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Maturing Pattern for Body Weight, Body Length and Height at Withers of Jamnapari and Boer Goats

Ariff, O.M.[1*], R.M. Hifzan[2], A.B.M. Zuki[1], A.J. Jiken[3] and S.M. Lehan[4]
[1]Department of Veterinary Preclinical Sciences, Faculty of Veterinary Medicine, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia
[2]Strategic Livestock Centre MARDI, Kluang, Malaysia
[3]Strategic Livestock Centre MARDI, Serdang, Malaysia
[4]GK Farm Air Hitam, Johor, Malaysia
[*]E:mail: ariff@vet.upm.edu.my

ABSTRACT

The objective of this study was to examine the growth pattern of three size measurements, namely body weight, body length, and height at withers of Jamnapari and Boer goats reared under common semi-intensive environment in Johor, Malaysia. Cross-sectional data of the above measurements of 234 Jamnapari and 312 Boer female goats (age ranged from 6 to 54 months) were used to fit Gompertz and von Bertalanffy growth curve models for the estimation of mature size, constant of integration, and maturing rate for the three size measurements. Jamnapari and Boer female goats were found to be significantly different ($p < 0.05$) in term of their mature weight (52.19 and 58.23 kg, respectively, for the Gompertz model and 53.89 and 59.31 kg, respectively, for the von Bertalanffy model). The estimates of height at maturity were significantly larger ($p < 0.05$) for the Jamnapari than Boer females. Although the maturing rate for body weight of the Jamnapari and Boer goats was not different, but their rates of maturing for body length and height at withers were found to be significantly different ($p < 0.05$). The correlation coefficients between the mature size and rate of maturing for their body weight, body length, and height at withers were negative, implying that goats of larger size measurements tended to have a slower growth rate in relation to their mature size.

Keywords: Goats, Boer, Jamnapari, body weight, growth models, mature size

INTRODUCTION

The goat population in Malaysia comprises mainly of the Kajang breed and Kajang crossbreds. In an attempt to improve the productivity of the local goats, many goat breeds have been introduced into the country by the government and private enterprises for the purpose of upgrading the indigenous Kajang goats. Two major goat breeds (namely, Jamnapari goats from Java, Indonesia and Boer goats from South Africa and Australia) were imported in substantial numbers in the past several years. These two goat breeds have been observed to acclimatize well to the Malaysian environment which has the temperature range of 26 – 32°C, relative humidity of 80 – 90%, and an average total annual rainfall of 2500 mm. Many of these goats are reared semi-intensively in raised floor-houses and allowed to graze on native and cultivated pastures from late morning until early afternoon, and are fed with supplementary concentrate feed during the rest of the day.

Jamnapari is a dual purpose milk- and meat-type goat breed found mainly in the Etawah district of Uttar Pradesh in India (Acharya, 1982). The breed is described as predominantly

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[*]Corresponding Author

white in hair coat colour with a thick hair growth on its back, a large body, short and flat horns, and long and pendulous ears. Boer goats have their origin in South Africa. They are known for excellent growth, fertility, and meat quality (Malan, 2000). It is a breed that has been able to adapt to a wide range of climatic and feeding environments and is highly fertile with a kidding rate exceeding 189%.

Information regarding the growth pattern of different breeds of livestock is useful in developing a genetic improvement programme to produce the most efficient biological type for a particular feeding environment in a specific market situation (Stobart *et al*., 1986). Altering the growth pattern (e.g. by reducing mature weight) provides an opportunity to breed females of the parental population which costs less to maintain (Cartwright, 1979). This will markedly reduce maintenance cost of does, and hence contribute to a reduction in the total cost of kid production. Thus, the characterization for major traits related to the growth of available goat breeds will lead to a more efficient utilization of these important genetic resources, as has been shown in cattle by Brown *et al*. (1976).

The objective of this study was to examine the growth pattern of three size measurements, namely body weight, body length and height at withers of two breeds of goats, i.e. Jamnapari and Boer, which are semi-intensively reared at two farms in the Johor, Malaysia. In this study, growth pattern was described by two parameters, namely A (an asymptotic measure of size) and k (the rate of maturing), which were obtained from two growth curve models, Gompertz and von Bertalanffy (Brown *et al*., 1976).

MATERIALS AND METHODS

Data Source and Animal Management

The cross-sectional data for the body weight, body length, and height at withers belonging to Jamnapari and Boer female goats were used in this study. The data of the above parameters were taken from 234 Jamnapari and 312 Boer female goats, distributed over 5 age groups, as shown in Table 1. The age of goats with birth records was determined as the difference in months between the date of birth and the date of measurement. Those goats with no records of birth date had their age estimated by the number of permanent incisors present (<12 months of age = presence of 4 pairs of milk teeth, 13-18 months of age = 1 pair of permanent incisors, 19-24 months of age = 2 pairs of permanent incisors, 25-36 months of age = 3 pairs of permanent incisors, 37-48 months of age = 4 pairs of permanent incisors and >49 months of age = teeth spreading apart).

The Jamnapari goats were located at Ladang GK Air Hitam, Johor, Malaysia. They comprised of young and primiparous does from an original importation of 400 breeding females from Java, Indonesia in November 2007 and kids born in 2008. The imported goats were

TABLE 1
The number of female goats of the Jamnapari and Boer breeds by age groups

Breed	Age group (months)					
	6-12	13-24	25-36	37-48	≥49	Total
Jamnapari	64	79	38	18	37	234
Boer	31	12	247	16	6	312

of purebred Jamnapari and high graded or crossbred Jamnapari stock, possessing common features of predominantly white hair coat, roman nose, thick growth of hair on the posterior end of the body, and long pendulous ears. Mating was carried out throughout the year in separate mating groups, each with a buck assigned to about 20 does. Every day, from around 10:00 a.m. to 1:00 p.m., the goats, except does with pre-weaned kids, were allowed to graze native pasture comprising mainly of grasses, *Axonopus compresses, Paspalum conjugatum* and *Imperata cylindrica*, and broad-leafed plants, *Asystasia intrusa*. For the remaining period of the day, the goats were confined in-door on slatted floors in raised houses. While in-door, the goats were fed with concentrate feed at a rate of 300 g/doe/day (14.9% crude protein and 8.9 MJ/kg ME). The ingredients such as palm kernel cake, rice bran, maize, soy bean meal, palm oil mill effluent, and oil palm frond were used in the goat concentrate, which was provided together with green chopped Napier grass (*Pennisetium purperum*) fed *ad libitum*. Water was supplied through piped-water nipples at all times of the day.

The Boer goats used in this study were imported from three registered farms in Australia in April 2007. They were kept in raised houses on slatted floors at MARDI Research Station, in Kluang, Johor. The animal management of the Boer goats was similar to that of the Jamnapari goats mentioned above, except the grazing pasture was entirely of the cultivated Guinea grass (*Panicum maximum)*.

Parameters

In this study, three parameters of size measurement (body weight, body length, and height at withers) were taken on the female goats sampled in the two farms on two different periods. Data for the Jamnapari goats were collected from 22 to 24 December 2008 and this was done from 12 to 14 October 2008 for the Boer goats. Body weight without overnight fasting was obtained using an electronic weighing scale for all the goats. Meanwhile, measurement of the body length was done as the horizontal distance from the point of the withers to the ischium or pin bone, and height at withers was measured as the vertical distance from the top of the withers to the ground. Using a measuring tape, the measurements of the body length and height at withers were recorded in centimetres. The animals were in the average body condition of 3 (i.e. the 5-point body condition scores of 1= being emaciated, 3= being in moderate fat cover, and 5= being in excess fat cover) when their weight and body measurements were taken.

Growth Functions

Two growth curve models, namely Gompertz and von Bertalanffy (Brown *et al*., 1976), were chosen to be fitted to individual records for the body weight, body length, and height at withers of the Jamnapari and Boer goat datasets. The SAS package PROC NLIN (SAS, 1998) was utilized to estimate the growth parameters of the two growth curve models below:

$$\text{Gompertz model: } Wt = Ae^{-Be^{-kt}}$$

$$\text{von Bertalanffy model: } Wt = A(1-Be^{-kt})^3$$

where Wt is the observed measurement of size (body weight, body length, and height at withers) at age t in months, A is the asymptote for measure of size, B is a constant of integration and k is the rate of maturing per day. The parameter A is the asymptotic limit for the size measurement and it is not an estimate of the largest size measurement reached by an animal. The constant of integration, B, has no biological interpretation, and the rate of maturing, k, is the growth rate after birth, which is relative to the mature measure of size.

Degree of maturity (U) for the body weight was calculated as a ratio of weight at age t in months divided by the asymptotic weight A obtained from the growth curve models (Fitzhugh and Taylor, 1971). The parameter U was calculated based on the parameter A for each breed.

An analysis of variance using PROC GLM (SAS, 1998) was carried out to determine the difference between the breeds for the three

parameters of growth curves obtained for the Jamnapari and Boer goats. Similarly, PROC GLM (SAS, 1998) was conducted for the degrees of maturity for body weight (UW), body length (UL), and height at withers (UH) as dependent variables, whereas breed and age group as the independent variables.

RESULTS AND DISCUSSION

Mature Size and Rate of Maturing

The asymptotic values for the body weight, as represented by the parameter A of the Gompertz and von Bertalanffy growth curve models, were significantly higher for Boer compared to Jamnapari does (Table 2). The estimates for the mature weight from the von Bertalanffy model were higher than those of the Gompertz model, but not for the maturing rate in both the Jamnapari and Boer goats. Boer does were 10.8% heavier at maturity than Jamnapari does based on the estimates of the mature weight from the Gompertz and von Bertalanffy models. However, the rates of maturing of both breeds of goats were not different, although the heavier Boer goats were associated with a slightly lower rate of maturing in both the Gompertz and von Bertalanffy models. Tsukahara *et al*. (2008) reported a lower mature weight of Katjang and crosses of Katjang-German Fawn, which ranged from 28.8 to 33.3 kg (estimated using the Bertalanffy model) and from 28.1 to 32.9 kg (estimated using the Gompertz model). The estimates for the maturing rate for the body weight in this study were generally lower in the Bertalanffy model as compared to the Gompertz model, as was also found by Tsukahara *et al*. (2008).

The correlation coefficient between the mature weight and maturing rate was large and negative, i.e. -0.96 and -0.84 for the Jamnapari and Boer goats, respectively (for the Gompertz model) and -0.97 and -0.87 for the Jamnapari and Boer goats, respectively (for the von Bertalanffy model), as shown in Table 3. The correlation coefficients were higher ($p > 0.05$) in Jamnapari compared to Boer breeds for both the growth curve models.

The body length at maturity derived from the Gompertz and von Bertalanffy models did not differ significantly between the Jamnapari and Boer does (Table 2). In particular, Boer does had slightly longer body length at maturity as compared to Jamnapari does. The rate of maturing for the Boer does' body length was significantly higher ($p < 0.05$) than that of Jamnapari goats. The correlation between the mature size for the body length was large and negative in both the Jamnapari and Boer does (Table 3) – a similar finding as that for the body weight.

The estimates of height at withers at maturity, derived from the Gompertz and von Bertalanffy models, were larger ($p < 0.05$) for the Jamnapari than Boer does (Table 2). For the height at withers, the Jamnapari does were 8.8% taller at maturity than the Boer goats. Unlike the rate of maturing for the body length, the Jamnapari does were shown to mature much faster ($p < 0.05$) for height at withers than the Boer goats. Similarly, the correlation coefficients between the Jamnapari and Boer goats were high and negative, thus, a strong negative correlation was found between the maturity size and rate of maturing for height at withers in both the Jamnapari and Boer females. The correlation between the mature size and rate of maturing for height at withers was higher ($p > 0.05$) in Jamnapari than Boer does.

Degree of Maturity

As for the degree of maturity for the body weight, no significant difference was detected between the Jamnapari and Boer goats during the phase of growth for ages prior to 12 months to maturity above 49 months (Table 4). Jamnapari and Boer goats attained a similar degree of maturity at the same phases of growth. However, the degree of maturity for body length showed a significant difference ($p < 0.05$) between the Jamnapari

TABLE 2
Least square means for the growth curve parameters[1] and coefficient of determination (R^2) for the Gompertz and von Bertalanffy models fitted to body weight, length of body and height at withers for the Jamnapari and Boer female goats

	Breed	
	Jamnapari	Boer
Number	213	234
Body weight (kg)		
Gompertz:		
A[1]	$52.19^{a}\pm3.66$	$58.23^{b}\pm3.08$
B[1]	1.451 ± 0.080	1.434 ± 0.126
k[1]	0.045 ± 0.007	0.043 ± 0.007
R^2	0.97	0.96
von Bertalanffy		
A	$53.89^{a}\pm4.44$	$59.31^{b}\pm3.44$
B	0.397 ± 0.028	0.425 ± 0.036
K	0.036 ± 0.007	0.030 ± 0.006
R^2	0.97	0.96
Length of body (cm)		
Gompertz:		
A	83.63 ± 4.14	85.20 ± 1.73
B	0.557 ± 0.403	0.544 ± 0.044
K	$0.035^{a}\pm0.008$	$0.045^{b}\pm0.006$
R^2	0.99	0.99
von Bertalanffy		
A	84.28 ± 4.51	85.39 ± 1.79
B	0.172 ± 0.012	0.169 ± 0.013
K	$0.033^{a}\pm0.008$	$0.043^{b}\pm0.006$
R^2	0.99	0.99
Height at withers (cm)		
Gompertz:		
A	$74.66^{a}\pm0.90$	$68.12^{b}\pm1.19$
B	0.497 ± 0.027	0.351 ± 0.035
K	$0.078^{a}\pm0.012$	$0.045^{b}\pm0.008$
R^2	0.99	0.99
von Bertalanffy		
A	$74.72^{a}\pm0.92$	$68.17^{b}\pm1.21$
B	0.155 ± 0.008	0.112 ± 0.011
K	$0.075^{a}\pm0.012$	$0.044^{b}\pm0.008$
R^2	0.99	0.99

Means with different superscripts in the same row differ significantly at $p<0.05$
[1]A, asymptotic measure of size (mature size); B, constant of integration; k, rate of maturing

TABLE 3
The correlation coefficients between the mature size and rate of maturing derived from the Gompertz and von Bertalanffy growth models for the body weight, body length and height at withers in the female Jamnapari and Boer goats

Parameter	Gompertz		von Bertalanffy	
	Jamnapari	Boer	Jamnapari	Boer
Body weight	-0.9599	-0.8405	-0.9726	-0.8701
Body length	-0.9784	-0.8490	-0.9819	-0.8609
Height at withers	-0.8830	-0.8557	-0.8899	-0.8632

and Boer goats throughout all the phases of growth, except from 37 to 48 months of age for both the Gompertz and von Bertalanffy models. Meanwhile, the degree of maturity for height at withers, the difference between Jamnapari and Boer goats was only significant for the pre-yearling period. The results derived from the analysis of variance for UW, UL, and UH revealed that the effect of breed was significant ($p< 0.05$) for UW and UL and breed x age group interaction effect was significant ($p < 0.05$) for UW and UH (result not shown).

The estimates for the mature weight for the Jamnapari and Boer goats of 52.19 and 58.23 kg, respectively (for the Gompertz model) and 53.89 and 59.31 kg, respectively (for the von Bertalanffy model), were higher than those reported for the Katjang and Katjang-German Fawn crossbred goats (Tsukahara *et al*., 2008). Similarly, the estimates for the mature weight derived from the von Bertalanffy model were higher than those obtained from the Gompertz model.

Beside body weight, body length, and height at withers are the other two size measurements of interest in this study. The estimates of parameter A for the body weight, body length, and height at withers indicated that the Boer goats were longer and heavier but shorter in height at maturity than the Jamnapari goats. Animals with longer bodies were associated with heavier weight as was also found in cattle (Brown *et al*., 1974). In an earlier study by Brown *et al*. (1973), Hereford bulls were reported to have shapes of varying descriptive categories, such as large framed and heavy, wide at shoulders, loins and hips but with shorter body and height, deep in flank, wide hips and tall, but narrow loin and shoulders and long body, short in stature, and narrow at the loin. The Boer goats could be categorized as having long body and are heavy, while the Jamnapari goats are tall but with shorter body. Genes, which are simultaneously responsible for increasing body length and decreasing height at withers, could also be postulated to have positive effect on body weight.

This study revealed that a negative correlation was observed between the mature weight and rate of maturing in the two breeds (Jamnapari and Boer goats), which ranged from -0.84 (the Gompertz model) for the Boer goats to -0.97 (the von Bertalanffy model) for the Jamnapari goats. The Jamnapari goats with a lower mature weight showed a faster rate of maturing whereas the Boer goats had a higher mature weight and a slower maturing rate. This finding is in agreement with the negative relationship found between the mature weight and the rate of maturing reported by Bathaei and Leroy (1998) in sheep and DeNise and Brinks (1985) in cattle. Similarly, Tsukahara *et al*. (2008) also showed negative correlation coefficients between the parameters A and k, which ranged from -0.13 to -0.81 (von Bertalanffy) and -0.07 to -0.81 (Gompertz) for the Katjang and Katjang crossbred goats. Fitzhugh (1976) postulated that cows with higher mature weight would take a longer time

TABLE 4
Least square means and standard errors for the degree of maturity for the body weight (UW) and length of body, (UL) and height at withers (UH) by age groups for the female Jamnapari and Boer goats using the parameters derived from the Gompertz and von Bertalanffy models

Age	UW		UL		UH	
	Jamnapari	Boer	Jamnapari	Boer	Jamnapari	Boer
Gompertz model						
6-12 mo	23.70 ± 1.84	31.77± 5.31	57.35[a]± 0.96	65.34[b]± 2.76	65.74[a]± 0.88	72.42[b]± 2.61
13-24 mo	50.40± 3.07	47.76± 3.25	73.07[a]± 1.60	79.89[b]± 1.69	84.53± 1.47	87.99± 1.55
25-36 mo	63.28± 2.11	59.49± 0.83	79.14[a]± 1.10	84.41[b]± 0.43	91.86± 1.01	89.46± 0.39
37-48 mo	78.31± 1.40	71.27± 3.76	86.89± 0.73	89.98± 1.95	98.07± 0.68	94.56± 1.80
≥49 mo	84.41± 1.75	83.73± 2.08	90.57[a]± 0.92	95.04[b]± 1.08	98.95± 0.84	97.42± 0.99
Von Bertalanffy model						
6-12 mo	22.95 ± 1.80	31.19± 5.19	56.91[a]± 0.95	65.18[b]± 2.75	65.69[a]± 0.88	72.37[b]± 2.53
13-24 mo	48.81± 2.99	46.89± 3.18	72.51[a]± 1.59	79.70[b]± 1.68	84.46± 1.46	87.92± 1.55
25-36 mo	61.28± 2.06	58.40± 0.81	78.53[a]± 1.09	84.21[b]± 0.43	91.78± 1.01	89.39± 0.39
37-48 mo	75.84± 1.37	69.97± 3.67	86.22± 0.73	89.77± 1.94	97.99± 0.67	94.49± 1.80
≥49 mo	81.75± 1.71	82.21± 2.04	89.87[a]± 0.91	94.82[b]± 1.08	98.87± 0.84	97.34± 0.99

[a, b] Means with different superscripts in the same row between two breeds for UW, UL and UH of each age groups are different at $p < 0.05$

to mature, and are therefore older when reaching a constant degree of maturity as compared to cows with lower mature weight, as increase in the mature size is associated with longer time taken to mature.

Body weight at a certain age is an economically important trait because of its value in the sale of slaughter animals. Market price of slaughter animals is related to age, which is often quoted based on a per unit weight. Animals differ in age when a targeted market weight is reached, as indicated by the differences in the degree of maturity at specific age; the same finding was also reported by Fitzhugh and Taylor (1971). Variation in age at a constant degree of maturity exists between and within breeds, thus emphasizing the potential of selecting animals within a genetic group based on the rate of maturing or mature weight.

CONCLUSIONS

As shown by the measurements of the body weight, body length, and height at withers in this study, breeds of goats differ in their mature size. In particular, Boer goats with heavier mature weight are associated with a slower rate of growth relative to their mature weight and they have been shown to reach a constant degree of maturity much later as compared to the Jamnapari goats. Breeds of goats that originated from the Asiatic Tropics would have evolved as a faster maturing genotype to maintain a relatively smaller mature weight in adjusting to the less than optimum feeding environment of the local habitat, as shown by the Jamnapari breed undertaken in this study.

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