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Analyses of Growth Curve Parameters of N'Dama Cattle Raised in the Humid Tropics.

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Abstract

Individual growth curve parameters are suitable phenotypic variables for the assessment of growth course and early maturity. This study focused on the analyses of growth curves parameters of N'Dama cows derived from the Richards growth function. Data consist of field records of weight measurements from birth to 36 months old of 98 N'Dama cows born and raised between 1992 and 1998. The coefficient of variation was moderately high in both the curve and the predicted parameters except for point of inflation (m). The estimates of heritability for maturing traits ranged from 0.18 to 0.30, while those for body weights and growth traits ranged from 0.21 to 0.47. High correlation coefficients were observed between mature weight parameter (A) and body weights at 180 days, 365days and 550days of age. A negative relationship was observed between A and maturing rate index k,(-0.51) and between A and all maturing parameters associated with stages of growth (degrees of maturity and relative growth rates). Sire variation was an important source of variation (P<0.05) for all the parameters studied except for residual mean squares (RMS). Year of birth was also a significant (P<0.05) source of variation for A, k, RMS, degrees of maturity at 180days of age and the relative growth rates at 180 days and 365days of age, while age of dam significantly (P<0.05) affected the constant of integration b, the maturing rate index k, body weight and degrees of maturity at 180days of age. Season of birth affected the point of inflation (m) RMS, body weight at 180days and absolute growth rate at 365 days of age. The interaction between year of birth and age of dam was significant (P<0.05), affecting only the A and the k parameters

Keywords: Curve parameters, maturing traits, mature weight, Sire and environmental factors, N'Dama.

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1.0 Introduction

Growth functions have been used extensively to represent changes in sizes with age, so that the genetic potential of animals for growth can be evaluated and nutrition matched to possible growth (Gwaze *et al.*, 2002). The use of growth functions is usually empirical and the form of the function is chosen by its ability to fit the observed data. In our previous study (Ozoje, *et al.*, 2006), we reported that the Richards function best described the observed growth curve data of N'Dama cows and resulted in a curve that agreed better with conventional standards of biological growth. Richards function, according to Brown, *et al.*. (1976). Sager (1983), DeNise and Brink (1985) and Perotto *et al.*. (1992) most appropriately fits to actual data owing to its general character providing the least sums of squares. However, its computational difficulty is high in comparison with other functions. Nevertheless, some other authors reported better results with other models in other breeds of cattle. Vaccaro and Riverto (1983); Lopez de Torre *et al.*, (1992) and Carrijo and Duarte (1999) reported that the von Bertalanffy model resulted in a curve that better agreed with conventional standards of biological growth in Holstein Friesian, Chianina and Nelore cattle breeds, while Meyer, (1995) preferred the Gompertz model because the position of the inflation point at $^1/_3$ of asymptotic weight was suitable for the growth curve in cattle. Growth equations according to Richards (1959) are important in estimating parameters that are biologically uninterpretable, such as, age at point of inflation of the growth curve, mature weight and maturity rate. Individual growth curve parameters, both basic and derived are suitable phenotypic variables for the assessment of growth course and early maturity (Lopez de Torre and Rankin 1978, Kratochvilova *et al.*, 2002). Growth curve parameters such as mature weight (A) and general maturity rate (k), estimated from weights taken periodically during the life of the animal can be used to evaluate the development of an animal (Brody, 1945).

From the viewpoint of development (measured in terms of body weight at different ages), growth is a combination of hereditary and environmental effects. The application of nonlinear algebraic functions to weights could help detect both genetic and environmental variability, a fundamentally important factor for selection in breeding programmes (Carrijo and Duarte 1999). Genetic and environmental factors affecting growth curve parameters have been examined under varying temperate environmental conditions (Lopez de Torre and Rankin, 1978; De Nise and Brinks, 1985), but, little or no report exists on curve parameters in tropical cows. The aim of this study therefore, was to estimate the growth curve parameters in N'Dama cows in the humid tropics using the Richards function and to determine the effects of sire, year of birth, age of dam and season of birth on these growth curve parameters.

2.0 Materials and Methods

2.1 *Location and source of animals*

Performance records of ninety eight N'Dama cows calved and raised between 1992 and 1995 at the International Livestock Research Institute, Ibadan research station, located at Fashola were used for this study. This research station is located on latitude 7°54'N and longitude 3°43'E, North-west of Ibadan. It lies on a smooth stretch plain of between 250m and 300m above sea level in a derived savannah zone. High temperatures (26°C – 36°C), high humidity (78%-90%) and an annual rainfall of between 1105mm and 1580mm with peak in June characterize the climate of this zone. The dry season period of the year extends from October to April with average temperature of 30.6°C.

Animals in the research station are offspring of the foundation stock obtained by the research institute in the late eighties. About 30 bulls had contributed progenies to the herd at the time this data was collected. The animals were weighed at monthly interval from birth until the animals are culled. However, only growth data of each cow comprising of a sequence of body weights record taken at birth and at monthly interval from birth to 36 months of age were included in this analysis. Data from cow with less than 12 consecutive weights records were however, excluded from the study.

2.2 *Management practices.*

The cattle herd was on range all year round and depended on natural pasture except for the dry season period when supplementary feeds were provided depending on the pasture condition and the severity of the dry season. The cattle grazed on extensively managed pastureland characterized predominantly by *Andropogan spp, Panicum maximum, Cynodon plectostachyus, Pennisetum purpureum, Centrosema pubescens and Imperata cylindrical.* Pasture was constantly slashed to improve its nutritive value. All cows were grazed from 07.00 – 16.00 hours on natural pasture daily. They were also provided free access to trace mineralized salt. Routine management practices included regular deworming and spraying against endo-and ecto-parasites, monthly recording of body weight of animals and vaccination against rinderpest, pluero-prieumonia, black-quarter, septicemia, anthrax, foot and mouth disease. All heifers were exposed to bulls all year round. Calves were weighed within 6 to 12 hours after birth and allowed to suckle their dams freely. They were tagged within the first 7 days of birth and records made of date of birth, dam, sire, sex, and birth weight. Management of calves remained fairly constant over the years. Female calves were managed together following weaning until the age of initial mating. Male progenies were kept intact and managed through to slaughter. To estimate the growth curve parameters of the N'Dama cows used, the Richards function was chosen for its goodness of fit to the available data based on our previous study (Ozoje, *et al.*, 2006).

$$Y_t = A(1-be^{-kt})^M$$

It was fitted to weight-age data from birth to 24 months of age for each individual by nonlinear regression model using the NLIN procedure of SAS package (1999).

In this equation, Y_t is the size or the observed body weight at age t expressed in months. A is its final (asymptotaic) limit of the weight when age (t) approaches infinity. This does not imply that A is the heaviest weight attained by the individual but it indicates the average weight of the mature cow independent of short term fluctuations due to temporary environmental effects. It is commonly interpreted as mature weight. The parameter b is a constant of integration that adjusts for situations where y_o and/or t_o do not equal 0. It indicates the proportion of the asymptotic mature weight to be gained after birth, established by the initial values of y and t. K is a constant that expresses the rate at which a logarithm function of y, specific for each of the nonlinear equations changes linearly with time. It is interpreted biologically as a maturing index, establishing the earliness with which y approaches A. It is normally referred to as the maturing rate. It is related to postnatal rate of maturing and serves both as a measure of growth rate and of the rate of change in growth rate. Large k value indicates early maturing animals and vice versa. Genetic and environmental factors that influence the slope of the growth curve or the asymptotic weight will also influence the estimates of the rate of maturing. M is the point of inflation or inflation parameter, which occurs where the estimated growth rate changes from an increasing to a deceasing function. Rate of change in weight is maximum at the point of inflation because by definition these equations have zero gradients at point of inflation. It is responsible for the differences in shape among the graphic solutions that this equation generates. M takes on any positive value in Richards function. In essence, it permits a variable point of inflation for ($0<M\leq1$). This means that the weight at inflation is a function of M.

The data used in this study are unadjusted weights and as such are representative of growth under normal management conditions. The logic of using unadjusted weights in this study drives from the fact that serial measurements are simultaneously considered in estimation of parameters.

Individual estimates of the parameters for each model were obtained using the multivariate secant or the DUD (Doesn't' use Derivatives) method of iteration for nonlinear models. Under this procedure, the derivatives are estimated from the history of iterations rather than supplied analytically. The iterative procedure converged whenever:

$$(SSE_{i-1} - SSE_i)/(SSE_i) + 10^{-6})\ 10^{-8}$$

Where SSE is the residual sum of squares and i denotes the round of iteration. To assure biologically feasible solutions as well as to avoid mathematically invalid computations, bounds were set to the parameter estimates of Richards equations so that $b \leq 0.99$ and $M \leq 10$.

Individual curves and their first derivatives were used to compute the following growth traits: Predicted body weight at 180, 365, 550 and 720 days of age, growth rates in grams per day between 180, 365 and 550 days of age (slope of the curve at these ages), degree of maturity at 180, 365, 550 and 720 days of age and relative growth rate in grams-day^{-1} .kg^{-1} at 180, 365 and 550 days of age. These estimated curve parameters along with A (Asymptotic weight), b (constant of integration), k (maturing rate index) and the residual mean squares were used to obtain maximum information on intrinsic characteristics of the model.

The growth rate function (GR[t]) was equal to the first derivative of the Richards function: Where $GR(t) = dy_t/dt = Mky(u^{-1/M}-1)$ u is degree of maturity, Here, growth rate (g/d) at a particular time point describes gain in weight, which depends not only on previous weight points but also on curve points in later stages of growth. Degree of maturity (U) is defined as follows: $U = y_t/A = (1 + be^{-kt})^M$

This is a measure of dynamic growth relative to mature weight. It is the proportion of mature size attained at age t.

Relative growth rate, RGR(t) is defined as: $RGR(t) = Gr(t)/y_t)$

Relative growth rate is a measure of growth rate relative to weight at a particular age. Based on the correlation analysis, relationships between the growth curve parameters were obtained

2.3 *Statistical Analysis.*

Sire variation and some environmental factors effects on the growth curve parameters were analysed by the mixed model least squares analysis procedures for data with unequal subclass numbers, (SAS, 1999). The model used included the fixed effects of year of birth, age of dam, season of birth and the random effect of individual sire. Preliminary analysis showed that all first order interactions were not significant except for year of birth x age of dam and hence wee removed from the final model. Differences among means that showed significance was subjected to New Duncan multiple range tests (Steele and Torrie, 1980). Least squares analyses of variance and covariance of predicted and estimated parameters obtained from the Richards function of individual curves was conducted using sire and dam information to obtain estimates of between sires (σ^2_s), between dam within sires (σ^2_D) and between progenies within dam (σ^2_e) components of variance and covariance from the varcomp procedure of SAS, (1999). Estimate of heritability was then obtained by paternal half-sib procedure.

3.0 Results and Discussions

3.1 Estimated Curve Parameters.

The mean statistics and the heritability estimates of curve parameters and traits estimated from the Richard's growth curves function are presented in Table 1 and 2 respectively. Coefficients of variation were moderately high in estimated curve parameters, except for point of inflation, (m). However, percentage variations were higher in body weights and absolute growth rates than in degrees of maturity and relative growth rates. On the average, cows were about 61 percent matured at 12 months, which is considerably high, compared to the values reported among temperate breeds (Kaps *et al* 2000). Similarly estimated relative growth rates in this study, were significantly higher than the values reported by Kaps *et al* (2000) and Kratochvilova *et al* (2002) among Angus and Holstein cows.

The estimates of heritability for maturing traits (i.e maturing rate index k, degrees of maturity and relative growth rates) ranged from 0.18 to 30. For the curve maturing rate parameter k, the value obtained in this study is similar to that reported by Kaps *et al* (2000) which varied from 0.17 to 0.32. However, DeNise and Brinks (1985) and Jenkins *et al* (1991) reported heritability estimates of 0.20 and 0.27 respectively. Kaps *et al* (2000), reported that relative growth rate and degrees of maturity exhibit moderately high heritability which indicates that a trait can be altered by

Table 1: Statistics of the growth curve and maturing traits parameters predicted from Richards Equation

Parameters	Mean	S.E	CV,%
Asymptotic Weight, A, kg	265.78	10.67	21.35
Constant of Integration, b	0.93	0.04	10.10
Maturing rate index (k), per day	0.07	0.01	14.81
Point of Inflation, m	1.09	0.01	10.20
Residual mean squares	695.12	17.89	11.76
180-day Weight, kg	109.58	9.89	28.52
365 – day weight, kg	163.47	11.34	25.56
550-day weight, kg	215.56	9.77	23.56
180-day growth rate, g/d	359.62	39.32	30.72
365-day growth rate, g/d	226.43	26.11	29.01
180-day Degree of maturity	0.41	0.08	23.19
365 – day Degree of maturity	0.62	0.11	19.95
550- Degree of maturity	0.81	0.14	17.12
180-day Relative growth rate, $g.d^{-1}.kg^{-1}$	3.28	0.61	20.91
365-day Relative growth rate, $g.d^{-1}.kg^{-1}$	1.38	0.55	18.89

Table 2: Heritabilty estimates of predicted growth curve and maturing parameter estimates from the Richards Function

Parameters	h^2	S.E
Mature Weight.	0.47	0.11
Maturing rate index (k), per day	0.30	0.13
180-day Weight, kg	0.21	0.09
365 – day weight, kg	0.25	0.09
550-day weight, kg	0.32	0.15
180-day growth rate, g/d	0.24	0.10
365-day growth rate, g/d	0.28	0.08
180-day Degree of maturity	0.18	0.09
365 – day Degree of maturity	0. 23	0.10
550- Degree of maturity	0.26	0.14
180-day Relative growth rate, $g.d^{-1}.kg^{-1}$	0.19	0.09
365-day Relative growth rate, $g.d^{-1}.kg^{-1}$	0.22	0.12

selection. Similar conclusion can be drawn in this study (Table 2). They nevertheless stated that selection only for ratio traits could lead to unpredictable and undesirable responses in the denominator and numerator traits. For example, changing the degrees of maturity or maturing rate index could lead to smaller mature weight and lower daily gain. Therefore, aggregate information about weights, growth rates and maturing rates at different ages should be viewed as valuable information to beef cattle breeding programs, especially when multiple-trait selection is applied. Heritability estimates for the predicted weights and growth rates in the present study ranged from 0.21 to 0.47, which compares favourably with the report of Northcutt and Wilson, (1993), Nunez-Dominguez *et al* (1993) and Bennett and Gregory (1996), who estimated heritability from nine purebreds and three composites and stated that the residual variances for post-weaning gain increased with increase in weight. However, contrary to these reports, Carrijo and Duarte, (1999), comparing growth parameters in Chianina and Nelore cattle, reported low heritability for curve parameters, especially for mature weight. High heritability for mature weight according to Northcutt and Wilson, (1993) and Bullock *et al* (1993), suggests that mature weight could be genetically altered by selection.

Correlations coefficients between the estimated curve parameters are presented in Table 3.The highest coefficient of 0.61 was observed between matured weight and predicted body weights at 550days of age, followed by body weights at 365 days of age (0.58). High and positive relationship between mature weight (A) and weights at different age intervals were also reported by Carrijo and Duarte, (1999) and Northcutt *et al.* (1994). The correlation coefficient values tended to increase with increase in age, agreeing with the observation of Bullock *et al* (1993).

Biologically, the most important relationship is that between the mature weight A, and the maturing rate index k, according to Lopez de Torre and Rankin (1978). In this study, a significant negative relationship was observed between A and k (-0.51) and for all maturing parameters associated with stages of growth, i.e. degrees of maturity at 180 days, 365 days and 550 days of age and relative growth rates at 180 days and 365 days of age (Table 3). Reporting similar observation, Carrijo and Duarte, (1999), stated that parameters A and k showed a pronounced inverse relationship, such that animals with heavier average A values presented the slowest average k values. On the other hand, those that grew with fast maturing rates were lighter at maturity, while those that matured later tended to have higher weight at maturity. An inverse relationship between mature weight and maturing rates were also reported by Duarte, (1975); Lopez de Torre and Rankin (1978); Nelson, *et al* (1982); Perroto *et al* (1992); Bullock *et al* (1993); Perroto *et al.* (1994) and Kratochvilkova *et al.* (2002). Similar conclusion can also be drawn with respect to the negative relationship observed between growth traits (body weights, growth rates) and maturing traits (degrees of maturity, relative growth rates) at different ages. Thus, indicating that selection for faster maturity rates could result

Table 3: Pearson correlation matrix between estimated growth curve parameters

	A	b	k	m	180_{days}	365_{days}	550_{days}	AGR_{180}	AGR_{365}	180dU	365dU	550dU	RC	RGR_{365}
A														
b	-0.13													
k	-0.51*	0.34*												
m	-0.24	0.21	-0.11											
180_{days}	0.31*	0.12	-0.38*	0.41*										
365_{days}	0.58*	0.18	-0.27*	0.32*	0.71*									
550_{days}	0.61*	0.14	-0.18	0.31*	0.63*	0.78*								
AGR_{180}	0.49*	0.09	-0.34*	0.47*	0.91*	0.76*	0.66*							
AGR_{365}	0.56*	0.04	-0.29*	0.38*	0.63*	0.96*	0.78*	0.93*						
180dU	-0.37*	0.23	0.51*	-0.32*	-0.61*	-0.68*	-0.31*	-0.26*	-0.19*					
365dU	-0.41*	0.22	0.44*	-0.30*	-0.42*	-0.71*	-0.45*	-0.21*	-0.27*	0.72*				
550dU	-0.34*	0.25	0.41*	-0.21*	-0.39*	-0.61*	-0.55*	-0.28*	-0.31*	0.69*	0.78*			
RGR_{180}	-0.27*	0.16	0.33*	-0.29*	-0.45*	-0.39*	-0.28*	-0.22*	-0.19*	0.66*	0.57*	0.61*		
RGR_{365}	-0.19	0.18	0.37*	-0.18	-0.41*	-0.59*	-0.36*	-0.27	-0.28*	0.60*	0.63*	0.69*	0.81*	

* $P < 0.05$

dU - degrees of maturity, AGR- average growth rate, RGR – relative growth rate in a reduction in mature weights. The negative correlation between k and (m) (-0.11) observed here indicates that faster rate of maturing will result in lower weight at inflation point. The positive correlation between A and the point of inflation m, reflects the definite relationship between A and the coordinates of the point of inflation (weights and age) where growth rate changes from increasing to decreasing. Correlation coefficient between constant of integration, b and the other parameters were low and not significant except for the maturing rate index, k.

3.2 *Sire and Environmental factors effects on Estimated curve parameters*

Tables 4 and 5 showed the mean squares values from the analysis of variance of the effect of sire, year of birth, season of birth, age of dam and the interaction between year of birth and age of dam on the estimated growth curve parameters. Sire significantly ($P<0.05$) affected all traits studied except the residual mean squares (RMS), indicating substantial genetic variations within the population of N'Dama cows used. It also demonstrated the large influence of sire variation on the entire process of growth within the N'Dama breed of cattle. Reporting similar results between two breed of cattle, Lopez de Torre and Rankin (1978) stated that the significant effect of breed on the b and k parameters indicate differences in early growth. Bianchini Sobrinho and Duarte, (1991) and Carrijo and Duarte, (1999) also reported that bulls significantly affected estimated growth curve parameters.

Year of birth significantly affected mature weight A, ($P<0.05$), maturing rate k, ($P<0.05$), residual mean squares (RMS) ($P<0.01$), degrees of maturity at 180days of age and relative growth rate at 180 and 365 days ($P<0.05$), while, age of dam, significantly ($P<0.05$) affected the constant of integration b, maturing rate index k, body weight and degrees of maturity at 180 days of age. Tables 6 and 7 showed the least square means of the effect of sire, year of birth, age of dam and season of birth on the estimates of the growth curve parameters studied. The average mature weight A, of cows born in 1992 and 1994 were significantly higher than those born in 1993

Table 4: Analysis of variance for the estimates of growth curve parameters (A, b,k m) and the predicted body weight traits

		Mean Squares							
Source	df	A	b (10^{-2})	k (10^{-2})	m (10^{-3})	RMS (10^{2})	180_{dwt}	365_{dwt} (10^{2})	550_{dwt} (10^{2})
Sires	5	2116.15**	0.044*	79.35**	96.45**	723.22	678.99*	776.56*	876.93*
Year of birth	4	1042.75*	0.081	3.22*	6.67	7341.72**	358.65	467.88	366.24
Age of dam	3	362.37	0.197*	8.23*	7.98	891.24	562.11*	276.43	387.32
Season of birth	3	276.91	0.034	4.78	87.33*	2534.12*	499.77*	344.55	277.98
Year X Dam Age	12	1032.76*	0.068	45.62**	33.67	1102.33	214.15	233.87	377.22
Error	69	972.11	0.088	5.24	55.38	2135.35	404.76	468.91	455.74
R^2		0.27	0. 34	0.37	0.31	0.39	0.41	0.39	0.42

*$P<0.05$, ** $P<0.01$, *** $P<0.001$

Table 5: Analysis of variance for the predicted parameters of growth rates parameters and degrees of maturity

		Mean Squares						
Source	df	180dU (10^{-2})	365dU (10^{-2})	550dU (10^{-2})	AGR_{180}	AGR_{365} (10^{-2})	RGR_{180} (10^{-2})	RGR_{365}
Sires	5	11.11**	0.155*	69.75**	623.22*	628.69*	0.093*	0.084*
Year of birth	4	10.79*	0.082	3.22	741.72	254.61	0.054*	0.045*
Age of dam	3	9.34*	0.076	4.23	591.24	362.41	0.032	0.040
Season of birth	3	2.97	0.039	4.78	434.12	439.17*	0.028	0.039
Year X Dam Age	12	4.71	0.061	4.62	102.33	264.75	0.022	0.019
Error	69	9.21	0.083	5.24	605.35	411.33	0.055	0.049
R^2		0.27	0.28	0.29	0.36	0.38	0.37	0.40

* $P<0.05$, **$P<0.01$, ***$P<0.001$

Table 6: Least squares means of predicted estimates of growth curve parameters (A,b,k,m) and body weight (kg) traits as affected by sire variation, year of birth, age of dam, and season of birth

	N	A	b	k	m	RMS	180_{dwt}	365_{dwt}	550_{dwt}
Sires No									
18	21	266.62b	0.93b	0.069c	1.10b	709.77	113.83b	162.92b	212.59c
27	14	268.83ab	0.89c	0.067cd	1.15a	684.69	106.54bc	163.30b	217.48b
35	18	271.72a	0.97a	0.065d	1.09b	679.54	112.72b	170.31a	223.61a
41	15	264.67c	0.96a	0.074b	0.99d	702.46	119.26a	170.36a	225.70a
58	13	259.16d	0.89c	0.078a	1.04c	702.54	100.87c	157.44c	205.57d
64	17	263.71c	0.94b	0.075b	1.17a	691.75	104.36c	156.49c	208.43cd
Year of birth									
1992	26	267.45a	0.94	0.069a	1.10	670.57c	110.76	163.60	217.74
1993	34	263.14b	0.92	0.074b	1.08	726.41a	107.00	162.24	214.66
1994	20	268.89a	0.93	0.070ab	1.10	681.27bc	106.61	165.36	215.38
1995	18	263.66b	0.93	0.072b	1.08	702.23b	114.02	162.68	214.47
Age of dam									
< 3 yrs	16	265.27	0.96a	0.069b	1.11	698.17	102.76c	162.44	213.64
3 - 5 yrs	32	266.69	0.92bc	0.073a	1.08	687.49	108.27b	164.70	216.76
5 - 7 yrs	35	264.70	0.90c	0.072ab	1.08	702.31	116.60a	164.86	216.88
> 7 yrs	15	266.48	0.94b	0.070b	1.09	692.53	110.72b	161.88	214.97
Season of birth									
Jan - March	25	266.69	0.94	0.070	1.08b	715.17a	109.57b	162.94	215.04
April - June	33	267.27	0.93	0.072	1.12a	677.49b	115.80a	165.20	217.56
July - Sept.	26	264.70	0.92	0.072	1.10a	682.53b	109.25b	163.84	215.68
Oct. - Dec.	14	264.48	0.93	0.070	1.06b	707.31a	103.68c	161.90	213.97

Columns with the same letters are not significantly different ($P>0.05$)

and 1995 respectively. Looking at the weight records taken on these cows, it was realized that there was an unusual low values in the weights records obtained between February and March, 1993 and August, 1995, which was probably due to low feed availability and the fibrous nature of the grasses usually observed between August and September. Naturally, heifers' usually lose weight at the peak of dry season (January – March) when availability of grasses is usually low and supplemented feed is not sufficient.

Maturing rates index k, were higher in heifers born in 1993 and 1995 respectively, although the differences appears to be minor. Heifers born in 1993 appeared to have a more efficient maturing pattern than those born in other years, maturing earlier to lighter weight at maturity. Heifer born in 1993 probably attained full reproductive potentials earlier and had lower nutrition requirements at maturity. Residual mean squares were higher for cows born in 1993, an indication of more accurate prediction of growth pattern of cows born in other years as compared to those born in 1993. In addition, the irregularity in growth pattern in relation to the model used (Richards) varied with year of birth. Degrees of maturity and relative growth rates were higher in animals born in 1993 and 1995 (Table 7). The significant effect of year of birth on mature weight A, RMS and maturing rate index was also reported by Lopez de Torre and Rankins, (1978), DeNise, (1982); DeNise and Brinks, (1985) and Carrijo and Duarte, (1999). Carrijo and Duarte, (1999) also reported significant effect of age of dam ($P<0.05$) on the constant of integration and maturing rate index. Dam, aged dH3 years gave birth to cows with higher constant of integration, while dams within the age bracket of 3-5 years gave birth to cows that matured at a faster rate of 0.73. Dams, aged between 5-7 years produced females with heavier weights at 180 days of age, while 3-5 years old dams produced heifers with higher degrees of maturity at 180 days of age. Parity, according to Brown et al, (1972); Smith *et al* (1976) and Lopez de Torre *et al* (1992) tends to increase

Table 7: Least squares means of predicted estimates of degrees of maturity (%) and growth rates (g/d and g.d-1,kg respectively) as affected by sire variation, year of birth, age of dam and season of birth.

Variables	N	180dU	365dU	550dU	AGR_{180}	AGR_{365}	RGR_{180}	RGR_{365}
Sires No								
18	21	0.37bc	0.58bc	0.76c	367.32a	237.48a	2.65c	1.31cd
27	14	0.43ab	0.65ab	0.82b	355.39bc	223.70b	3.00bc	1.46a
35	18	0.47a	0.69a	0.88a	349.51c	210.82c	3.97a	1.67a
41	15	0.44a	0.64ab	0.85ab	354.40bc	216.56c	3.91a	1.41a
58	13	0.35c	0.55c	0.75c	371.65a	242.58a	3.15b	1.21d
64	17	0.40b	0.62b	0.80bc	359.44b	227.45b	3.01b	1.23c
Year of birth								
1992	26	0.40b	0.60	0.81	361.32	227.48	2.85b	1.24b
1993	34	0.46a	0.64	0.82	360.15	225.58	3.92a	1.52a
1994	20	0.36ab	0.63	0.78	358.69	229.45	3.41a	1.50a
1995	18	0.42c	0.62	0.83	357.30	222.82	2.90b	1.26b
Age of dam								
≤ 3 yrs	16	0.39b	0.61	0.80	355.70	224.60	3.16	1.36
3-5 yrs	32	0.44a	0.63	0.83	363.27	230.54	3.41	1.40
5-7 yrs	35	0.42ab	0.63	0.82	362.71	226.49	3.39	1.39
> 7 yrs	15	0.39b	0.62	0.79	356.78	223.70	3.17	1.37
Season of birth								
Jan – March	25	0.41	0.63	0.81	357.60	225.69ab	3.11	1.35
April – June	33	0.42	0.62	0.81	364.36	230.59a	3.61	1.39
July – Sept	26	0.42	0.64	0.82	361.75	227.80a	3.40	1.40
Oct – Dec	14	0.39	0.60	0.80	354.75	221.25b	3.00	1.38

Columns with the same letters are not significantly different ($P>0.05$)

with increase in age and parity has being reported to significantly influence preweaning growth rate. The effect of parity is associated with increase in uterine size which exerts a positive effect on preweaning growth. This is probably why dams 5-7 years produced heifers with faster growth rate and heavier body weight at 180 days of age. However, an inverse relationship exist between growth rate and maturing rate such that animals growing at a faster rate matures at a slower rate(Carrijo and Duarte, 1999; Fitzhugh and Taylor, 1971 and Smith *et al* 1976).

Season of birth significantly ($P<0.05$) affected point of inflation m, RMS, body weight at 180 days of age and growth rates at 365 days and 550 days of age respectively (Tables 6 and 7). The interaction between year of birth and age of dam significantly affected matured weight ($P<0.05$) and maturing rate k ($P<0.01$). Cows produced by older dams (eH7) in 1992 tended to have heavier mature weight than cows produced by relatively younger dam (eH5), whereas in 1995, the cows produced by young dams had heavier mature weights compared to those produced by dams age 7years and above. Nevertheless in 1992, cows produced by older dams matured at a lesser rate and at a faster rate in 1995. This observation may be associated with fluctuation in climatic conditions, feed availability and ability to adapt to changes in grazing conditions. The recorded rainfall per annum was relatively low in 1992 (900mm) as compared to 1995 (1350mm).

In order to visualize what the above mentioned effects on growth parameters actually mean in terms of weight at the distinct stages of development, analysis of variance were made for all actual weights and estimated weights from the individual growth curves. The two analysis did not differed significantly, which seems to indicate a good agreement of the actual weights with the estimated weights, that is, the adequacy of the model in generating these estimated weights.

Conclusion

The coefficients of variation were moderately high in the estimated curve parameters, indicating enough room for selection. Moderate to high heritability found for the estimated parameters suggests that selection for growth and maturing traits based on the values of curve parameters may lead to satisfactory response. The significant effect of sire variation on the estimated parameters indicates a large influence of sire on the entire process of growth within the N'Dama population used. Also the significant influence of year of birth and age of dam on the entire process of growth was demonstrated. One trait of importance in beef cattle production is the mature weight of the cow herd. The high and positive correlation obtained between mature weight and weights at 180 and 365 days of age is an indication that selection for weight at 180 days or 365 days of age will increase mature weight leading to animals that grow faster and attain maturity younger and heavier. However, the negative correlation between mature weight and maturing rate index indicates that early maturity can not be linked to a large body size. Therefore, increasing emphases on growth rate and days to market in beef cattle production system will likely have a negative effect on earliness to maturity and subsequent reproductive performance. Early maturity is requested with respect to the herd effectiveness as a whole, that is, to reduce non-productive rearing inputs by breeding replacement heifers earlier at the same stage of maturity.

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