male	Female	Significance level	Male	Female	Significance level
Logistic			-			-
A	113.60±0.60	113.20±0.74	*	100.29±0.57	97.41±0.56	*
B	1.05±0.01	1.12±0.01	*	1.07±0.01	1.00±0.01	*
k	0.0060±0.0002	0.0047±0.0001	*	0.0045±0.0001	0.0066±0.0002	*
R^2	0.90	0.91	-	0.90	0.89	-
MSE	39.4	40.7	-	33.8	29.6	-
BIC	4595.1	4929.5	-	4683.7	4457.9	-

A: The asymptotic limit of the weight when age (t) approaches infinity; B: The proportion of the asymptotic mature size; k, the growth rate; R^2: The adjusted coefficient of determination; MSE: the Mean Square Error and BIC: The Bayesian Information Criterion. *Significantly different between male and female using pairwise differences between means (p<0.05)

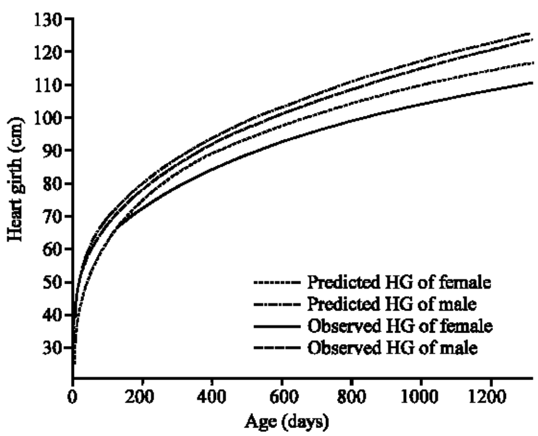

Fig. 1: The shape of Brody model to describe Heart Girth (HG, cm) from birth to 1, 320 days of age according to the sex of Lagune cattle breed

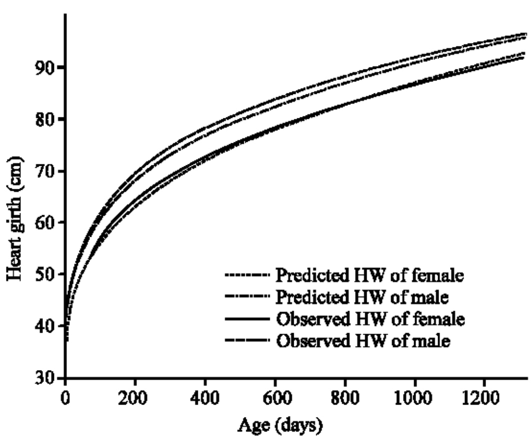

Fig. 2: The shape of Brody model to describe Height at Withers (HW, cm) from birth to 1, 320 days of age according to the sex of Lagune cattle breed

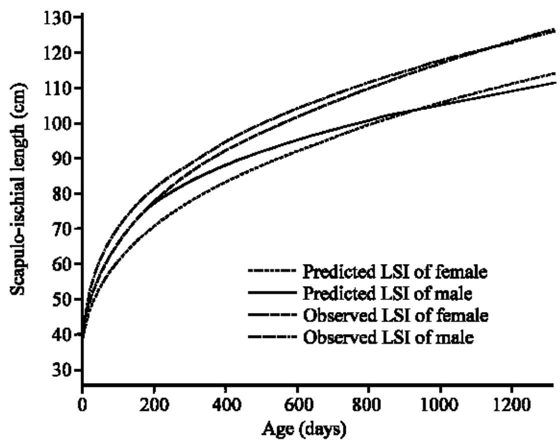

Fig. 3: The shape of Brody model to describe Scapula-Ischial Lengh (SIL, cm) from birth to 1,320 days of age according to the sex of Lagune cattle breed

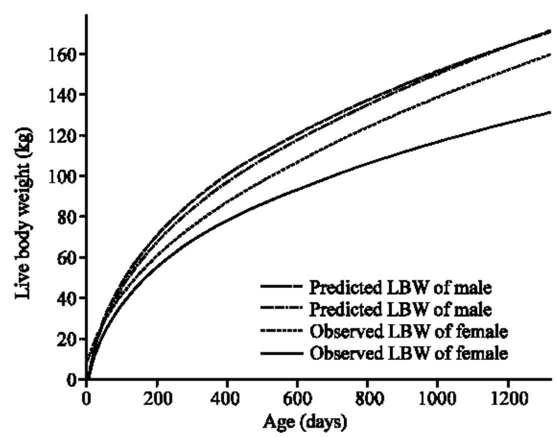

Fig. 4: The shape of Brody model to describe Live Body Weight (LBW, kg) from birth to 1,320 days of age according to the sex of Lagune cattle breed

Gompertz (4079.2 -10.843.5 and 18.9-158.8) and Logistic (4105.7-10850.7 and 18.8-161.3). Brody function was ranked 1st followed by Gompertz and Logistic (Brody <Gompertz<Logistic). Similar rank was found between sexes among the competing models (Table 2 and 3) and Brody function fitted better females and males than Gompertz and Logistic. Previous studies suggested the Brody function as the most appropriate to describe beef cattle growth because of its goodness of fit,

Table 4: Degree of maturity (%) of Live Body Weight (LBW, kg), Height at Withers (HW, cm), Heart Girth (HG, cm) and Scapulo-Ischial Length (SIL, cm) of male and female lagune cattle from birth up to 3.67 years (1,320 days) of age

	Degree of maturity (%)							
	Female				Male			
Age (year)	LBW	HW	HG	SIL	LBW	HW	HG	SIL
0.00 (birth day)	4.89	50.60	42.72	39.83	4.86	54.59	42.43	44.40
0.50 (180)	39.02	75.09	67.66	73.30	34.80	79.94	67.65	67.95
1.00 (360)	62.08	87.71	82.14	92.41	56.42	91.25	80.64	81.93
1.50 (540)	76.91	94.01	90.30	93.63	71.64	96.23	87.22	90.00
2.00 (720)	86.19	96.99	94.85	94.42	82.20	98.49	90.68	94.59
2.50 (900)	93.01	98.71	97.46	95.93	89.74	99.39	92.27	97.29
3.67 (1,320)	98.81	99.70	99.15	99.02	92.06	99.87	99.88	99.70

Table 5: Equations for estimating body weight from different body measurements R^2 (%), adjusted coefficient of determination; LBW, Live Body Weight (kg), HW: Height at Withers (cm), HG: Heart Girth (cm), SIL: Scapulo-Ischial Length (cm); *Significantly different between male and female (p<0.05)

Male		Female	
Equation	R^2 (%)	Equation	R^2 (%)
LBW = -92.39+0.86 HG	81	LBW = -49.72+1.26 HG	71
LBW = -94.33+2.13 SIL	79	LBW = -46.35+1.07 SIL	70
LBW = -130.09+2.87 HW	79	LBW = -61.54+1.62 HW	68
LBW = -100.08+0.52 HW+1.54 HG	81	LBW = -48.70-0.10 HW+1.34 HG	70
LBW = -115.98+1.62 HW+0.94 SIL	79	LBW = -46.55+0.01 HW+1.06 SIL	69
LBW = -92.67+1.79 HG +0.09 SIL	81	LBW = -49.38+0.96 HG+0.26 SIL	71
LBW = -100.90+0.60 HW+1.61CC-0.14 SIL	81	LBW = -44.18-0.52 HW+1.09 HG+0.49 SIL	71
$LBW = -156.78+3.69\ HW-0.006\ HW^2$	79	$LBW = -48.34-2.05\ HW+0.02\ HW^2$	71
$LBW = -109.59+2.29\ HG-0.002\ HG^2$	81	$LBW = -20.26+0.40\ HG+0.04\ HG^2$	72
$LBW = -137.11+3.34\ SIL-0.008\ SIL^2$	79	$LBW = -22.61-0.73\ SIL+0.015\ SIL^2$	72
$LBW = -169.88+3.78\ HW-0.02\ HW^2-1.81\ HG+0.01\ HG^2+2.72\ SIL-0.01\ SIL^2$	81	$LBW = -18.55+0.24\ HW-0.01\ HW^2+0.92\ HG+0.01\ HG^2-1.70\ SIL+0.00\ SIL^2$	73
$LBW = -183.34+5.61\ HW-0.083\ HW^2-0.57\ HG-0.01\ HG^2$	81	$LBW = -38.90+2.47\ HW-0.02\ HW^2+0.87\ HG+0.002\ HG^2$	73
$LBW = -139.06+1.17\ HW+0.002\ HW^2+2.03\ SIL-0.006\ SIL^2$	79	$LBW = -24.45+0.41\ HW+0.001\ HW^2-1.20\ SIL+0.01\ SIL^2$	72
$LBW = -126.47-0.75\ HG+0.01\ HG^2+3.91\ SIL-0.02\ SIL^2$	81	$LBW = -19.42+0.96\ HG+0.01\ HG^2-1.54\ SIL+0.0\ SIL^2$	73

computational simplicity interpretability of parameters, model convergence and ability to accommodate with missing data (Bullock *et al*., 1993; Kaps *et al*., 2000; Arango and van Vleck, 2002; Forni *et al*., 2009). However, in Hereford cattle breed, the less convergence rate of Brody function that seems to be inadequate for the description of growth have been reported.

The R^2 was higher (>0.80) within models and sexes, suggesting the overall good adjustment of the data (Table 1-3). Similar trend was reported in Belgian Blue cattle (De Behr *et al*., 2001) for R^2 values using Logistic (0.815-0.861), Gompertz (0.819-0.862) and Brody (0.821- 0.862).

Models parameters: In Brody model, the values of A for LBW, HW, HG and SIL were 88.28, 82.91, 115.27 and 100.65 but ranged, respectively from 87.10-87.40, 81.90- 82.38, 112.66-113.69 and 98.44-99.35 in Gompertz and Logistic models (Table 1). The parameter A was higher (p<0.05) in Brody than in Gompertz and Logistic (Table 1). Similar trend has been reported (Brown *et al*., 1976; Lopez de Torre *et al*., 1992) indicating that Brody model tend to over-estimate mature weight during the growing phase and this may be one of its disadvantages. Based on mature animals from 1.2-5 years old, the findings of Domingo in Lagune cattle for HW (80.6-96.2 cm), HG (102.8-136.3 cm) and SIL (92.3-119.7cm) were consistent of the result of this study. The HW (93.38±1.63 cm), HG (125.92±1.82 cm), SIL (108.00±5.47 cm) reported in Somba cattle of 3-4 years old corroborates also this study. However, Mwacharo *et al*. (2006) reported higher value of HW for Maasai zebu (110.3±0.7 to 119.0±2.0 cm), Kamba zebu (104.9±0.8 to 115.3±1.6 cm) having three and four pairs of permanent incisor teeth) and Rege (1999) for Nandi zebu (110-122 cm), Angoni zebu (119-127 cm), Mongalla zebu (100-110 cm), Gasara zebu (101-129 cm) and Baharie zebu (98-124 cm). This clearly justify that Lagune breeds are found to be one of the shortened cattle breeds such as Somba and Borgou breeds in West Africa (Aboagye *et al*., 1994).

The maturating rate k (0.0036-0.01) was smallest (Table 1) in the Brody (0.0036-0.0065) and largest in Gompertz (0.0046-0.0091) and Logistic (0.0055-0.0102). The relationship between larger estimate of A and lowest estimates of k in Brody model has been also reported (Brown *et al*., 1976; Lopez de Torre *et al*., 1992). The gender of calve affected significantly (p<0.05) the parameter A and k (Table 2 and 3). The higher A and lower rate of maturing of male agree with previous reports on Holstein-Friesian (Koenen and Groen, 1996) and beef cows (Brown *et al*., 1976; Lopez de Torre *et al*., 1992).

The parameter B (Table 1), ranging from 0.49-2.99 represents the integration constant, related to the initial weight but lacking a clear biological interpretation. In this case the sex show significant effects effects on B, revealed higher value ($p<0.05$) in female than male (Table 2 and 3).

Overall growth performance: The magnitudes of the expected body measurements from birth up to 1, 320 days of age between sexes are plotted using the selected Brody Model. The male calves were +3.7 and +9.6 cm larger (Fig. 1), +7.6 and +3.9 cm taller (Fig. 2), +6.8 and +2.1 cm longer (Fig. 3) and + 0.33 and +5.7 kg heavier (Fig. 4) than female at birth (day 0) and 1, 320 days of age, respectively. In this study, sexual dimorphism was evident in Lagune cattle, similarly to the observed marked differences between males and females in others growth and morphological studies (Okeyo *et al*., 1996) and could be due to the usual between-sex differential hormonal effects on growth. The faster growth of male in this study could be better exploited for fattening.

Degree of maturity: The degree of maturity (percent of the a-value of the Brody function) of the different body measurements, given stages of age was reported (Table 4). The maturity degree at birth (≤5%) of Lagune cattle in this study for LBW was <6% in Angus, Brahman and Santa Gertrudis (Francks and Burns, 1975) and 7% in Herefords cows (Fitzhugh and Taylor, 1971). Except LBW, Lagune cattle breeds are more mature (39.8-54.5%) at birth (day 0) for HG, HW and SIL. At the age of 2 years (720 days), both sexes are fully (≥90%) developed. They take less time to reach a given degree of maturity (Table 4) when comparing with the Angus cattle at 223 days (41 and 43%), 589 days (67 and 69%), 1, 149 days (92 and 93%), 1, 830 days (97 and 100%) and 2, 575 days (100 and 100%) of age (Beltran *et al*., 1992). These differences could be attributed the difference between race, the prevailing nutritional conditions, the level of management and genetic improvement. Even if female could be mated for the first time when they reach about 60% of their final live body weight (Salisabury *et al*., 1978) this clearly correspond to 360 days of age in this study (Table 4).

Predicting Live Body Weight (LBW) from linear measurements: Equations to predict the LBW from different body measurements (HW, HG and SIL) are shown in Table 5. R^2 range between 68 and 81% and was to +0.1 to +0.7 higher in male than female ($p<0.05$). The best fit determined by R^2 (79-81%) was obtained when dealing only with HG or in combination with HW and SIL to predict the LBW. In Baoule female cattle breed, Poivey provide the evidence of using simultaneously HG and HW to predict the LBW, through the levels of differences between the R^2. In Somba cattle breed from 1-4 years old, Adanlehoussi reported the predicted LBW from HG ($LBW = 13910^{-6} \times HG^{2.88}$) with higher R^2 (0.98).

CONCLUSION

The present study described the path by which the Lagune cattle breed follow from birth to 1, 320 days of age. Among the three competing models applied (Brody, Gompertz and Logistic), the Brody Model provide the goodness of fit, determined by higher R^2, lower MSE and BIC. Divergent growth responses for LBW, HW, HG and SIL have been found and male calves were larger, taller, longer and heavier than female. The degree of maturity from Brody model reveals that except for LBW, both sexes are fully developed (≥90%) at 720 days of age. The practical application of these results is about the perspective for the use of polynomial regression to predict the LBW involving only HG or with inclusion of HW and SIL. According to the maturity degree, the recommendable age at first mating for females when they reach about 60% of their final live body weight is 360 days. This study also suggests the importance of separating males and females within breeds when studying growth and size.

Under field condition such as small-scale farmers who do not have access to a weighbridge, body measurements may be useful as selection criteria for performance traits in those scenarios where weight measurements might not be feasible.

Consequently, the knowledge of LBW, HW, HG and SIL trends using Brody model would serve as valuable tools for overall productivity, feeding and drugs administration, selling and slaughtering Lagune cattle breeds. However, it cannot be assumed that the Brody model could *ad aeternam* produce the goodness of fit in the Samiondji breeding farm when the environmental conditions change.

ACKNOWLEDGEMENTS

The Benin Republic office of animal breeding is gratefully acknowledged for its contribution towards the supply of the data.

REFERENCES

Aboagye, G.S., C.L. Tawah and J.E.O. Rege, 1994. Shorthorn cattle of West and Central Africa III: Physical, adaptive and special genetic characteristics. World Anim. Rev., 78: 22-32.

Akaike, H., 1974. A new look at the statistical model identification. IEEE Trans. Automat. Control, 19: 716-723.

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

Alderson, G.L.H., 1999. The development of a system of linear measurements to provide an assessment of type and function of beef cattle. Anim. Genet. Resour. Inform., 25: 45-56.

Arango, J.A. and L.D. van Vleck, 2002. Size of beef cows: Early ideas, new developments. Genet. Mol. Res., 1: 51-63.

Beltran, J.J., W.T. Butts, T.A. Olson and M. Koger, 1992. Growth patterns of two lines of Angus cattle selected using predicted growth parameters. J. Anim. Sci., 70: 734-741.

Brody, S., 1945. Bioenergetics and Growth. Reinhold Publishing Co., UK., pp: 1023.

Brotherstone, S. and W.G. Hill, 1991. Dairy herd life in relation to linear type traits and production 1: Phenotypic and genetic analysis in pedigree type classified herds. Anim. Prod., 53: 279-287.

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

Bullock, K.D., J.K. Bertrand and L.L. Benyshek, 1993. Genetic and environmental parameters for mature weight and other growth measures in Polled Hereford cattle. J. Anim. Sci., 71: 1737-1741.

Buvanendran, V., E.J. Umoh and B.Y. Abubakar, 1980. An evaluation of body size as related to weight of three West African breeds of cattle in Nigeria. J. Agric. Sci., 95: 219-224.

De Behr, V., J.L. Hornick, J.F. Cabaraux, A. Alvarel and L. Isfasse, 2001. Growth patterns of Belgian Blue replacement heifer and growing males in commercial farms. Livest. Prod. Sci., 71: 121-130.

Epstein, H., 1971. The Origin of Domestic Animals of Africa. Vol. 2, Africana Publishing Corporation, New York.

Fernandez, G., J.A. Baro, L.F. de la Fuente and F. San Primitivo, 1997. Genetic parameters for linear udder traits of dairy ewes. J. Dairy Sci., 80: 601-605.

Fitzhugh, Jr. H.A. and C.S. Taylor, 1971. Genetics analysis of degree of maturity. J. Anim. Sci., 33: 717-725.

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

Francks, D.E. and W.C. Burns, 1975. A discussion of growth curves of Angus, Brahman, Hereford and Santa Gertrudis cows. Florida Agricultural Experiment Station Report No. AL-1975-1, Gainesville, FL., USA.

Gatesy, J. and P. Arctander, 2000. Hidden morphological support for the phylogenetic placement of *Pseudoryx nghetinhensis* with bovine bovids: A combined analysis of gross anatomical evidence and DNA sequences from five genes. Syst. Biol., 49: 515-538.

Goonewardene, L.A., R.T. Berg and R.T. Hardin, 1981. A growth study of beef cattle. Can. J. Anim. Sci., 61: 1041-1048.

Kaps, M., W.O. Herring and W.R. Lamberson, 2000. Genetic and environmental parameters for traits derived from the Brody growth curve and their relationships with weaning weight in Angus cattle. J. Anim. Sci., 78: 1436-1442.

Koenen, E.P.C. and A.F. Groen, 1996. Genetic analysis of growth patterns of Black and White dairy heifers. J. Dairy Sci., 79: 495-501.

Lambe, N.R., E.A. Navajas, G. Simm and L. Bunger, 2006. A genetic investigation of various growth models to describe growth of lambs of two contrasting breeds. J. Anim. Sci., 84: 2642-2654.

Lopez de Torre, G., J.J. Candott, A. Reverter, M.M. Bellido, P. Vasco, L.J. Garcia and J.S. Brinks, 1992. Effects of growth curve parameters on cow efficiency. J. Anim. Sci., 70: 2668-2672.

Luo, M.F., G.R. Wiggans and S.M. Hubbard, 1997. Variance component estimation and multitrait genetic evaluation for type traits of dairy goats. J. Dairy Sci., 80: 594-600.

Mwacharo, J.M., A.M. Okeyo, G.K. Kamande and J.E.O. Rege, 2006. The small East African shorthorn zebu cows in Kenya. I: Linear body measurements. Trop. Anim. Health Prod., 38: 65-74.

Okeyo, A.M., R.O. Mosi, C.O. Ahuya, J.E.O. Rege and M.A. Okomo, 1996. Phenotypic characteristics of the small East African zebu cattle in the Lake Victoria basin and coastal lowlands of Kenya: Morphological and physical characteristics. Proceedings of the 5th Kenya Agricultural Research Institute Scientific Conference, October 14-16, 1996, KARI Headquarters, Nairobi, Kenya, pp: 345-355.

Rege, J.E.O., 1999. The state of African cattle genetic resources. I. Classification framework and identification of threatened and extinct breeds. Anim. Genet. Resourc. Inform. Bull., 26: 1-25.

Renne, U., M. Langhammer, E. Wytrwat, G. Dietl and L. Bunger, 2003. Genetic statistical analysis of growth in selected and unselected mouse lines. J. Exp. Anim. Sci., 42: 218-232.

SAS, 2006. User's Guide: Version 9.1. SAS Institute Inc., Cary, NC., USA.

Salisabury, G.M., N.L. van Demark and J.R. Lodge, 1978. Physiology of Reproduction and Artificial Insemination in Cattle. 2nd Edn., H. Freeman and Co., San Francisco, pp: 329-365.

Schwarz, G., 1978. Estimating the dimensions of a model. Ann. Stat., 6: 461-464.

Zechner, P., F. Zohman, J. Solkner, I. Bodo, F. Habe and E. Marti, 2001. Morphological description of the Lipizzan horse population. Livest. Prod. Sci., 69: 163-177.