Non-linear growth pattern for body weight, height at withers and body length of Dorper sheep

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Abstract

There is a dearth of information on age-weight relationship in indigenous and imported sheep breeds raised in tropical region especially in South East Asia. Growth curve parameters estimated from non-linear function are useful to determine optimum market and slaughter weights. The objective of this study was to estimate mature size for body weight, body length and height at withers of Dorper ewes using Brody and Gompertz growth models. Cross-sectional data of body weight, height at withers and body length of 126 Dorper ewes (birth to 6 y of age) were collected and fitted to growth models for estimation of mature size (A), constant of integration (B) and rate of maturing (k). Gompertz model showed higher R^2 values for body weight, body length and height at withers (96.4, 99.6 and 99.6, respectively) compared to Brody (87.7, 88.3 and 90.0, respectively). Mature size for body weight, body length and height at withers estimated by Brody model were 62.81$\pm$1.833 kg, 67.18$\pm$0.5771 cm and 66.90$\pm$1.609 cm, respectively, while Gompertz model estimated 60.34±1.486 kg, 67.06+0.551 cm and 66.90$\pm$1.596 cm for body weight, body length and height at withers, respectively. Both models estimated negative correlation between parameter A and k for body weight, body length and height at withers, indicating that animals with faster rate of maturing grow faster towards their mature sizes but with smaller sizes compared animals of slower maturing rate.

Keywords: Dorper sheep, mature size, body measurements, non-linear growth model.

Introduction

The Malaysian sheep population in 2011 was 121,796 heads and increased slightly to 135,795 heads in 2015 (Department of Veterinary Service, 2017). It is lower compared to goats and other livestock (Somarny *et al*., 2013). In 2013, the self-sufficiency level for small-ruminant meat was 15.51% and decreased to 11.46% in 2015 (Department of Veterinary Service, 2017). Many efforts have been taken by the Malaysian government to achieve a targeted self- sufficiency of 35% - a feat which requires an increment of more than 1.5 million heads of goats and sheep by 2020 (Rafiu *et al*., 2012). One of the initiatives was the importation of new breeds of sheep to increase the domestic sheep population and fulfill local meat production. The indigenous Malin sheep are known for their capability to adapt to hot and humid climate of Malaysia but are characterized by low growth rate and small mature weight to meet current population target (Ahmad *et al*., 1991).

In 2008, Dorper sheep was introduced in Malaysia by Malaysian Agricultural Research and Development Institute (MARDI) with the initial importation of 120 ewes and 6 rams from South Africa to evaluate its adaptability, suitability, growth and reproductive performances under the Malaysian climatic condition (Johari *et al*., 2010). Dorper is a synthetic breed developed by the crossbreeding between Dorset Horn and Blackhead Persian, and were named as half-cross Dorset x Persian at the beginning (Milne, 2000). This breed was selected for meat purpose that could adapt to harsh climate. The Dorper sheep are known to have good growth and reproductive performance. Most literature consistently reported good fertility of Dorper ewes, ranging from 0.8 to 0.97, under various management systems (Cloete, 2000).

The growth of an animal can be explained by non-linear models such as Brody (Malhado *et al*., 2009), Gompertz (Hafiz *et al*., 2014), Logistic (Ben Mahouda and Atti, 2011), and von Bertalanffy (Kum *et al.*, 2010). These non-linear models are well known of their effectiveness and suitability to describe the sigmoidal curve of animal growth. The use of non-linear models helps to compile the large volumes of information of size measurements and age into a small set of parameters that can be interpreted biologically. Animal growth curves provide the prediction of an animal growth and development at every stage of its age, and the optimum age for slaughter (Ariff *et al*., 2010). An establishment of growth pattern of target animals is of importance for both producers and breeders in livestock production. Several studies reported using of non-linear model to describe mature size and rate of maturing of cattle (Berry *et al*., 2005; Hafiz *et al*., 2014), goats (Alade *et al*., 2008; Ariff *et al*., 2009; Hifzan *et al*., 2015) and sheep (Malhado *et al*., 2009; da Silva *et al*., 2012). The objective of this study was to determine the best fitted non-linear model to estimate the mature body weight and body length and height at withers of Dorper sheep.

Materials and Methods

Cross-sectional data of body weight, body length and height at withers of female Dorper sheep (n=126) born in MARDI Cherating, Pahang were used in this study. The Dorper sheep were raised semi-intensively under 7 to 20 y old coconut plantation planted with Pandan, Mawa and Ceylon varieties. The animals were let to graze from morning until early afternoon (0930 to 1500) in the coconut plantation with *Bracharia humidicola* grass planted as under-growths and were fed with supplementary commercial concentrate (15% crude protein, fibre 12%, fat 5%, moisture 9% and calcium1%) at 250-300 g/head/d during the rest of the day in slatted raised floor-houses. Water and mineral blocks were provided *ad-libitum.*

Table 1. Number of Dorper ewes by age groups

Age group (mo)	Number
Birth	10
1-6	8
7-12	21
13-18	10
19-24	10
25- 30	11
31-36	18
3-42	12
43-48	15
>48	11
Total	126

The age of animals ranged from birth to 6 y (Table 1). The data were fitted to two non-linear models, namely Brody and Gompertz, for the estimation of mature size (A), the constant of integration (B) and maturing rate (k) for body size (body weight (kg), height at withers (cm) and body length (cm)). Data were analyzed using PROC NLIN SAS (2003) for non-linear growth curve fitting. The two growth models were as described by Waheed *et al.* (2011):

Brody :$Y_t=A(1-Be^{-kt})$

Gompertz :$Y_t= Ae^{-Be^{-kt}}$

where Y_t is the observed measurement of size (body weight, body length and height at withers, at t age in mo), A is the asymptote measure of size, B is the constant of integration related to animal size and k is the maturing rate per d. The best model was determined by the highest coefficient of determination (R^2).

Results and Discussion

The estimates of growth parameters (A, B and k) derived from Brody's and Gompertz's models and their coefficient of determination (R^2) for body weight, body length and height at withers of Dorper sheep are presented in Table 2.

Gompertz growth model showed higher goodness of fit for body weight as shown by higher R^2 at 96.4 compared to Brody (87.7). The estimated mature weight of female Dorper sheep were 62.81$\pm$1.833 kg from Brody's and 60.84±1.486 kg from Gompertz's model. Dorper crossbred with local Brazillian sheep breeds, namely Morada Nova, Rabo Largo and Santa Ines, had lower mature weight that ranged from 29.35 kg to 31.51 kg as reported by Malhado *et al.* (2009). Brody model estimated 4.1% (2.47 kg) higher in mature weight compared to Gompertz model. The disadvantage of Brody model was it tended to estimate a higher A value than the other models as mentioned by Bathaei and Leroy (1996) and while Gompertz model estimated a lower mature size and attained faster mature size than Brody model estimation (Waheed *et al.*, 2011).

Dorper sheep raised under semi-intensive grazing system in Kluang, Johor also had similar mature weight as reported by Hifzan *et al.* (2014). Gompertz and Brody models estimated similar height at withers at maturity of Dorper ewes at 66.90 cm. Gompertz model estimated higher maturing rate at 0.024±0.004 compared to Brody at 0.019±0.008. The parameter k indicates the growth speed of an animal relative to its mature size. An animal with high k value shows a precocious maturity compared to an animal with lower k value (Malhado *et al.,* 2009). The present analysis showed that Brody model estimated lower k value, indicating the animals attained their mature weight at later age. The correlation between parameters A and k showed a negative correlation, explaining that animals with higher maturing rate had lower mature body weight and attained their mature weight earlier. The negative correlation between A and k as estimated by Brody and Gompertz models were -0.99 and -0.98, respectively. This negative correlation was similar to that reported for Santa Ines sheep (da Silva *et al.,* 2012), Dorper crossed with Brazillian native breed (Malhado *et al.,* 2009), Boer goats (Ariff *et al.*, 2010) and Brakmas cattle (Hafiz *et al.*, 2014). Gompertz model showed higher R^2 value of 99.6% compared to Brody (88.3%), indicating that Gompertz model was the better model to estimate the mature size for body length. Brody model estimated a higher mature body length compared to Gompertz model (67.18±0.5771 vs. 67.06±0.551 cm). The Gompertz model showed higher maturing rate for body length indicating that this model estimated lower mature size compared to Brody model at the magnitude of 0.062±0.006 and 0.053±0.008, respectively. Gompertz model also showed better goodness of fit when estimating the mature height at withers, where it gave higher R^2 of 99.6 compared to 90.0 for Brody. It also showed higher maturing rate at 0.056±0.008 compared to Brody at 0.055±0.009. Both models showed negative correlation for A and k parameters for body length and height at withers, with Gompertz model showing negative correlation for body length and height at wither at -0.92 and -0.99, respectively, while Brody model estimated the correlation at -0.93 and -0.87, respectively. It indicates that animals with higher maturing rate tend to have lower mature size and similar to the finding with the body weight.

Study of growth pattern can be an indicator for producers in selecting animals with higher maturing rate for the replacement stock. Therefore, it can produce progenies with almost similar performance. Information of growth pattern in Dorper sheep revealed point of intervention for producers to capitalize the genetic variability for growth at different phases of market production, and as a selection tool for breed improvement program, regardless maintaining its purebred, or to improve animals with low maturity rate by crossbreeding. Identifying the phase of fastest growth could facilitate in the formulation of feeding strategy in the growing and fattening of kids destined for the slaughter market. Another use of growth parameters is the predictions of weight for age of various management purposes.

Table 2. The estimates of growth parameters (A, B and k) and coefficient of determination (R^2) for body weight, body length and height at withers of Dorper sheep derived by Brody and Gompertz models

Size measurements	Parameter	Brody	Gompertz
Body weight (kg)	A	62.81±1.833	60.34±1.486
	B	0.56±0.087	0.77±0.175
	k	0.019±0.008	0.024±0.004
	R^2	87.7	96.4
Body length (cm)	A	67.18±0.5771	67.06+0.551
	B	0.40±0.479	0.46±0.580
	k	0.053±0.008	0.062±0.006
	R^2	88.3	99.6
Height at withers (cm)	A	66.90±1.609	66.90±1.596
	B	0.11±0.045	0.11±0.047
	k	0.055±0.009	0.056±0.008
	R^2	90.0	99.6

Table 3. Correlation coefficients between mature size (A) and rate of maturing (k) derived from Gompertz and Brody growth models

Size measurements	Brody	Gompertz
Body weight	-0.99	-0.98
Body length	-0.93	-0.92
Height at withers	-0.87	-0.99

Conclusion

Comparing these two models, Gompertz model showed the better goodness of fit to describe the growth pattern of body weight, body length and height at withers of Dorper ewes as shown by higher coefficient of determination. The correlation between mature size of body weight, body length and height at withers and rates of maturing were found to be negative, indicating that animals with higher maturing rate tend to attain their mature size earlier with smaller sizes. Non-linear model could be an alternative tool to predict an ideal age-body weight for sale, slaughter, to develop genetic improvement program and to strategize the best feeding regime for optimum growth performance.

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