The growth curve of body weight in Kacang goats managed by smallholders at Tambang District of Indonesia

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Abstract

Kacang goat (*Capra hircus*) is one of Indonesian germ plasm and kept by smallholders for meat production. This research was carried out to obtain the growth curve of body weight from 1 to 24 months of age in Kacang goats managed by smallholders at Tambang District of Indonesia. Total of 100 goats (51 buck and 49 does) were used in this study to obtain Logistic and Gompertz growth curves. Research showed that the Logistic and Gompertz growth curve have similar of coefficient of determination value (R^2= 0.98). However, the standard error (SE) value in Gompertz was lower than Logistic curves. The inflection weight (IW) was reached of 13.16 to 15.30 kg (Logistic) and 12.76 to 14.41 kg (Gompertz). The inflection age (IA) was reached of 12.95 to 15.57 months (Logistic) and 12.71 to14.41 months (Gompertz). The growth rate (GR) were reached of 1.06 to 1.23 kg/month (Logistic) and 1.02 to 1.10 kg/month (Gompertz). It was concluded that Gompertz growth curve was the best predictor to predict body weight in Kacang goats.

Keywords: Body weight, Growth curve, Kacang goats, Smallholders, Inflection

Introduction

Kacang goat (*Capra hircus*) are one of Indonesian native that kept by smallholders as meat production. Kacang goat was decided as the one of Indonesian native cattle through decision of Ministry of Agriculture No: 2840/Kpts/LB.430/8/2012. The average of body kg weight and carcass weight in Kacang bucks were 10.50 - 14.75 kg (Yurmiaty, 2006) and 5.63 kg (Sumardianto et al., 2013) respectively. Morever, Nuriadin et al. (2017) reported that the litter size, kidding interval, mortality rate at preweaning age and kid crop of Kacang does were 1.59±0.06; 8.05±0.38 months; 18.62±3.31% and 208.84±20.96% respectively.

Selection in the livestock can be performed based on growth traits. The growth of a livestock is a collection of the growth of parts of each component that can be seen from the physical appearance and weight of their life (Lawrence and Fowler, 2002). The growth of livestock can be evaluated based on their growth curve (Cak et al., 2017). Growth curve is a reflection of the ability of an individual or population to actualize themselves as a measure of the development of body parts to the maximum size (adult) in the existing environmental conditions. In general, growth in the form of sigmoid or "S". The "S" curve represents a form of acceleration and deceleration that is limited by turning points or inflection points. The inflection point is the maximum point of growth in body weight (Lawrence and Fowler, 2002).

Two growth curve of Logistic and Gompertz models were widely used to predict growth curve of body weight in many

goat breeds with highly accuracy. Previous studies used these model to predict the body weight in Katjang (Kacang), Angora, Alpine, Beetal, Damascus, Repartida, Saanen, Raeini Cashmere, Markhoz, Sirohi and Boer goats (Tsukahara et al., 2008; Özdemir and Dellal, 2009; Kume and Hajno, 2010; Waheed et al., 2011; Gaddour et al., 2012; Regadasfilho et al., 2014; Pires et al., 2017; Ghiasi et al., 2018; Kheirabadi and Rashidi, 2018; Waiz et al., 2019; Garcia-Muniz et al., 2019).

This study aimed to obtain the growth curve of body weight in Kacang goats managed by smallholders at Tambang District of Indonesia using Logistic and Gompertz models. The results of this study can be used as the early information to develop breeding program of Kacang goats at villager breeding center (VBC) in the future.

Materials and Methods

The records data of body weight (BW) in 100 Kacang goats (51 bucks and 49 does) at Tambang District, Kampar Regency of Indonesia were used in this study. All goats in this study were born with single birth status. The research site located between latitude 01°00'40" N - 00°27'00 S and longitude 100°28'30" - 101°14'30" E. The average of maximum air temperature about 21 - 35 °C with rainfall intensity about 2,846 mm/year and 26-100 m above sea level. The BW of goats were obtained from 1 to 2 animals per ages group with animal weighing scale. All goats were managed by smallholders with extensive traditional system.

Two growth curve models of Logistic and Gompertz were performed in this study using CurveExpert 1.4. software. The Logistic and Gompertz growth equations were presented in Table 1.

Table 1. The mathematics equation in the growth curve model of Logistic and Gompertz

Model	General formula				
Logistic	$Y_t = \dfrac{a}{1+be^{-ct}}$	$IW = 1/2(a)$	$IA = (\ln.b)/c$	$GR = c(IW)\left(1-\dfrac{IW}{a}\right)$	$AR = GR/a$
Gompertz	$Y_t = ae^{-e^{b-ct}}$	$IW = a/e$	$IA = a\exp(-be^{-c})$	$GR = c(IW)\ln.\left(\dfrac{IW}{a}\right)^{-1}$	$AR = GR/a$

Where: Y_t is the predicted body weight at t^{th} age; a is the asymptotic; b is the scale parameter; c is the the average rate of body growth until the animal reaches body maturity; e is the logarithm base (2.72); t is the animals age (months); IW is the inflection weight (kg) IA: is the inflection age (months); GR is the maximum growth rate (kg/month) and AR is the adult rate (kg/month).*Amrullah (2016).

Results and Discussion

The average of BW in Kacang goats in this study was presented in Table 2. Abadi et al. (2015) reported that the average of BW in Kacang does at 18-30 months old (3PPI) in Grobogan Regency was 21.13 kg and similar to Kacang does in this study at 21 months old. Waheed et al. (2011) reported that the average of BW at 12 months old in Beetal goat was 22.10±1.90 kg (male) and 20.70±1.54 kg (female) and close to the animals study at 21 months old. Özdemir and Dellal (2009) the average

of BW in Angora goat at 12 months old was 22.70±0.70 kg (male) and 16.40±0.70 kg (female) and higher than animals study at the same age. Thus, Waiz et al. (2019) reported that the average of BW in Sirohi goat at 12 months old was 26.58±6.16 kg (male) and 23.65±3.13 kg (female) and close to the animals study at 24 months old.

The growth curve of Logistic and Gompertz models had similar of coefficient of determination value (R^2 = 0.98).

Table 2. The average of body weight in Kacang goats

Age (months)	$\overline{X}_{BW}$ (kg)		Age (months)	$\overline{X}_{BW}$ (kg)	
	Male (N)	Female (N)		Male (N)	Female (N)
1	1.50 (3)	1.43 (3)	13	12.75 (2)	14.30 (2)
2	2.50 (3)	2.45 (2)	14	13.25 (2)	14.65 (2)
3	3.20 (2)	3.35 (2)	15	13.95 (2)	15.80 (2)
4	3.40 (2)	4.45 (2)	16	15.75 (2)	16.40 (2)
5	4.45 (2)	5.75 (2)	17	16.60 (2)	14.30 (2)
6	5.35 (2)	7.55 (2)	18	18.00 (2)	18.45 (2)
7	6.40 (2)	8.70 (2)	19	18.15 (2)	18.80 (2)
8	7.05 (2)	9.25 (2)	20	19.50 (2)	19.35 (2)
9	8.00 (2)	10.00 (2)	21	21.10 (2)	20.50 (2)
10	10.05 (2)	11.00 (2)	22	22.55 (2)	21.40 (2)
11	10.75 (2)	11.90 (2)	23	23.85 (2)	23.00 (2)
12	12.10 (2)	12.65 (2)	24	25.23 (3)	24.30 (2)

$\overline{X}_{BW}$: the average of body weight; N: number of animal

Table 3. The statistical analysis in growth curve of body weight in Kacang goats

Model / Sex	a	b	c	R^2	SE	IW (kg)	IA (months)	GR (kg/month)	AR (kg/month)
Logistic									
Male	30.60	12.08	0.16	0.98	0.71	15.30	15.57	1.23	0.04
Female	26.31	7.94	0.16	0.98	1.16	13.16	12.95	1.06	0.04
Gompertz									
Male	42.90	1.17	0.07	0.98	0.53	14.59	14.41	1.10	0.03
Female	31.12	0.98	0.09	0.98	0.99	12.76	12.71	1.02	0.04

a is the asymptotic; b is the scale parameter; c is the the average rate of body growth until the animal reaches body maturity; R^2: coefficient of determination; SE: standard error; IW is the inflection weight; IA is the inflection age; GR is the maximum growth rate and AR is the adult rate

In sheep, the R^2 value of 0.97 to 0.99 in the Logistic and Gompertz growth curves were reported in Morkaraman, Awassi, Akkaraman, Dorper cross, Norduz, Mengali, Hemsin, Madras red, Thalli, Mehraban and Mecheri breeds (Topal et al., 2004; Kucuk and Eyduran, 2009; Malhado et al., 2009; Kum et al., 2010; Tariq et al., 2013; Kopuzlu et al., 2014; Ganesan et al., 2015; Waheed et al., 2016; Hojjati and Hossein-Zadeh, 2017; Balan et al., 2017). Previous studies obtained the R^2 = 0.96 (Logistic) and 0.97 (Gompertz) in Hair, Markhoz and Sirohi goats (Tatar et al., 2009; Kheirabadi and Rashidi, 2019; Waiz et al., 2019). Meanwhile, the R^2 value in both models for Angora and Repartida goats were 0.91 and 0.96 respectively (Özdemir and Dallal, 2009; Pires et al., 2017).

The standard error (SE) value in Gompertz was lower than Logistic models. In Gompertz model, the growth curve in males was higher than females. Meanwhile, the growth curve of males in both models was lower than females (Figure 1). However, previous study reported that the growth curve of BW in bucks was higher than does (Waheed et al., 2011; Waiz et al., 2019; Kheirabadi and Rashidi, 2019). Despite, previous study reported that the growth curve of BW in rams was higher than ewes (McManus et al., 2003; Keskin et al., 2009; Gautam et

al., 2018). Soeparno (2005) stated that the mechanism sex hormonal (androgen) was caused the growth rate in male animal was faster than female animal. The IW and IA in Gompertz model were lower than Logistic model.

According to the Gompertz model, the mature weight in Kacang does of this study was reached at 12.71 months old and lower than Kacang does at Malaysia (18 months old) as reported by Tsukahara et al. (2008). Malhado et al. (2009) obtained the IW values in Dorper × Morada Nova (DMN); Dorper × Rabo Largo (DRL) and Dorper × Santa Ines (DSI) sheeps based on Gompertz model were 11,96 kg; 10.50 kg and 11.03 kg respectively with IA around 58.50 days (DMN), 67.10 days (DRL) and 75.70 days (DSI). Thus, Garcia-Muniz et al. (2019) reported IW and IA in Boer goat based on Logistic model were 24.8 kg and 115.1 days respectively. Hence, the IW and IA in Boer goat based on Gompertz model were 20 kg and 92 days respectively. Morever, Najari et al. (2007) obtained IW of 5.93 kg and IA of 39 days in native Tunisian goats recorded from birth until 8 months old.
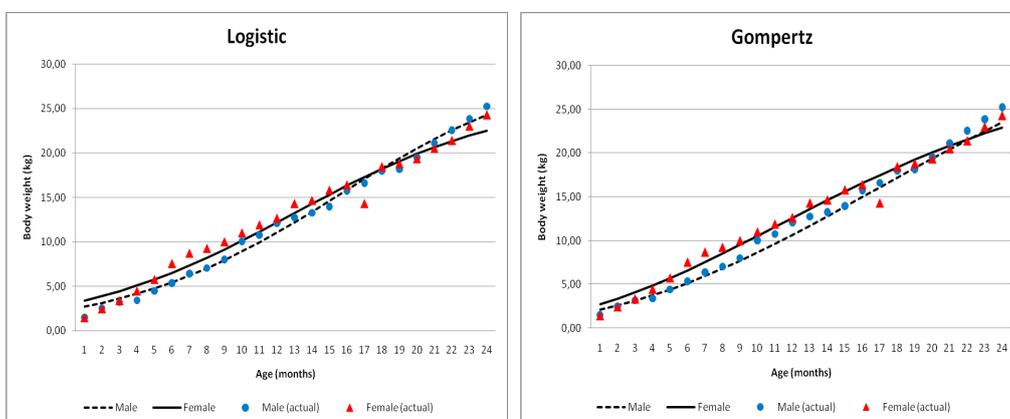
Figure 1. The growth curve of body weight in Kacang goats adjusted by Logistic and Gompertz models
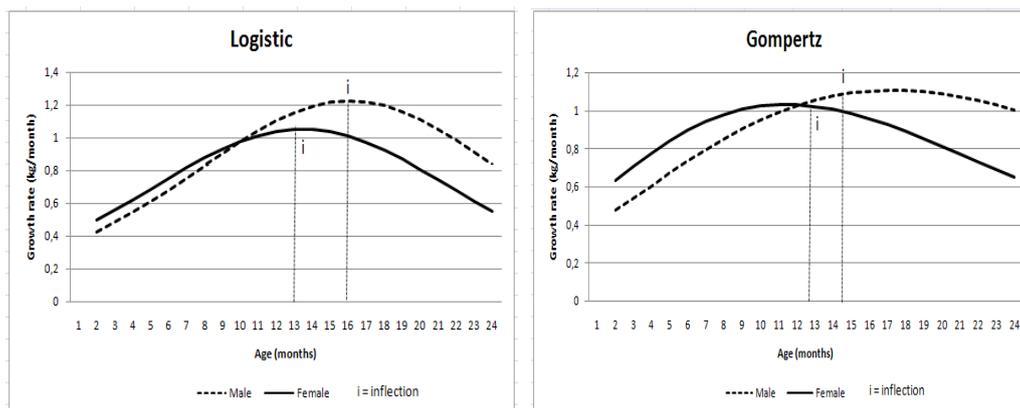
Figure 2. The absolute growth rate of body weight in Kacang goats estimated by Logistic and Gompertz models

The IW and IA values in animals studied with Gompertz were lower than Logistic models and similar to Boer goat (Garcia-Muniz et al., 2019). In this study, the mature weight of Kacang bucks was about 15 kg and reached at about 14-16 months old. Hence, the mature weight in Kacang does was about 13 kg and reached at about 13 months old. The IA value in animals studied based on Logistic and Gompertz models were presented in Figure 2. In addition, the GR for Kacang bucks in this study was 1.23 kg/month (Logistic) and 1.10 kg/month (Gompertz). Hence, the GR for Kacang does in this study was 1.06 kg/month (Logistic) and 1.02 kg/month (Gompertz) as presented in Figure 2. Morever, the AR in animals studied was 0.03-0.04 kg/month. Amrullah (2016) obtained the AR value in Brahman cows of 0.03 kg/month in Logistic or Gompertz models and close to the present study.

Conclusion

The growth curve of BW with Logistic and Gompertz models in animals studied had $R^2=0.98$. However, the Gompertz model had lower of SE value rather than Logistic model. Despite, selection of Kacang goat can be performed based on the BW at 14-16 months old (male) and 13 months old (female).

Compliance with Ethical Standards
Conflict of interest
The authors declare that for this article they have no actual, potential or perceived the conflict of interests.
Author contribution
The contribution of the authors is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.
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Consent for publication
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