Growth Curve in Aardi Goat

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ABSTRACT. Growth of Aardi goat kids was studied by examining growth curves expressing the relationships between weight and age of the animals. Out of 14 weight-age regression equations for each group of single- and twin-born males and females, one equation was chosen in each group to describe growth best. Means of least squares of adjusted biweekly body weights were used in this estimation. During the 1st year of life, males followed quadratic and females quadratic-cum-log type functions for growth. During the 1st two years, which studied only in males, an incomplete-gamma-type function was found to be the best. Type of birth did not change the growth rates were closely comparable, and decreased with advancing age. Males reached maturity later than females.

Growth is studied by means of growth curves expressing the relationship between weight of the animals and their ages. Although the form of growth is sigmoid (Parks 1982 and Loewer *et al.* 1983), several mathematical models have been used to describe this relationship from conception (Taylor 1980, Moore 1985, Bridges *et al.* 1985) or after birth (Brody 1945 and Fitzhugh 1976) to maturity. All these workers included mature weight of animals in their models. Few described growth curves before maturity. In goat, Dilwali (1943), Amble *et al.* (1964) and Mukundan *et al.* (1982) used more simple models to describe growth before animals reached maturity.

Growth and meat-producing patterns of goats have been studied less in spite of the need for meat in tropical and semiarid regions, where numbers of goats available may exceed those of other domestic species. With few exceptions, goats in developing countries are raised for meat. Studying the growth of this animal might help develop this potential.

The present study attempted to describe growth curves of young male and female Aardi goats of Saudi Arabia, and to ascertain the model that best fitted that curve.

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Materials and Methods

Weight-age data for this study were collected from 31 males and 27 females of the Aardi goat kids. Data covered the first year for females and the first two years of life for males. These animals were born and raised under management of the Animal Production Experimental Station of the College of Agriculture, King Saud University at Riyadh.

After birth, kids were left to suckle mothers freelly until weaning of 3 months of age. Fresh alfalfa, hay and small pelleted grain mixture (18% CP) were provided *ad lib* starting about 4 weeks after birth till weaned. Thenafter, feedstuffs were given to meet the requirements of animal growth. The grain mixture then used was 16% CP. Kids were housed indoor most of the weaning period; later they were allowed outdoors for most of the day, whenever it was appropriate.

Biweekly weights in kilograms from birth (day 1) to one year in females and two years in males were adjusted to dam weight after kidding (Salah *et al.* 1988) using the LSMEANS procedure of the Statistical Analysis System (SAS User's Guide 1986). Means of least squares of these weights then were used to estimate weight-age relationships. All possible equations relating body weight to age, age squared and the natural logarithm, 1n, of age were computed. Similar regression were of natural log transformations of body weight. The equation best fitting the data was selected from those generated, based on the highest coefficient of determination, R^2 , and on the adjusted minimum least squares error of Mallows' Cp statistic (Mallows 1973 and Hocking 1976) for an individual response with all components significant at p < .10. Statistical analyses were also performed by SAS using the RSQUARE, STEPWISE and GLM procedures.

Results

Male Growth Curves

Out of 14 regression equations expressing the relationship of body weight in kilograms with age (days) of single- and twin-born male kid of Aardi goats from birth up to 2 years old, the best fitted equation for the singlelets was as follows:

$$Y = 2.55 X^{\cdot 34} e^{.0025X - .000002X^2}; R^2 = 98.4$$

and for the twinlets was as follows:

$$Y = 2.39 X^{28} e^{.0037X - .000003X^2}; R^2 = 98.9$$

where Y is estimated body weight in kg, X is age of the kids in days and e is the base to the natural logarithm. Both equations are incomplete gamma-type

functions (exponential quadratic-cum-log function) and both had the least Mallows'Cp statistic. A graphic expression of these models is shown in Fig. 1.



Fig. 1. Male Aardi goat growth curve from birth to two years.

The estimated birth weight from these equations was 2.56 kg for single males and 2.40 kg for twins. The actual least squares means of body weight were 3.58 and 3.24 kg, respectively. Estimated and actual weights at 1 and 2 yrs were, respectively, 35.43, 33.72, and 50.84 and 51.24 kg for single males and 30.52, 29.27, and 42.63 and 42.98 kg for twins.

The inflection point of the equation for single males was at 740 days with maximum body weight of 50.89 kg. In the twin males, this weight was 43.12 kg at 675 days. Average estimated daily body gain from birth to maturity was 65 g for singles and was 60 g for twins. This rate was slower during the second year (40 g) than during the first year of age (85 g), with lower rates for twin-born males.

Female Growth Curves

To eliminate effects of pregnancy on growth, only body weight data during the 1st year of life were used to describe the growth curve. The corresponding weights of males during the same period also were used for comparison. The following prediction equations were chosen for single and twin males and females during the first year of age:

Y	=	3.59	+	.144	Х	-	.00018	X^2					$;R^{2} =$	99.7
Y	=	2.31	+	.077	Х	_	.00010	X^2	+	.75	1n	Х	$;R^{2} =$	99.7
Y	=	3.14	+	.108	Х	-	.00011	\mathbf{X}^2					$;R^{2} =$	99.8
Y	=	1.72	+	.093	Х	_	.00013	\mathbf{X}^2	+	.46	1n	Х	$;R^{2} =$	99.1

where Y,X and 1n are as defined earlier.

Regardless of litter size, during the 1st year of life male Aardi kids followed quadratic-type growth and females followed quadratic-cum-log type growth. Rate of growth was decreased with advancing age, as indicated by the negative sign of the quadratic term of each equation (Table 1). Females started their early life with higher rates of growth than males (Fig. 2). Soon, this difference decreased so that total gain was higher in males.

Table 1.	Observed and estimated	body weights of sing	le- and twin-born	Aardi goat kids	during the first
	year of age				

Age	Single	males	Single f	females	Twin	males	Twin females	
(month)	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.
Birth	3.58	3.71	2.88	2.38	3.24	3.25	2.51	1.81
1	7.41	7.76	6.89	7.08	6.17	6.29	5.31	5.95
2	11.65	11.61	9.65	9.64	8.96	9.24	8.64	8.72
3	15.35	15.14	11.84	11.82	12.41	12.01	11.81	11.14
4	19.12	18.35	14.01	13.72	14.92	14.59	14.17	13.27
5	21.96	21.24	15.42	15.40	17.32	16.98	15.77	15.15
6	23.77	23.81	16.59	16.86	19.52	19.18	16.97	16.79
7	25.55	26.06	17.98	18.13	21.16	21.19	17.36	18.18
8	27.23	27.98	19.14	19.19	22.61	23.01	18.33	19.35
9	28.88	29.59	19.74	20.07	24.39	24.65	19.52	20.28
10	30.32	30.88	20.55	20.76	25.57	26.09	20.75	20.98
11	31.90	31.85	21.41	21.26	27.08	27.35	22.04	21.45
12	33.80	32.49	22.15	21.57	29.43	28.42	22.54	21.69

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From the four equations and Table 1, average growth rates are shown to be 80, 53, 70 and 55 g for single male and female, and twin male and female kids, respectively. Assuming that these equations are appropriate for larger ages (more than one year), maximum mean body weight (inflection point) should occur at earlier ages in females than males. Also, single males reach maturity earlier than twin males. These maximum weights were 32.86, 21.71, 30.92 and 21.73 kg and estimated ages at maturity were 405, 395, 515 and 380 in the single males and females, and twin males and females.

Discussion

Various reports have discussed growth rates of goats for various stages of life, but few had tried to study the mathematical models to describe the shape of the growth curve (Dilwali 1943, Amble *et al.* 1964, Mukundan *et al.* 1982, and Khan and Garg 1983). The quadratic function fitted by Dilwali (1943) for growth in Jamunapari and Barbari goats of either sex separately showed decreased rates of

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growth with advanced age. However, Mukundan *et al.* (1982) found the linear function to be the best fit rather than the quadratic, for Malabari goats. Amble *et al.* (1964) reported a linear-type growth curve in Beetal goats for male and female kids. This linearity of growth indicates that these animals did not reach their point of inflection by 12 months and continued to grow beyond this age. The exponential function was not as efficient in their studies. In the present study, neither linear nor the exponential form of equation provided good fits to describe growth patterns of Aaradi goat kids. During the first year of life, the quadratic function fitted best for male singles and twins, and the quadratic-cum-log type equation fit best for females. This indicates that birth type had no influence with each sex on growth pattern. In males for the 1st two years of life, the exponential quadratic-cum-log equation was chosen for both single- and twin-born kids. Malhorta *et al.* (1980) used the quadratic-cum-log function to describe the lactation curve of Karan-Swiss cattle.

Although the prediction equations underestimated female birth weights, they all fit the data more closely in general (Table 1). Also, all had a negative sign for the quadratic term indicating a decrease in growth rate with advancing age. This result agreed with Dilwali (1943) for Jamunapari and Barbari goat of India. Maximum body weight (the minimum growth rate) estimated from these equation indicated continuation of growth of Aardi goats after they reached age one year, and that males grow for a longer period of time and reach maturity more slowly than females. The growth rate of our Aardi goats was almost double that of Malabari goats (Mukundan *et al.* 1982, 1984) and that of West African dwarf goats (Wilson *et al.* 1981) during the first year of life. This gain should encourage further studies on improving potential of this animal for meat production through good feeding regimes and better management. Superiority of female Aardi goat kids over the male in their body gains during early weeks of life also was obtained for the West African dwarf goat (Sada and Vohradsky 1973).

The variation among the same weight estimated from the 1st year data and that from the 1st two years data leads to the concluded caution of Mitchell *et al.* (1931) that it is risky to describe the advanced pattern of goat growth depending only upon early data. The empirical functions of the polynominal type can be used safely only within the range of the experimental data. As such, the estimated growth parameters are representative of growth only under conditions of the present study.

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منحنى النمو في الماعز العارضي

محمود سيد أحمد صلاح و سعيد محمد باسماعيل و حسن حسني مجاور قسم الإنتاج الحيواني ـ كلية الزراعة ـ جامعة الملك سعود ـ ص . ب ٢٤٦٠ الرياض ١١٤٥١ المملكة العربية السعودية

درس غو صغار الماعز العارضي بوساطة منحنيات النمو التي تبين العلاقة بين وزن الحيوان وعمره. من بين ١٤ معادلة انحدار مقدرة لهذه العلاقة في كل من الذكور والإناث الفرادي والمولودة توائم اختيرت إحداها فقط لتمثيل منحني النمو في الماعز. عدلت الأوزان (مرة كل أسبوعين) بالنسبة لوزن الأم بعد الولادة واستخدمت متوسطات أقل المربعات لاستنباط تلك العلاقة. خلال السنة الأولى من العمر كانت الذكور تتبع الدالة التربيعية لنمط النمو، أما الإناث فنمط غوها كان يتبع الدالة التربيعية اللوغاريثمية. وفي الذكور فقط فكانت الدالة من النوع جاما غير الكاملة هي المثلة جيداً لمنحنى النمو خلال السنتين الأوليتين من العمر، ولم يؤثر حجم الخلفة على غط النمو سواء في الذكور أو في الإناث، وتقاربت معدلات النمو الفعلية والمقدرة جداً وتناقص كلاهما مع تقدم العمر كذلك تتطور الذكور لفترة أطول ولتصل إلى وزن النضوج بطيئاً عن الإناث.