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A parametric modeling of growth curve on kids goat in Saudi Arabia

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Abstract. Current measures of growth patterns are not uniformly applicable to the variety of growth curves for individual goat. Moreover they are either difficult to interpret or are functions of whole growth and therefore inappropriate. In this study, six, robust parametric measure is derived from a perfect fit of fifth order polynomial function of the growth data from birth to 6 months. The curvilinear model (parabolic equation) is appropriate for trend analysis, a major manifestation of which is growth rate, the decrease rate in growth rate and the initial body weight. Data fitted to the model were obtained from a total of 338 pure Aradi, pure Damascus and crossbred kids from of 141 does and 21 sires. The results show that the six order polynomial function for growth has a little more advantage (was no significant) in accuracy but, its more complicated to calculate the parameters than the other one which have three parameters of them with no biological meaning. Therefore, the fitting of quadratic curve to growth pattern of goat data resulted in a simple, precise and robust parametric measure with biological interpretation. The largest growth rate was found in kids born in season 3. The largest (f) initial body weight(birth weight) was found in crossbred kids. The smallest daily decrease in growth rate was found in group 1 following by group 3crossbred (½ pure Aradi + ½ Damascus).

Keywords: Growth curve; Growth rate, Instantaneous growth rate, asymptotic weight, Aradi goat, Damascus goat , crossbreeding.

Introduction

Due to their adaptability to wide range of conditions, goats contribute significantly to livestock production in semi- arid regions. Goats are able to survive, produce and reproduce in varied agricultural system.

In Saudi Arabia goats are mainly raised for meat production, research in this species is concerned mainly with improvement of productivity through crossing with imported breeds.

The characterization of various goat breeds with respect to their pattern of growth is very important. Genetic improvement in livestock species depends on the identification of animals capable of transmitting desirable characteristics to their offsprings. For these reasons, extensive studies concerning growth pattern with more precise techniques are highly recommended.

Mathematical modeling of the animal growth curve has attracted considerable interest and attention (Grossman and Koops, 1988, Morant and Gnanasakthy, 1989, Beever *et al.*, 1991, Sherchand *et al.*, 1992, Rook *et al.*, 1993, Perochon *et al.*, 1996, Olori *et al.*, 1999, Grossman *et al.*, 1999 and Mostert *et al.*, 2003).

Many mathematical models have been used extensively to describe growth data in various species [Von Bertalanffy (Von Bertalanffy, 1957, 1960), Brody (Brody, 1945), Gompertz (Winsor, 1932), Logistic (Nelder, 1961), Richards (Richards, 1959), Exponential (Brody, 1945) Simple and multiple regressions (Rao, 1958, 1965; Leech and Healy, 1959; Sprint, 1967; Grizzle and Allen, 1969)].

Modelers seek to find parametric descriptors of the shape of the curve, factors that affect the shape and tools for predicting weights. Of course, growth curve parameters significantly contribute to feeding and management decision support systems for optimization of goat herd production processes.

Variations in the shape of the curve are believed to stem from both genetic and environmental factors (Wood, 1967, Wood ,1968,Wood, 1969, Wood, 1970 and Wood, 1980). They inferred that the suitability of empirical models of curve does not depend on the mathematical form of the function alone but rather on the biological nature of the growth traits. This empirical state is likely to remain, as long as modeled production patterns traverse combinations of climate, management, age, health, season and heritability.

Working with animals under diverse conditions often comes across growth pattern that cannot be adequately described by standard models.

The major environmental factors contributing to deviations from the curve include seasonal patterns in feeding availability, different sex of animals, litter size at birth, age of dams, location and genetic groups. Brody (1945) was one of the first authors who used a mathematical function to describe a growth curve.

As growth models are useful in prediction of future growth, in the present investigation two basic sets of formulas namely, the linear and the non-linear equations have been used to express the configuration of the growth curve. Results obtained from the current study will be helpful in procedure of culling or retaining an animal at earlier ages.

Material and Methods

Data

A total number of 338 kids of 21 sires and 141 does belonging to Animal Production Research Unit, Qassim University, Saudi Arabia were utilized in this study. Live body weight was recorded at birth and biweekly thereafter up to 24 weeks of age, while daily weight gain was computed on four- week interval basis.

Bucks were evaluated for semen characteristics and estrus synchronization was performed using intra-vaginal progestagen sponges containing 30-40 fluorogestone acetate (FGA) or controlled internal drug release (CIDR) device containing 60 mg progesterone. Pregnancy diagnoses were carried out with the aid of ultrasound scanner 45-60 days post insemination. All does in the present study were housed in semi-shaded/open front barn and they were ear-tagged. Animals were fed *ad libitum* commercial concentrate pellet diet and alfalfa hay. The amount of concentrate and hay were calculated according to the nutritional requirements for the goats depending on animal age and production status. Water, rice straw and minerals blocks were available freely to all animals. According to manufacturer guide, the commercial diet contains 15.0% crude protein, 12.35% digestible protein, 3.85 crude fats, 7.4% crude fiber. 0.8% calcium, 0.74% phosphorus, 0.5% NaCl salt.

In the present study a preliminary investigation on kids data, showed that the six order polynomial functions and parabola function (three order) are preferable over the others and consequently employed. This conclusion was based on the coefficient of determinations and interpretation of the estimated parameters. However, this technique has its limitations, since it is best utilized for short intervals of growth. For the period from birth and every 28 days until (wt168), a single six order polynomial and parabola functions fitted to the mean of seven continuous weights from birth (wt_0) and every 28 days until (wt_{168}) according to two models:

2. Model 1:

$$Y_t = at^5 + bt^4 + ct^3 + dt^2 + et + f + e_t \tag{1}$$

Where,

Y_t is the weight of kid at time t,

a, b, c are integrated parameters,

t is the time in days,

d is the decline rate in growth rate per day,

e is the growth rate,

f is the initial body weight and

e_t is the random error term.

Parabolic (power) growth is characteristic of many aquatic animals for certain stages of their development. The parabolic pattern describing growth in weight (or length) under constant ambient conditions can be expressed in the following general form:

3. Model 2:

$$Y_t = a + bt + ct^2 \qquad (2)$$

Where,

Y_t is the weight of kid at time t;

t is the time in days;

a is the initial body weight at age =0;

b is partial linear regression coefficient of body weight on t and

C is partial quadratic regression coefficient of body weight on t^2.

4. Growth rate

The first derivative of equation (1) of $\hat{y}_t$ (the predicted value of y_t) with respect to measuring the change of weight over time, know as instantaneous growth rate (Brody, 1945), as in the follows:

$$\partial y / \partial t = \partial(at^5 + bt^4 + ct^3 + dt^2 + et + f) / \partial t \qquad (3)$$

$= at^4 + bt^3 + ct^2 + dt + e$ instantaneous growth rate at t time

While the first derivative of equation 2 $\hat{y}_t$ (the predicted value of y_t) was :

$$\partial y / \partial t = \partial(a + bt + ct^2) / \partial t \qquad (4)$$

$= b + 2ct$ instantaneous growth rate at t time

However, $(y_{t2} - y_{t1})/(t_2 - t_1)$ measures the average growth rate (AGR) over a period of $(t_2 - t_1)$. This is equivalent to the instantaneous growth rate calculated in equation 2 and 4.

Relative growth rate (RGR), which is growth relative to the current weight is calculated according to the following formula:

RGR = $\partial y / \partial t \ (1/Y_t)$

Fitzhugh and Taylor (1971) found that relative growth rate and relative maturing rate (RMR) were equal and can be approximated by difference of log transformation as:

$$\text{RGR} = \text{RMR} \approx (\ell Y_{t2} - \ell Y_{t1})/(t_2 - t_1) \tag{5}$$

The kids were born in three classes of litter size single, twin and triple (lsb_1-lsb_3), different sex (male or female), three genetic group (pure Aradi ($group_1$), pure Damascus ($group_2$) and ½ Aradi ½Damascus ($group_3$) and by four different season.

The date analyzed for the overall mean of all data.

5. Mature weight

Fitzhugh and Taylor (1971) suggested a simple definition of mature weight as the final weight eventually reached and may often be adequate for traits which rarely display negative growth, e.g. height at withers, but are likely to be inadequate when measuring body weight, which are more affected by environment.

Brink *et al.* (1962) and Fitzhugh *et al.* (1967) defined mature body weight as the mean weight over many years after positive growth of skeletal and muscular tissue have become insignificant. In some situations this mean that a value may be estimated by the asymptote of a fitted growth curve (Brody, 1945; Brown, 1970; Brown *et al.* and 1976).

The time at which the maximum weight is attained can be estimated by the following equation, after setting the 1st derivative of $\hat{y}$ (equation 4)

to zero, the result is:

$$\begin{aligned} -b &= 2ct \\ t_{\max} &= -b/2c \end{aligned} \tag{6}$$

Maximum time (t_{max}) is the end of the time that can be predicting by the maximum weight ($Y_{\max}$) through a parabola equation. Now by substituting the value $t_{\max}$in equation 6 with their peer in equation 2, obtaining the maximum weight ($Y_{\max}$) as following in equation 7:

$$\begin{aligned} Y_{\max} &= a - (b^2/2c) + c(b2/4c^2) \\ &= a + [(b^2/2) - (b^2/2c)] \\ &= a + [b^2 - 2b^2/4c] \\ &= a - (b^2/4c) \end{aligned} \tag{7}$$

Weights records were taken between November 2006 and July 2009 for 338 Aradi kids covering 2366 records were used.

A statistical analysis and computation were performed using nonlinear procedure (Proc NLIN) in statistical analysis system SAS (1999) and Datafit version 9.0.59 1995-2008 Oakdal engineering.

Results and Discussion

1. Modling

1.1 Model 1

The values of the first three integrated parameters obtained from using model 1 ($Y_t = at^5 + bt^4 + ct^3 + dt^2 + ft + g + e_t$) are shown in table (1). These integrated parameters were a, b and c. The other three parameters which have biological meaning were predicted. Initial body weight (g), predicted growth rate (f) and the predicted rate of decline in growth rate (d) are presented in table (2).

The t test for the multiple regression analysis for six order polynomial function was highly significant ($p<0.01$) for the kids that born as a single or twins lsb ($_{1,\ 2}$), male, genetic group1, season 4, and were significant ($p>0.05$) for the classes lsb_3, female, genetic group $_{(2,3)}$ and season $_{(1,2,3)}$.

The largest coefficient of determination (R^2) for the model 1 was matching with the highly significant due to regression as shown in season 4.

The largest growth rate (e)was found in the kids born by sequence $season_3$ (0.256 kg), $group_3$ crossing (0.207kg) , lsb_3 (0.167kg), $season_1$ (0.129kg), $group_2$ (0.120kg) pure Damascus , lsb_1(0.119kg),$group_1$(0.118kg)pure Aradi , lsb_2 (0.115kg), $season_4$ (0.114kg), male (0.113), $season_2$ (0.110) and Female(0.110).

While, the largest body weights at birth which were predicted by the equation, as f parameter were found by the kids born from the crossing ($group_3$) and born as single type (lsb1). These results showed that crossing kids were having higher growth rate than the pure Aradi and Damascus. The single born kids were heavier than twining kids.

Applying model 1 after determination of the parameters estimates were shown in table (1) giving possibility to predict any weights at any time from birth to 168 day as following equation by the parameters of overall mean:

$$\hat{Y}_t = (1.6E-10)t^5 + (-8.9E-08)t^4 + (-1.55E-05)t^3 + (8.2E-04)t^2 + (.120)t + 3.13$$

Substituting for the value of any point of age (t) in the equation can be deduced the predicted weights from birth to 168 days. The accuracy (R^2) of this equation was very large and close to 1.00 and this can be due to the fact that said equations with large number of unknown parameters got good precisely predicted weights comparison with the true weights.

1.2. Model 2

Table (3) shows the estimates of a, b, c parameters, R^2 coefficient of determination and the maximum weight of kids (y_{max}) at maximum time restricted by the equation. This mean that the equation is suitable for the stage from birth to that maxi (t_{max}) determined by parabolic equation of different classes, when applied from birth to 168 days. Theses results indicated that a (initial body weight at time=0 or birth weight) for $group_3$ (½ Aradi+½Damascus) was higher than $gruop_1$ (pure Aradi) and $group_2$ (pure Damascus) by 3.80, 3.19 and 3.27 kg, respectively. Average of growth rate (b) for crossing was higher than pure Aradi and pure Damascus by 0.153, 0.128 and 0.129 kg, respectively. Estimate of c parameter (interpreted as decrease irate in daily gain over time t) was higher in $group_1$ (-1.46E-04) than $group_3$ (-1.29E-4) and $group_2$ (-1.13E-04), respectively.

The two estimates of (y_{max}) and (t_{max}) were higher in crossing (½ Aradi*½Damascus) than in pure Aradi and pure Damascus by 45.48 kg at 594 days, 28.05 kg at 411 days and 32.00 kg at 571 days, respectively.

The expression (b+2ct) equation 4 represents the instantaneous growth rates and is shown in table (4). These results indicated that crossbreed (½ Aradi+½Damascus) were having higher instantaneous growth rate than pure Aradi and Damascus and they reached to the peak of the rate during two week to 4 weeks.

Results for applying model 2 after determining the parameters estimates are shown in table (1) giving possibility to predict any weight at any time from birth to 168 day access to the maximum time (t_{max}) in the table (3) as the following equation for the parameters of overall mean:

$$\hat{Y}_t = 3.24 + 0.121t - .000120t^2$$

Where:
$\hat{Y}_t$ is the predicted weight at time t;
3.24 is the intial body weight (birth weight);
0.121 is the growth rate and
-.000120 is the decline rate in the growth rate

Table (1). Model 1 six order polynomial ($Y_t = at^5 + bt^4 + ct^3 + dt^2 + et + f + e_t$), the mean of integrated parameters a, b and c with all categorical of fixed effects and estimates of coefficients of determination (R^2) with standard error (S.E), t-ratio and level of t significance.

Integrated parameters	R^2	Value	S.E.	t-ratio	Prob(t)
***a*'s mean**	0.9999535	-1.63E-10	2.30E-10	-0.71	0.60737
(lsb1)*	0.9999996	-2.78E-10	2.30E-11	-12.100	0.05249
(lsb2)	0.9999843	-1.82E-10	1.41E-10	-1.292	0.41933
(lsb3)	0.9999643	.888E-10	1.99E-10	4.470	0.14023
(m)	0.9999879	-5.39E-10	1.41E-10	-3.833	0.16246
(f)	0.9998963	-1.73E-10	3.24E-10	-0.534	0.68795
(G1)	0.9999906	-6.98E-12	1.06E-10	-0.07	0.09583
(G2)	0.9999481	-2.19E-10	2.64E-10	-0.830	0.55913
(G3)	0.9999405	5.84E-10	3.39E-10	1.7180	0.33553
S 1	0.9999477	1.17E-10	2.62E-10	0.4480	0.73179
S 2	0.9999653	-2.65E-10	2.17E-10	1.2220	0.43672
S 3	0.9996315	5.03E-10	7.10E-10	0.709	0.6074
S 4	0.9999998	-5.29E-10	1.512E-11	-34.96	0.0182

Continue table (1).

Integrated parameters	R^2	Value	S.E.	t-ratio	Prob(t)
***b*'s mean**	0.9999535	-8.92E-08	9.74E-08	0.92	0.52787
(lsb1)	0.9999996	1.55E-07	9.73E-09	15.95	0.03987
(lsb2)	0.9999843	1.00E-07	5.95E-08	1.688	0.3404
(lsb3)	0.9999643	-3.70E-07	8.41E-08	-4.394	0.14247
(m)	0.9999879	2.30E-07	5.95E-08	3.8548	0.161159
(f)	0.9998963	8.81E-08	1.37E-07	-0.534	0.068795
(G1)	0.9999906	2.67E-08	4.50E-08	0.5930	0.65927
(G2)	0.9999481	1.05E-07	1.12E-07	0.9440	0.51846
(G3)	0.9999405	-2.43E-07	1.44E-07	-1.690	0.34043
S 1	0.9999477	-2.82-08	1.1107-07	-0.255	0.84106
S 2	0.9999653	1.31E-07	9.17E-08	1.431	0.38824
S 3	0.9996315	-2.14E-07	3.00E-07	0.712	0.60628
S 4	0.9999998	2.47E-07	6.40E-09	38.69	0.01645
***C*'s mean**	0.99995352	-1.55E-05	1.45E-05	-1.06	0.48027
(lsb1)	0.99999966	-2.85E-05	1.45E-06	-19.63	0.0324
(lsb2)	0.99998434	-1.79E-05	8.89E-06	-2.012	0.29369
(lsb3)	0.99996434	5.42E-05	1.25E-05	4.32	0.14486
(m)	0.99998798	-3.34E-05	8.89E-05	-3.75	0.16577
(f)	0.99989532	-1.48-05	2.05E-05	-0.722	0.60207
(G1)	0.99999056	-7.30E-06	6.72E-06	-1.090	0.47328
(G2)	0.99994815	-1.65E-05	1.67E-05	-0.993	0.50226
(G3)	0.99994057	3.59E-05	2.15E-05	1.672	0.34315
S 1	0.99994778	7.06E-07	1.65E-05	0.0430	0.97288
S 2	0.99996533	-2.19E-05	1.37E-05	-1.60	0.35601
S 3	0.99963152	3.49E-05	4.48E-05	0.772	0.5816
S 4	0.99999982	-3.64E-05	9.55E-07	-38.13	0.01669

* lsb1= litter size at birth single s1= season1 G1= genetic group1 (pureAradi) f= female
lsb2= litter size at birth twin s2=season 2 G2= genetic group2 (pure Damascus) m= male
lsb3= litter size at birth triplets s3= season3 G3=genetic group 3 (crossbred1/2 pure Aradi+1/2 Damascus).

Table (2). Model 1 six order polynomial ($Y_t = at^5 + bt^4 + ct^3 + dt^2 + et + f + e_t$), the mean of integrated parameters which have a biological meaning, decline in daily gain (d) in kg , growth rate (e) in kg and (f) initial growth rate in kg at all categorical of fixed effect and estimates of coefficients of determination (R^2) with standard error (S.E), t-ratio and level of t significance.

Biological parameters	R^2	value	Standard error	t-ratio	Prob(t)
d's mean	0.9999535	8.15E-04	9.03E-04	0.902625	0.60737
(lsb1)	0.9999997	1.74E-03	9.02E-05	19.261	0.03302
(lsb2)	0.9999843	9.88E-04	5.52E-04	1.790	0.03302
(lsb3)	0.9999640	-3.28E-03	7.80E-04	-4.201	0.14878
(m)	0.9999880	1.74E-03	5.52E-04	3.156	0.19537
(f)	0.9998953	7.42E-04	1.27E-03	0.5834	0.66377
(G1)	0.9999906	4.29E-04	4.17E-04	1.0300	0.49074
(G2)	0.9999482	7.94E-04	1.034E-03	0.7680	0.58319
(G3)	0.9999406	-2.39E-03	1.333E-03	-1.7900	0.32479
S 1	0.9999478	7.92E-06	1.026E-03	0.008	0.99509
S 2	0.9997920	1.24E-03	8.505-04	1.4531	0.38372

Continue table (2).

Biological parameters	R^2	value	Standard error	t-ratio	Prob(t)
S 3	0.9996315	-3.01E-03	2.784E-03	-1.081	0.47537
S 4	0.9999998	1.64E-03	5.93E-05	27.710	0.02297
e 's mean	0.9999535	0.1101	2.045E-02	5.3800	0.11690
(lsb1)	0.9999990	0.1188	2.043E-3	58.16	0.01095
(lsb2)	0.9999843	0.1154	1.250E02	9.231	0.06870
(lsb3)	0.9999644	0.1666	3.213E-02	0.1345	0.19870
(male)	0.9999880	0.1130	1.251E-02	9.0380	0.07015
(female)	0.9998953	0.1084	2.878E-02	3.766	0.16524
(genetic group1)	0.9999906	0.1184	9.445E-03	12.544	0.05064
(genetic group2)	0.9999482	0.1203	2.342E-02	5.136	0.12242
(genetic group3)	0.9999406	0.2071	3.020E-02	6.859	0.09216
Season 1	0.9999478	0.1286	2.324E-02	5.532	0.11386
Season2	0.9999653	0.1103	1.926E-02	5.729	0.11002
Season 3	0.9996315	0.2561	6.305E-02	4.061	0.15369
Season 4	0.9999998	0.1149	1.343E-03	85.502	0.00745
f's mean	0.9999540	3.13	0.1113	28.088	0.023
(lsb1)	0.9999997	3.53	1.1112	317.584	0.002
(lsb2)	0.9999843	3.30	6.7992	48.557	0.013
(lsb3)	0.9999643	2.48	9.61E-02	25.84	0.025
(m)	0.9999880	3.35	0.0680	49.20	0.013
(f)	0.9998953	3.01	0.1566	19.20	0.033
(G1)	0.9999906	3.13	5.138E-2	60.90	0.010
(G2)	0.9999482	3.15	0.1274	24.68	0.026
(G3)	0.9999406	3.62	0.1643	22.04	0.029
S 1	0.9999478	3.00	0.1264	23.71	0.027
S 2	0.9999653	3.50	0.1048	33.35	0.019
S 3	0.9996315	2.68	0.3430	7.808	0.081
S 4	0.9999998	2.90	7.308E-03	397.28	0.002

See footnote above

Table (3). Model 2 parabola equation $Y_t = a + bt + ct^2$ with the estimates means of three parameters with biological meaning (a), initial body weight, (b) growth rate and (c) the decline in growth rate at all fixed classes.

Biological parameters	R^2	value	S.E	t-ratio	Prob(t)	t_{max}= $b/2c$	y_{max}= $a-(b^2/4c)$
Overall mean	0.9968					504	30.50
a		3.240	0.25	12.84	0.00021		
B		0.121	7.04E-03	17.22	0.00007		
C		-1.20E-04	4.01E-05	-2.98	0.04080		
for LSB_1	0.9984					327	26.12
a		3.550	0.31	11.52	0.0032		
B		0.160	8.60E-03	18.50	0.0001		
C		-2.45E-04	4.90E-05	-5.00	0.0075		
for LSB_2	0.9987					406	26.41
a		3.390	0.25	13.55	0.0002		
B		0.130	6.47E-03	19.11	0.00004		
C		-1.60E-04	3.97	-4.02	0.01590		
For LSB_3	0.9990					1165	54.98

Continue table (3).

Biological parameters	R^2	value	S.E	t-ratio	Prob(t)	t_{max}= $b/2c$	y_{max}= $a-(b^2/4c)$
a		2.680	0.21	12.77	0.00022		
B		9.32E-02	5.86E-03	15.91	0.00009		
C		3.95E-05	3.34E-05	1.18	0.30226		
for male	0.9996					551	38.58
a		3.390	0.1550	21.87	0.00003		
B		0.140	04.32E-3	33.13	0.00		
C		-1.27E-04	2.46E-05	-5.16	0.00668		
for female	0.9990					383	23.17
a		3.080	0.2179	16.04	0.00009		
B		0.121	5.35E-03	22.66	0.00002		
C		-1.58E-04	3.05E-05	-5.18	0.00662		
For $group_1$	0.9990					411	28.05
A		3.193	0.2108	15.144	0.00011		
B		0.128	5.878E-03	21.81	0.00003		
C		-1.46E-04	3.350E-5	-4.360	0.01206		
For $group_2$	0.9990					571	32.00
		3.27	0.2255	14.51	0.00013		
		0.1288	6.29E-03	20.49	0.00003		
		-1.13E-04	3.58E-05	-3.165	0.03401		
For $group_3$	0.9996					594	45.48
a		3.80	0.1780	21.37	0.00003		
b		0.1532	4.95-03	31.08	0.00001		
c		-1.29E-04	2.822E-05	-4.59	0.01013		
For season1	0.9995					596	29.02
a		3.007	0.1572	19.127	0.0004		
b		0.1350	4.38E-03	30.76	0.00001		
c		-1.57E-04	2.50E-5	-6.280	0.00329		
For season 2	0.9992					472	31.66
		3.55	0.211	16.86	0.00007		
		0.1341	5.87E-03	22.86	0.00002		
		-1.42E-04	3.34E-05	-4.235	0.01332		
For season3	0.9964					236	20.14
		3.164	0.4364	7.25	0.00192		
		0.1710	1.217E-2	14.03	0.00015		
		-3.63E-04	6.431E-05	-5.24	0.00633		
For season 4	0.9910					1326	71.64
		3.42	0.6822	5.01	0.00744		
		0.108	1.902E-02	5.672	0.00477		
		4.07E-05	1.08E-04	0.0376	0.9718		

See footnote above

Table (4). The instantaneous growth rate (g/d) out put from the first derivative of equation 4 for crossbreed and pure Aradi and Damascus.

week	Crossbreed(1/2 Aradi+1/2 Damascus	Pure Aradi	Pure Damascus
2 weeks	0.150	0.123	0.126
4 weeks	0.146	0.125	0.123
6 weeks	0.142	0.116	0.120
8 weeks	0.139	0.112	0.116
10 weeks	0.135	0.108	0.113
12 weeks	0.132	0.103	0.110
14 weeks	0.128	0.099	0.107
16 weeks	0.124	0.095	0.104
18 weeks	0.121	0.091	0.101
20 weeks	0.117	0.087	0.097
22 weeks	0.113	0.083	0.094
24 weeks	0.110	0.079	0.91

Conclusion

Although the six order polynomial function for growth has a little more advantage in accuracy but, its more complicated to calculate the parameters in which three of them have no biological meaning. Therefore, the fitting of quadratic curve to growth pattern of goat data resulted in a simple, precise and robust parametric measure with biological interpretation. The largest growth rate was found in kids born in season 3. The largest (f) initial body weight) birth weight) found in crossbred kids. The smallest daily decrease in growth rate was found in group 1 following by group 3 (crossbred)

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تقدير المجاهيل لمنحنى النمو في الماعز بالسعودية

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ملخص البحث. المعادلات المختلفة التي تصف إجمالي النمو في مجموعة من الحيوانات تكون في معظم الأوقات غير قابلة للتطبيق بشكل موحد على مجموعة أخرى من مقاييس النمو الفردية .علاوة على ذلك فأن هذه المعادلات بمجاهيلها قد يصعب بتفاوت تفسيرها تفسير بيولوجيا وبعضها قد يسهل تفسيرها أو قد تكون غير مناسبة لنموذج النمو جزئيا أو كلياً.

لذلك فأن اختيار المعادلة المناسبة التي تصف النمو في مجموعة من الحيوانات أمر غاية في الأهمية.

في هذه الدراسة جربت معادلتين الأولى معادلة من الدرجة السادسة ولها ٦ (مجاهيل) طبقت من الميلاد حتى ستة أشهر . والمعادلة الثانية هي معادلة المنحني الخطي (القطع المكافئ) ولها ٣ (مجاهيل) هي معدل النمو ومعدل التناقص في معدل النمو وأخيرا الوزنة عند البداية وهذه المعادلة أظهرت مناسبتها لتحليل بيانات النمو . تم الحصول على بيانات ٣٣٨ فرد من ١٤١ أم ملقحين من ٢١ طلوقة .

أظهرت النتائج المتحصل عليها أن المعادلة ذات الستة مجاهيل تفوقت تفوق غير معنوي على المعادلة ذات الثلاثة مجاهيل وذلك في الدقة ولكنها كانت أكثر تعقيداً في الحساب

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