

## The Post-weaning Growth of Lambs from Crossbreeding Between Garut Ewes with Dorper Rams

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### ABSTRACT

This study investigates the performance of post-weaning growth of Garut lambs and the results of crossing Garut ewes with Dorper rams. This research phase occurred in the post-weaning phase period of 3–7 months using 168 lambs consisting of 85 Garut lambs and 83 crossed Dorper lambs in the post-weaning phase with an average body weight of  $15.15 \pm 3.23$  kg. The lambs were assigned to a factorial completely randomized design (2 x 2 factorial experiment). They were then divided into two groups based on breed (Garut and Crossed Dorper) and two sex groups (male and female). Data observed included feed consumption, as fed feed consumption, dry matter (DM) consumption, DM consumption per body weight, crude protein (CP) consumption, total digestible nutrient (TDN) consumption, average daily gain (ADG), and feed conversion. Results showed that consumption of as fed, DM, CP, TDN, and ADG were higher ( $P < 0.05$ ) in crossed Dorper lambs than in Garut lambs; a total ADG of crossed Dorper, Garut, male, and female lambs were  $106.92 \pm 11.68$ ,  $79.25 \pm 10.02$ ,

$102.49 \pm 17.54$ , and  $86.79 \pm 14.48$  g/day, respectively. Male lambs showed higher results ( $P < 0.05$ ) in as-fed feed consumption, DM, DM consumption per body weight, CP, TDN, and ADG than female lambs. The feed conversion of crossed Dorper lamb and male lamb was lower ( $P < 0.05$ ) than that of Garut and female lamb. There was an interaction between male breed and sex at seven months ADG and feed conversion at 4 and 7 months. Sheep from Garut ewes crossed with Dorper

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rams improved the growth performance of their offspring.

*Keywords:* Average daily gain, crossbreeding, Dorper cross, Garut sheep, sheep performance

## INTRODUCTION

Sheep farming has a high economic benefit and potentially effectively achieves national food security. According to Badan Pusat Statistik (BPS) (2023), the sheep population in Indonesia in the last five years has decreased by 11.40%, from 17.61 million in 2018 to 15.62 million in 2022. On the other hand, there is an ongoing demand for sheep and sheep meat for religious rituals, large restaurants or small traders, and export demand. Consumer trends, interests, and preferences favor sheep under one year old because they have a more tender meat quality for consumption (Athifa et al., 2022). These consumer preferences demand that sheep have a high weight at a relatively young age. Thus, in responding to these customer needs, an improvement in sheep productivity is essential.

The weight of the sheep reflects productivity improvement and is consistent with the growth performance rate as seen from feed consumption and feed conversion ratio (FCR) (Budisatria et al., 2021). To improve sheep productivity regarding the growth rate as an essential trait that determines lamb production. Thus, indigenous and local sheep's productivity must be improved to boost output and profitability (Ayichew, 2019). Sheep crossbreeding is one way to improve

and increase genetic combinations to provide favorable opportunities to increase production efficiency by exploiting breed diversities, heterosis, and complementary breeds (Getahun et al., 2019). Heterosis or hybrid vigor is the combined performance of the genetic average of the two sheep of origin, so this heterosis effect is used to increase the offspring's output. Therefore, the combination of genetic breeds can merge the advantages of each breed as seen from the crossbred offspring (Panjono et al., 2022).

One of the superior sheep growing in Indonesia is the Garut sheep. Garut sheep are a popular germplasm cultivated as meat producers. This sheep is a crossbreed of Fat Tail sheep (Gibas), Parahyangan Local sheep, and Merino sheep. According to the Badan Standardisasi Nasional (BSN) (2015), the body weight of males and females Garut sheep aged 8-12 months is 23 and 22 kg, respectively. Garut sheep are local Indonesian sheep adaptable to tropical climates and resistant to disease (Wijaya et al., 2019). However, indigenous and local sheep have a relatively small body size, slow maturity, and low carcass yield (Udo & Budisatria, 2011). The weaning weight of Garut sheep is  $11.55 \pm 2.15$  kg, with ADG post-weaning until eight months of age is  $45.85 \pm 8.15$  g/head/day (Praja et al., 2020). Therefore, it is considered necessary to cross with superior breeds to increase body weight and improve the productivity of local sheep. Dorper is one of the sheep that is excellent in growth.

Dorper sheep is a superior meat composite sheep produced in 1930 that was originally from South Africa due to crossing Black-headed Persian and Dorset Horn (Gavojdian et al., 2013). Dorper has excellent performance in weaning weight and post-weaning growth rate with good feed efficiency (Castillo-Hernández et al., 2023; Wanjala et al., 2023). After weaning, Dorper weighs 18.2 kg and can grow 0.23 kg/day (Cloete et al., 2000). Hence, it can reach a weight of 46.1 kg at eight months and an adult weight of 60–120 kg (Gavojdian et al., 2013). Dorper is used as a terminal-sires to improve the performance of crossbred lambs. In Ethiopia, body weight at different ages was significantly higher in 50% of Dorper crosses than in indigenous sheep breeds (Ayichew, 2019).

The initiative to introduce Dorper sheep (imported) to enhance the productivity of local sheep in Indonesia through crossbreeding has been widely practiced. Athifa et al. (2022) reported that the productivity of Garut sheep mated with Dorper rams was significantly better than that of Garut rams. Meanwhile, crossbred lambs (F1) also have better pre-weaning growth than Garut lambs. Birth weight, weaning weight, and ADG of Garut and Dorper crossbred lambs were  $2.20 \pm 0.54$  and  $2.60 \pm 0.71$  kg;  $14.91 \pm 3.57$  and  $16.27 \pm 3.69$  kg;  $90.21 \pm 32.11$  and  $119.12 \pm 42.64$  g/day, respectively. Following this previous study, the crossbred lambs' productivity during the weaning period must be continuously measured. Furthermore, this research was conducted to determine the productivity of

the offspring resulting from the crossbreeding between Garut ewes and Dorper rams during the post-weaning period.

## MATERIALS AND METHODS

### Ethical Clearance

The design of this experiment has been approved by the Ethical Clearance Commission, the Faculty of Veterinary Medicine, Universitas Gadjah Mada, Indonesia (No: 0037/EC-FKH/EKs/2020).

### Research Location and Animals

This study was conducted at PT Agro Investama Sheep Farm, Malangbong, Garut Regency, West Java, Indonesia. This study was completed for 150 days, from August 2020 to January 2021. The research employed lambs from crossbreeding between Garut ewes with Garut rams and Dorper rams. Mating was carried out naturally in the colony pens ( $8 \times 5 \text{ m}^2$ ) with 11–15 heads per colony equipped with feed and water bunks. The lamb's parents, the selected Garut ewes used, were above parity one or over sixteen months old with a live weight of 20 kg or above, then randomized mated with the Garut and Dorper ram. The rams were over two years old, with a live weight of 80–100 kg for Dorper and 60–70 kg for Garut ram. The mating duration was a month; the ewes were checked for with the *Draminski* ultrasound scanner probe transducer 5 MHz. The non-pregnant ewes were mated again, and those pregnant ewes were kept until the delivery. Routine maintenance of ewes, rams, and lambs

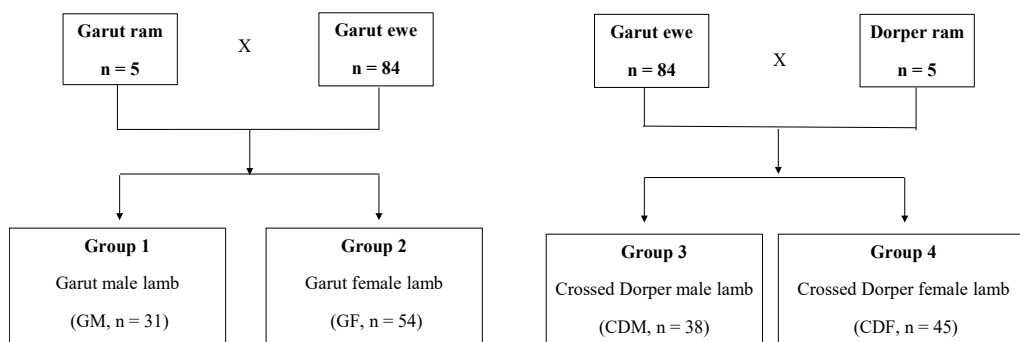


Figure 1. Diagram of the mating between Garut and Dorper ram with Garut ewe

included cleaning the pens every morning, bathing the sheep once a week, and shearing and trimming the long nails. The mating scheme is presented in Figure 1.

Lambs from Garut ewes mated with Garut rams are then referred to as Garut lambs, and lambs from Garut ewes mated with Dorper rams are then referred to as crossed Dorper lambs. The blood composition of crossed Dorper lambs is 50% Garut and 50% Dorper. The total sheep used in this study were 168 lambs consisting of 85 Garut lambs (31 male and 54 female) and 83 crossed Dorper lambs (38 male and 45 female) aged between 60 to 90 days or in the post-weaning phase with an average body weight of  $15.15 \pm 3.23$  kg. This research occurred in the post-weaning period of 3–7 months. The lambs were assigned to a factorial completely randomized design (2 x 2 factorial experiment) and then divided into two groups based on breed (Garut lamb and Crossed Dorper lamb) and two sex groups (male lamb and female lamb).

The pens are wooden stilt cages of 8 x 5 m<sup>2</sup> containing 10–12 sheep equipped with separate feed and water containers. Feeding

is given twice daily at 08.00 a.m. and 04.00 p.m. Drinking water is supplied *ad libitum*. Feed is provided according to the needs of DM consumption, which is about 2.5% to 5% of the total body weight (National Research Council [NRC], 2010). Sheep in the growth phase with a live weight of 20 kg and a daily weight gain of 100 g require 410 g of DM or 3.5% of their weight (Kearl, 1982). The feed requirement calculation was based on body weight at the beginning of the research and updated after monthly weighing. The feed given is a complete feed, a mixture of concentrate and forage. The nutritional content of the complete feed included DM at 44.80%, CP at 15.14%, crude fat at 3.85%, crude fiber at 14.26%, ash at 9.40%, and the calculation of TDN was 64.15%.

### Measurement Variables and Data Collection

The variables observed in this study were the growth performance of Garut lambs and crossed Dorper lambs, including feed consumption, ADG, and feed conversion. The calculation of feed consumption was

determined by weighing the feed and leftovers for three consecutive days in each month in each cage. The consumption calculation consists of as fed feed consumption, DM consumption, CP, and TDN. DM consumption consists of DM consumption per day (g/day) and DM consumption per body weight (%). The following is the formula for estimating feed consumption:

#### ***As Fed Feed Consumption***

As-fed feed consumption is a form of as fed feed consumed by lambs with the following formula (Budisatria et al., 2021):

$$AF \text{ consumption} = [AG - AL]$$

where,

AF = As fed feed consumption (kg/head)

AG = As fed feed given (kg/head)

AL = As fed feed leftover (kg/head)

#### ***DM Consumption***

The amount of DM consumed with the following formula (Budisatria et al., 2021):

$$DMC = [FC \times DM]$$

where,

DMC = Dry matter consumption (g/head)

FC = Feed consumption (g/head)

DM = Dry matter content in feed (%)

#### ***DM Consumption per Body Weight***

The amount of DM consumed is divided by body weight with the following formula (Budisatria et al., 2021):

$$CBW = [DMC / BW] \times 100\%$$

where,

CBW = Consumption per body weight (%)

DMC = Dry matter consumption per day (g/head)

BW = Body weight (kg)

#### ***CP Consumption***

The amount of CP consumed is calculated according to the following formula (Budisatria et al., 2021):

$$CPC = [DMC \times CP]$$

where,

CPC = Crude protein consumption (g)

DMC = Dry matter consumption (g/head)

CP = Crude protein content in feed (%)

#### ***TDN Consumption***

TDN is calculated based on the following formula (Budisatria et al., 2021):

$$TDNC = [DMC \times TDN]$$

where,

TDNC = Total digestible nutrient consumption (g)

DMC = Dry matter consumption (g/head)

TDN = Total digestible nutrient content in feed (%)

#### ***Average Daily Gain***

Lambs were weighed every month at the age of 4 to 7 months, and initial body weight was used as a covariate to analyze body weight

gain. ADG was calculated according to the following formula (Budisatria et al., 2021):

$$ADG = [FBW-IBW]/T$$

where,

ADG = Average daily gain (g/day)

FBW = Final body weight (g)

IBW = Initial body weight (g)

T = Duration of observation (days)

### **Feed Conversion**

The calculation of feed conversion is made by counting the ratio or difference between the amount of feed consumed by the lambs and the resulting body weight gain as calculated according to the following formula (Budisatria et al., 2021):

$$FCR = AF/ADG$$

where,

FCR = Feed conversion ratio

AF = As fed feed consumption (g/head)

ADG = Average Daily Gain (g/day)

Differences in feed consumption, ADG, and feed conversion between sheep breed and sheep sex groups were analyzed using a two-way analysis of variance (ANOVA). Initial body weight was used as a covariate for analyzing body weight gain. Statistical analyses were conducted using SPSS (version 21).

## **RESULTS AND DISCUSSION**

Feed consumption of crossed Dorper lambs was higher ( $P<0.05$ ) than Garut lambs. Male lambs' as-fed consumption was higher

$P<0.05$  than female lambs. However, there was no interaction between breed and sex on the consumption of as fed feed (Table 1). Crossed Dorper lambs have a better appetite than Garut lambs. It can be seen in the DM consumption (Table 1), which indicates that crossed Dorper lambs have higher DM consumption than Garut lambs ( $P<0.05$ ). Table 1 also reveals that the DM consumption of male lambs is higher than females ( $P<0.05$ ).

As fed feed consumption of crossed Dorper lambs was higher than that of Garut lambs. Garut lambs left much more stubble, while crossed Dorper lambs ate it. This condition is in line with the opinion of Ocak et al. (2016), who stated that Dorper is a sheep that is not selectively feeding. Male lambs have a better appetite than females. Table 1 shows that male lambs consume more as fed feed than female lambs. The male lambs produce hormones, such as androgen, in the testicular glands. However, the ovaries produce little. This hormone can stimulate masculine traits, making the males more aggressive when consuming large amounts of feed during the post-weaning period to get a mature weight (Lewis & Emmans, 2010). DM consumption is directly related to as fed feed consumption. Higher as fed feed consumption influences higher DM consumption. Consequently, the DM consumption of crossed Dorper lambs is higher than that of Garut lambs. Similarly, male lambs consumed more DM compared to female lambs. Data in Table 1 presents a significant difference in as fed and DM consumption of lambs in months 4, 5, 6,

Table 1

*As fed and nutrients consumption of Garut lambs and Crossed Dorper lambs<sup>1</sup> during the post-weaning period*

Variable	Month	Breed		Sex		Significancy		
		Garut (n = 85)	Crossed Dorper (n = 83)	Male (n = 69)	Female (n = 99)	B <sup>2</sup>	S <sup>3</sup>	B x S
As fed consumption (kg/day)								
	4	1.20±0.07	1.50±0.05	1.40±0.15	1.30±0.18	*	*	ns
	5	1.30±0.13	1.64±0.13	1.59±0.19	1.35±0.18	*	*	ns
	6	1.49±0.10	1.85±0.35	1.72±0.17	1.62±0.22	*	*	ns
	7	1.91±0.18	2.22±0.07	2.13±0.17	1.99±0.17	*	*	ns
	Total	1.47±0.29	1.80±0.29	1.71±0.32	1.56±0.33	*	*	ns
Dry matter consumption (g/day)								
	4	515.66±59.17	621.59±18.86	587.68±53.72	549.63±62.84	*	*	ns
	5	564.78±46.61	684.49±45.55	666.57±65.05	582.69±66.28	*	*	ns
	6	644.52±34.73	771.84±11.68	726.03±60.96	690.34±81.17	*	*	ns
	7	837.39±29.71	949.17±25.27	91779±60.13	868.77±62.94	*	*	ns
	Total	640.61±129.43	756.77±128.56	724.52±136.55	672.86±142.41	*	*	ns
Dry matter consumption per body weight (%)								
	4	3.12±0.33	2.95±0.07	3.05±0.06	3.03±0.14	ns	ns	ns
	5	2.88±0.03	3.03±0.02	2.97±0.07	2.94±0.10	ns	*	ns
	6	2.88±0.08	3.09±0.05	3.00±0.14	2.97±0.12	*	*	ns
	7	3.14±0.03	3.27±0.02	3.22±0.09	3.20±0.06	*	*	ns
	Total	2.96±0.12	3.13±0.10	3.06±0.13	3.03±0.15	*	*	ns
Crude protein consumption (g/day)								
	4	81.39±4.91	101.74±3.27	95.17±10.41	87.96±11.98	*	*	ns
	5	88.18±8.86	111.05±8.83	107.66±12.51	91.57±12.59	*	*	ns
	6	101.15±6.70	125.10±2.26	116.54±11.46	109.71±15.33	*	*	ns
	7	129.25±5.51	150.35±4.89	144.43±11.49	135.17±11.74	*	*	ns
	Total	99.99±6.49	122.06±4.80	115.95±11.47	106.10±12.91	*	*	ns
Total digestible nutrient consumption (g/day)								
	4	344.87±20.81	431.09±13.85	403.26±44.11	372.69±50.78	*	*	ns
	5	373.61±37.56	470.55±37.40	456.17±53.04	387.98±53.33	*	*	ns
	6	428.58±28.39	530.08±9.58	493.81±48.57	464.85±64.94	*	*	ns
	7	547.64±23.36	637.05±20.75	611.96±48.72	572.73±49.76	*	*	ns
	Total	423.67±27.53	517.19±20.39	515.06±47.11	449.56±54.70	*	*	ns

*Note.*\**P*<0.05; ns = Non-significant<sup>1</sup>Crossbreeding between Dorper ram and Garut ewe<sup>2</sup>Breed<sup>3</sup>Sex

B x S = Interaction between breed and sex

and 7. However, there was no interaction between breed and sex on feed consumption. Rodríguez et al. (2008) also reported no interaction between breed and sex on feed consumption in Assaf sheep.

DM consumption per body weight in this study ranged from 2.87-3.49% of body weight, as presented in Table 1. Similar to feed and DM consumption, DM consumption per body weight in the crossed Dorper lambs had a higher percentage ( $P<0.05$ ) than Garut. Similarly, male lambs had a higher percentage ( $P<0.05$ ) than female lambs. CP consumption in crossed Dorper lambs was higher than in Garut lambs ( $P<0.05$ ). In the same way, male lambs had a higher CP consumption than female lambs ( $P<0.05$ ).

The results of this study indicated that DM consumption per body weight in all groups ranged from 2.87% to 3.49% of body weight, as presented in Table 1. DM consumption of both breeds or groups is still in the normal range. According to NRC (2010), DM consumption of sheep is between 2.5–5% of body weight; DM consumption will determine the feed consumed by livestock. Significant differences in crossed Dorper lambs in months 6 and 7 were higher ( $P<0.05$ ) than Garut, as well as DM consumption per body weight of male lambs in months 5, 6, and 7 were higher ( $P<0.05$ ) than that of female lambs. The difference in DM consumption between the lambs is due to the ability of digestibility and digesta rate of feed between different animals (McDonald et al., 2011).

Table 1 demonstrates that CP consumption in Garut and crossed Dorper lambs varies between 81.35 and 150.35 g. The TDN of male lambs is higher ( $P<0.05$ ) than female lambs ( $P<0.05$ ). TDN in male lambs was higher ( $P<0.05$ ) than female lambs ( $P<0.05$ ). Similarly, TDN in crossed Dorper lambs was higher ( $P<0.05$ ) than Garut lambs. TDN consumption presented in Table 1 indicates that TDN consumption is 326.62–655.98 g (63.34–69.18%). This TDN consumption is still in the normal range of 60–70% (Hasanah et al., 2021). However, there was no interaction between breed and sex on DM consumption per body weight, CP consumption, and TDN consumption.

There was a significant difference ( $P<0.05$ ) in CP consumption between crossed Dorper lambs and Garut lambs, with higher CP consumption in crossbred lambs in months 4, 5, 6, and 7. The same applies to the CP consumption of male lambs compared to female lambs ( $P<0.05$ ). It can be concluded that breed and sex significantly affect CP consumption (Table 1). Tao et al. (2022) reported that the amount of genetic variance affects protein consumption, and different hormones between males and females also have an influence that causes the protein needs of male livestock to be different from females. Different protein requirements between sexes and breeds relate to metabolic energy consumption (Abbasi et al., 2014). Metabolic energy is readily utilized by livestock for physical activity, reproduction, production, metabolism, and tissue formation (McDonald et al., 2011). In



addition, it is known that CP consumption is in the normal range. According to NRC (2010), sheep require 127–167 g CP.

TDN consumption determines nutrient consumption for energy sources, which consists of digestible components of protein, crude fiber, ether extract, and digestible N-free extract. The TDN required for local sheep body weight in Indonesia is 400–800 g (Jayanegara et al., 2017). Kearl (1982) noted that to meet the TDN requirement of 15–25 kg, it is 310–410 g/head/day. Jayanegara et al. (2017) also add that the TDN requirement of sheep is 80%. The value of TDN consumption in this study ranged from 326–637 g/head/day, indicating appropriate TDN consumption. The results also showed an increase in TDN consumption from the 4<sup>th</sup> to 7<sup>th</sup> month, which is in line with the increase in body weight. Ngadiyono et al. (2019) stated that energy consumption will result in a faster growth rate and increase the size of livestock.

TDN consumption in this study indicated crossed Dorper lambs had higher TDN consumption ( $P < 0.05$ ) than Garut lambs, and male lambs had higher TDN consumption ( $P < 0.05$ ) than female lambs. It is attributed to the fact that feed consumption tends to be higher. In addition, larger animals certainly consume more feed in the form of DM to meet their needs (Table 1). Ngadiyono et al. (2019) explained that TDN consumption is determined by the percentage of DM consumed, the content of minerals and fat digested in DM, and the coefficient of DM digestibility. Another factor affecting DM consumption

is hormones in male livestock, which support higher feed consumption than in female livestock (Purbowati et al., 2015). In addition, the genetic origin of the sheep also affects the feed consumption of the sheep itself. Sheep with larger genetic weights require higher consumption (Knapik, 2017). It can be seen from the crossed Dorper and Garut lamb consumption levels.

The ADG of crossed Dorper lambs was higher ( $P < 0.05$ ) than Garut lambs (Table 2). The difference in body weight between Garut lambs and crossed Dorper lambs is presented in Figure 2. The ADG of male lambs was higher than that of females ( $P < 0.05$ ). It is consistent with the feed consumption of males, which is more than that of females, as presented in Table 1—the interaction of male breed and sex on average at seven months of age.

The different body weights between Garut lambs and crossed Dorper lambs indicate that the crossbreeding of Garut ewes with Dorper rams affects the crossing outcome in the form of higher body weight of crossed Dorper lambs ( $P < 0.05$ ), as shown in Figure 2. The superior body weight will affect the ADG values. The difference in the breed of the parents causes the crossed Dorper lambs to have higher body weights and ADG. Souza et al. (2013) reported that Dorper was used as a ram in several crossbreeding to produce fast-growing sheep post-weaning. Getahun et al. (2019) added that the advantage in the growth of crossbred sheep results from heterosis or complementary effects between breeds.

**Table 2**

*Average daily gain and feed conversion of Garut lambs and crossed Dorper lambs<sup>1</sup> during the post-weaning period*

Variable	Month	Breed		Sex		Significancy		
		Garut (n = 85)	Crossed Dorper (n = 83)	Male (n = 69)	Female (n = 99)	B <sup>2</sup>	S <sup>3</sup>	B x S
Average daily gain (g/day)								
	4	79.66±13.12	115.64±21.81	109.20±27.65	89.97±20.44	*	*	ns
	5	79.40±14.10	105.00±16.23	101.87±18.60	85.65±17.96	*	*	ns
	6	77.67±15.33	103.94±15.62	98.72±21.83	85.58±17.12	*	*	ns
	7	80.28±13.30	103.11±19.08	100.18±17.35	85.95±19.87	*	*	*
	Total	79.25±10.02	106.92±11.68	102.49±17.54	86.79±14.48	*	*	*
Feed conversion ratio								
	4	6.35±0.26	5.37±0.41	5.56±0.62	6.15±0.47	*	*	*
	5	6.93±0.20	6.48±0.67	6.59±0.18	6.82±0.32	*	*	*
	6	8.18±0.28	7.41±0.52	7.50±0.62	8.09±0.31	*	*	*
	7	10.25±0.50	9.18±0.52	9.26±0.60	10.17±0.59	*	*	ns
	Total	7.93±1.56	7.11±1.48	7.23±1.48	7.81±1.61	*	*	ns

*Note.*

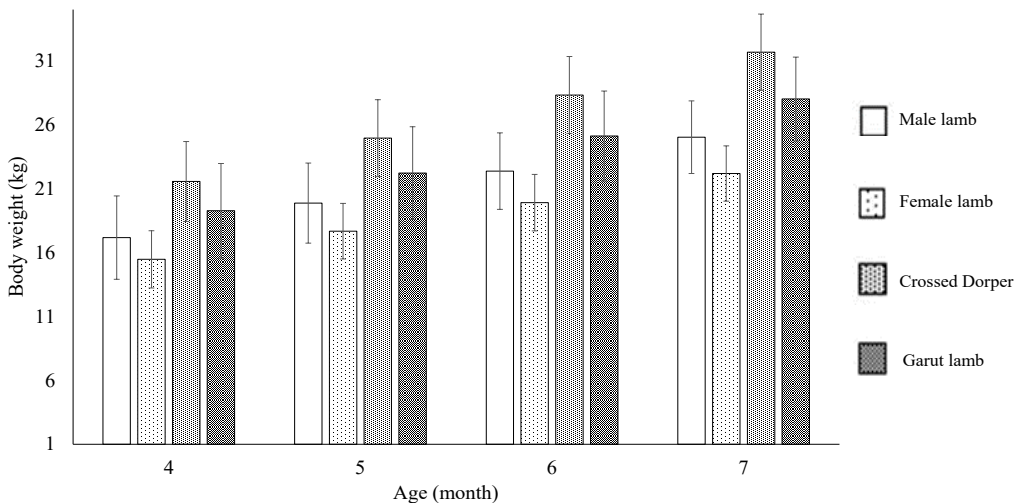
\**P*<0.05; ns = Non-significant

<sup>1</sup>Crossbreeding between Dorper ram and Garut ewe

<sup>2</sup>Breed

<sup>3</sup>Sex

B x S = Interaction between breed and sex



*Figure 2.* Body weight of Garut lambs and crossed Dorper lambs during the post-weaning period

The higher ADG ( $P<0.05$ ) in male lambs indicates that sex affects body weight gain, as seen from the consumption of as fed feed or more DM consumption. Gemiyo et al. (2017), as well as Lewis and Emmans (2010), reported that high aggressiveness in consuming feed causes males to grow faster, resulting in higher body weight gain than females. Gemiyo et al. (2014) added that sexual dimorphism and hormonal differences between males and females affect growth differently. Mohammadi et al. (2010) explained that estrogen has a low effect on female growth in the endocrine system.

In this study, the ADG of Garut and crossed Dorper lambs ranged from 79–106 g/day. ADG in this study is under the normal range. Several studies reported the ADG of local and exotic lambs during post-weaning: Fetherstone et al. (2022) reported that New Zealand lamb have ADG of 247–274 g/day, Waheed et al. (2022) reported that

Thalli lambs have ADG of 102 g/day, and Maulana et al. (2021) reported that Garut lamb have ADG of 104–195 g/day. Crossed Dorper lambs grow faster than Garut lambs, as depicted in Figure 3. The male lambs grow faster than the female lambs. However, the growth is not as significant as the crossed Dorper. Sheep body weight gain is influenced by genetics and sex (Ayele & Urge, 2019). Dorper belongs to a fast-growing sheep breed (Cloete et al., 2000). Freitas et al. (2020) reported in their research that there was an interaction between sex and breed significantly on ADG of crossbreeding between Dorper and Santa Inez in post-weaning rearing ( $P<0.05$ ). There was interaction between breed and sex on ADG during the post-weaning period. This result follows the study of Nugroho et al. (2023), which reported the interaction factor between genetic factors (the buck breed and litter size) and environmental factors (birth season) in post-weaning

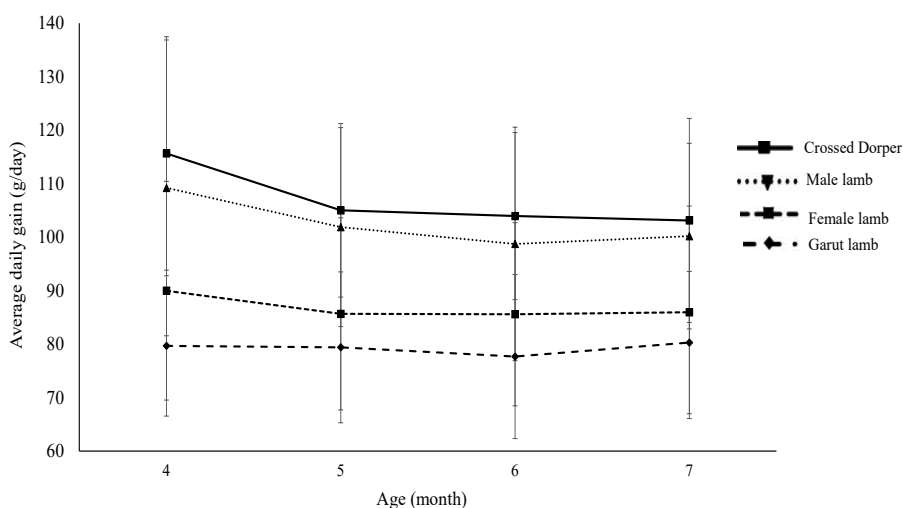


Figure 3. Average daily gain of Garut lambs and crossed Dorper lambs during the post-weaning period

growth of Boer and Boer Cross goats. Growth traits are important indicators of meat-type livestock performance, given their direct association with economic value. It is widely recognized that genetic factors, environmental conditions, and the interaction between genetics and the environment influence growth performance.

It was found that the FCR were significant differences ( $P<0.05$ ) in crossed Dorper and Garut lambs, and male lambs and female lambs presented in Table 2. The highest ADG was in crossed Dorper lambs (Figure 3). FCR (Table 2) suggests that crossed Dorper lambs have lower FCR than Garut lambs ( $P<0.05$ ). FCR of male lambs was more efficient than female lambs ( $P<0.05$ ). There was an interaction between breed and sex in terms of feed conversion during the post-weaning period in 4–6 months. In this study, the feed conversion of crossed Dorper lambs ranged from 5.45 to 10.79.

FCR in this study is still in the normal range. FCR of sheep weighing 10–20 kg is 2.5–4 (NRC, 2010). The standard score of FCR for sheep is 4 in subtropical areas, which tends to be higher in Indonesia as it has a tropical climate (NRC, 2010). Purbowati et al. (2022) stated that the FCR of sheep in Indonesia ranges from 9–13, meaning that 9–13 kg of feed (in DM) produces 1 kg of body weight gain. There were significant differences in crossed Dorper lambs with Garut lambs and male lambs and female lambs, as shown in Table 2 ( $P<0.05$ ). The crossed Dorper lamb is more efficient in consuming feed to produce body

weight gain. The crossed Dorper lambs were more efficient than Garut lambs. Male lambs were more efficient than female lambs for producing body weight gain.

Crossed Dorper lambs are more efficient in converting feed into meat. It can be seen from the cross Dorper lambs that have a faster growth with 3% DM consumption per body weight (Table 1). Gavojdian et al. (2013) reported that Dorper is a sheep breed that is quite good in feed efficiency after weaning. Ocak et al. (2016) stated that Dorper is a productive sheep breed. It can increase FCR by 20% than other crossbred sheep. Dorper FCR is 4, meaning that 4 kg of feed consumption (in DM) produced 1 kg of body weight gain. Male lambs in this study are more efficient in converting feed into meat. Freitas et al. (2020) explained that feed consumption of male sheep results in a better quantity of muscle tissue and muscle distribution than females, and the accumulation of male muscle is more significant due to differential hormonal effects on growth. Sjaastad et al. (2010) also noted that testosterone, which appears in male livestock, has anabolic effects. Testosterone increases the growth of muscle tissue and bone in males by stimulating the synthesis and inhibiting protein breakdown.

Crossbreeding is one of the strategies used to address the interaction between genetics and the environment. This approach aims to develop superior genetic qualities that adapt to specific environmental conditions. Crossbreeding between exotic breeds and local Indonesian sheep breeds has been implemented in Indonesia.

This measure was primarily undertaken because most Indonesian local sheep have smaller body sizes. These crossbreeds are expected to be advantageous due to their larger body size and adaptability to the Indonesian environment. However, as crossbreeds, they may possess diverse genetic potentials, leading to varying responses to environmental stimuli. The result of this study would be beneficial for evaluating the crossbreeding program of Indonesian local sheep crossed with exotic sheep before it can be implemented widely by the farmers.

## CONCLUSION

The lambs resulting from the crossbreeding between Garut ewes and Dorper rams have more excellent productivity, as seen from the performance of the crossed Dorper lambs in as fed feed consumption, DM, protein, TDN, ADG, and FCR that are better than Garut lambs. Crossed Dorper lamb has a 25% higher ADG, namely 106.92 g/day, compared to Garut lamb, which is 79.25 g/day, and Crossed Dorper lamb has an FCR 0.82 higher than Garut lamb. Male lambs also have better post-weaning performance than female lambs.

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