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Growth Curves of Body Weight from Birth to Four Years in Bikaneri Breed of Indian Camel (*Camelus dromedarius*)

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ABSTRACT

Body weight of Bikaneri Camel at 3 months intervals up to 18 month of age fallowed by 6 month intervals up to 4 years of age were used to evaluate the growth curves using linear, exponential and modified exponential equations. All three equations were solved through simple linear regression analysis. The equations were developed separately for male and female calves as well as for both. The relative efficiency of each equation was evaluated. It was found that the linear regression equation (Y=a+bt) had the maximum coefficient of determination fallowed by the modified exponential model (Y=at b). With respect to the reliability, all equations ranked similarly in males, females and pooled observations. The shape of the growth curves obtained by linear equation was much closer to the shape of observed growth curve than those obtained by other equations. The predicted equations for body weight from birth to 4 years of age at an interval of 180 days derived on the basis of pooled data for the linear equation and modified exponential equations, respectively, were as fellow: Body weight (kg)= 82.71 + 0.2861 * age in days and Body weight (kg) = antilog, (3.5852+0.3257)(log, for age in days). It can be concluded that the growth curve up to the age of four years can be best explained by a linear equations.

Key words: Body weight, Birth weight, Camel, India

INTRODUCTION

The growth pattern in various livestock species has been studied extensively by many research workers. Several functions have been attempted to represent the growth curve. The most widely used is the linear function ($Y = a + bx$). Another function described by Brody (1964), where $Y = ae^{bx}$ has also been used. But in camels only a few studies have been conducted. Beniwal & Chaudhry (1983) studied the growth pattern in Bikaneri calves from birth to 30 months of age and developed growth curve equation. Maximum monthly growth was attained in the first 3 months of postnatal life. Thereafter, it declined up to 24 months, but increased from 24 to 27 months of age. They tested the growth curve using linear functions and exponential function and found that growth from birth to 30 months was best expressed by the linear function.

Field (1979) reported maximum growth rate in the first year of age in dromedaries from Kenya. The mean rate of growth during the first year was 0.58 kg per day. Richard & Gerard (1985) reported the average daily gain in Dankali dromedary (Ethiopia) as 350 g and 244 g daily in males and females, respectivelly, in first year of life. Degan *et al.,* (1987) noted average daily gain as 680 g up to 180 days, whereas high daily gain was observed by Meredov (1989) as 950-1030 g in Arvana type of camel (*Camelus dromedarius*) in USSR up to one year. Khanna (1988) reported the average gain per day as 610, 381, 244 and 236 g from birth to 6 months, 6 to 12 months, 1 to 2 year and 2 to 3 year old camels, respectively. Khanna *et al.,* (1990) studied the growth pattern in Bikaneri and Kachchhi breeds. In the Bikaneri breed, the daily weight gain were 732, 616, 349 and 209 g, whereas in the Kachchhi breed wer 800, 686, 254 and 132 g in 0-3 months, 3-6 months, 6-12 months and 1-2 year age groups, respectively. The objective of this research was to study the growth curves from birth to four years of age in Bikaneri breed of Indian camel.

MATERIALS AND METHODS

At The National Research Centre on Camel in bikaner, body weights recorded at 3 month intervals up to 18 months of age and at 6 month intervals up to 4 years of age were used. The data were analyzed sex-wise as well as pooled over the two sexes to study the growth trend using linear, exponential and modified exponential equations. The mathematical functions used for predicting the shape of the growth curves are described as follows: Linear model:

$Y_t = a + bt$,

where, Y_t = Body weight of measurement at time t in kg or cm, a = True value of Y at birth, b = Weight daily gain, t = Age in days.

Exponential model: This model was suggested by Brody (1964) to predict the growth curve in terms of instantaneous relative growth rate. The equation is described as follows:

$$Y_t = ae^{bt},$$

where, Y_t = Body weight or measurement at time t in kg or cm. a = True of y at birth, e = Base of natural logarithm, b = Instantaneous relative growth, t = Age in days.

Through natural log transformation this equation as follows:

$$Log_e\ Y_t = log_e\ a + e^{bt} \text{ or } Log_e\ Y_t = A + e^{bt},$$

Where $A = Log_e a$

Modified exponential model: This model was also suggested by Brody (1964) to express the growth curve in terms of linear growth and the body weight as affected by the age and mathematical model is given as follows:

$$Y_t = a\ t^b,$$

Where, Y_t = The body weight or measurement at time t in kg or cm, a = True value of Y at birth, b = Growth rate, t = Age in days.

Through natural log transformations this equation linearizes as follows:

$$Log_e\ Y_t = Log_e\ a + b\ log_e t \text{ or } Log_e\ Y_t = A + b\ Log_e t,$$

Where $A = Log_e\ a$.

All the three equations were solved through simple linear regression analysis after using natural logarithmic transformations when required. The observed growth pattern and the estimated growth pattern were plotted on graphs and the efficiency was compared.

RESULTS AND DISCUSSION

The average body weights along with standard error at various ages are given in table 1. The equations were developed separately as well as pooled for male and female calves from the means for various growth measures. The equations along with reliability and mean squares values are given in table 2 and 3 for body weight up to one and four years of age, respectively.

It was observed that out of the three regression equations, the linear regression equation (Y = a + bt) had the maximum coefficient of determination 97.69% for males, 97.27% for females and 97.5% for pooled. The second best equation was $Y = a_t^b$ which had about 2-4% less coefficient of determination than the linear equation.

The $Y = ae^{bt}$ also had significant F values but the coefficient of determination was about 10% less than that of the linear equation.

The critical examination of the reliability of the prediction equations revealed that all the equations had significant regression coefficients and similar ranking in males, females and pooled observations. However, on ranking different equations on the basis of R^2 values on pooled observations, it may be concluded that growth up to one year was predicted best by linear equation. The second best equation was modified exponential equation.

The growth trend in terms of body weights was also investigated from birth to four years at six-month intervals. The prediction equations, their reliability and mean squares are given in table 3, it revealed that reliability of a given equation was not affected by the sex, on comparing the three equations linear and maximum R^2 (97.82%) followed by modified exponential (95.49%) and exponential (76.77%) equation. On comparing these values with respective R^2 values (Table 2). It may be observed that R^2 values of linear and modified exponential functions were not affected by extending the scope of equation from one year to four years; whereas that of exponential equation dropped from 87.08% (0-1 year) to 76.77% (0-4 years). Superiority of linear functions over exponential and modified exponential function was also reported by Beniwal & Choudhary (1983) while shaping the growth in terms of body weight from birth to 30 months of age at an interval of 3 months.

The shapes of the growth curves for body weight from birth to four years estimated through linear, exponential and modified exponential were compared with the observed curve. The observed curves showed that the rate of growth was fast from birth to six months, it slowed from 6 to 24 months and increased linearly from 24 to 48 months. On increasing the time unit at an interval of 180 days, the linear function estimated the shape most closely and it overlapped the observed one from 2-4 years of age. The exponential functions overestimated the body weight at birth and after three years, and under estimated between 6 to 24 months. On the other hand, the modified exponential functions overestimated the growth from 3 to 6 months and underestimated after 3 years.

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Table 1: Mean and standard error (SE) of body weight (kg) from birth to four years in Bikaneri camels.

Age in days	Male			Female			Pooled		
	N	Mean	SE	N	Mean	SE	N	Mean	SE
1	91	41.60	0.572	92	39.59	0.548	183	40.60	0.402
90	84	97.22	2.425	82	99.50	2.560	166	98.34	1.740
180	84	150.13	3.148	81	149.86	2.505	165	150.00	2.014
270	80	185.30	3.827	73	182.97	3.216	153	184.18	2.515
360	79	211.82	4.552	73	210.16	3.601	152	211.02	2.922
450	70	259.52	5.994	62	246.98	5.234	132	253.63	4.041
720	62	297.54	6.435	59	282.54	5.160	121	290.23	4.187
900	52	336.07	8.503	56	321.35	6.702	108	328.44	5.392
1080	43	388.88	9.083	55	361.00	7.042	98	373.23	5.757
1260	28	438.96	13.098	9	423.22	7.640	37	435.13	0.089
1440	21	486.52	15.414	3	490.00	20.00	24	486.95	3.608

Table 2: Prediction equations, reliability and mean squares of various regression equations to describe growth curve from birth to one year.

Parameter		Regression equation	
	$Y = a + bt$	$Y = ae_b^t$ or Log_e Y = A=bt	$Y = a_t^b$ or Log_e Y = A + bLog_et
Male calves A	51.2523	3.9970	3.6664
B	0.4770	0.0043	0.2627
SE of b	0.0423	0.0009	0.387
R2%	97.69	87.89	93.89
Regression Mean squares	18351**	1.5185*	1.6220**
Residual Mean squares	144.37	0.0697	0.0352
Female calves A	51.2373	3.9776	3.6233
B	0.4727	0.0044	0.2705
SE of b	0.0457	0.0010	0.0345
R2%	97.27	86.22	95.35
Regression Mean squares	18018**	1.5558*	1.7206**
Residual Mean squares	168.75	0.0829	0.0279
Pooled A	51.2317	3.9874	3.6451
B	0.4750	0.0044	0.2666
SE of b	0.0439	0.0010	0.0366
R2%	97.50	87.08	94.64
Regression Mean squares	18195**	1.5372*	1.6706**
Residual Mean squares	155.39	0.0760	0.0315

*Significant at P < 0.05. **Significant at P < 0.01.

Table 3: Regression equations, reliability and mean squares of various regression equations to describe growth curve from birth to four years.

Parameter		Regression equation	
	$Y = a + bt$	$Y = ae_b^t$ or $Log_e Y = A=bt$	$Y = a_t^b$ or $Log_e Y = A + bLog_e t$
Male calves A	84.90	4.5204	3.6059
B	0.2850	0.0013	0.3250
SE of b	0.0156	0.0003	0.0271
R2 %	97.94	76.96	95.35
Regression Mean squares	157753	3.5156	4.3559
Residual Mean squares	473.49	0.1504	0.0303
Female calves A	80.58	4.4864	3.5643
B	0.2777	0.0013	0.3263
SE of b	0.0168	0.0003	0.0265
R2 %	97.50	76.51	95.59
Regression Mean squares	149754	3.5132	4.3892
Residual Mean squares	547.70	0.1540	0.0289
Pooled A	82.71	4.5036	3.5852
B	0.2816	0.0013	0.3257
SE of b	0.0159	0.0003	0.0267
R2 %	97.82	76.77	95.49
Regression Mean squares	154004	3.5173	4.3748
Residual Mean squares	489.76	0.1520	0.0295

All regression mean squares had significant F value at $P < 0.01$.

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The equations for the three functions derived on the basis of pooled data are given below:

Body weight (kg) = 82.71 + 0.2816 x age in days.

Body weight (kg) = Antilog$_e$ (4.5036 + 0.0013 x age in days).

Body weight (kg) = Antilog$_e$ (3.5852 + 0.3257 x log$_e$ (age in days).

The shape of the curves from birth to one year estimated after increasing the time unit at an interval of 3 months showed fast growth from birth to six months. The rate of growth was slow from 6-9 months and further slowed down from 9-12 months. The shape was estimated most closely by the linear function. The exponential function overestimated the body weight at birth and after 9 months and it underestimated from 45 days to 9 months, whereas the modified exponential function overestimated the growth from 45 days to 6 months and under-estimated after 6 months.

Early growth in terms of gain per day up to one year of age were studied by Field (1979), Richard & Gerard (1985), Degen *et al.,* (1987), Khanna (1988), Meredov *et al.,* (1989) and Khanna *et al.,* (1990). Field (1979) recorded an average daily gain of 580 g in Kenya. In Ethiopia Richard & Gerard (1985) observed a slightly slower growth rate of 350 and 240 g, respectively in male and female calves in the first year of life. A gain of 950 to 1030 grams per day up to one year of age were reported by Meredov *et al.,* (1989). Khanna (1988) reported a drop in growth rate with increasing age and obtained average daily gain estimates of 610, 388, 244 and 236 g respectively from birth to 6, 6 to 12 months, 1 to 2 years and 2 to 3 years.

The fast gain from birth to three months and three to six months with subsequent decrease in rate of gain in body weight up to 24 months of age and a further increase in gain from 24 to 30 months of age was observed by Beniwal & Chaudhry (1983). This supported the view that there is fast early growth while the calves are suckling up to 6 months of age and there is slow growth rate when the calves are weaned till the period they are able to browse efficiently from the pasture. Once they have gained expertise in browsing at the age of two years then, again, there is improvement in rate of gain up to 4 years of age. This may also be concluded that the growth continues beyond 4 years and for determining a typical growth curve beyond 4 years further investigations are required.

The following linear and modified exponential equations may be used to describe the growth curves for body weight from birth to 4 years of age at an interval of 180 days.

Body weight (kg) = 82.71 + 0.2861 x age in days.

Body weight (kg) = antilog$_e$ (3.5852 + 0.3257 x log$_e$ (age in days).

The following linear and modified exponential equations may be used to describe the growth curves for body weight from birth to 1 year of age at an interval of 90 days.

Body weight (kg) = 51.23 + 0.4750 x age in days.

Body weight (kg) = antilog$_e$ [(3.6451 + 0.2666 x log$_e$ (age in days)].

IMPLICATIONS

The growth curves up to the age of four years can be predicted through a linear function. The growth in Indian camels continues beyond the age of four years and, hence, it would be useful to test suitable functions to describe the shape of growth curves beyond four years.

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