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Effect of Parity and Type of Birth on Reproduction Performance of Garut Ewes in Indonesia

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ABSTRACT

Garut sheep is one of the superior sheep breeds originating from Garut, West Java, Indonesia. Garut sheep have a good reproductive system with a relatively high birth rate. This facilitates the process of breeding and developing sheep populations. However, it is not yet known whether there is an influence of non-genetic factors (parity and birth type) on reproduction (liiter size, lambing interval, birth weight, and weaning weight) of Garut sheep. Therefore, this study aims to determine the relationship of non-genetic factors on reproductive traits of Garut ewes. The total number of female Garut sheep used was 327 heads with the criteria of having given birth. The results showed that the average litter size, lambing interval, birth weight, and weaning weight were 1.87 heads, 241 d, 2.73 kg, and 12.86 kg, respectively. The 3rd parity had the highest litter size and a shorter kidding interval than other parities. In addition, the type of birth also has a significant effect, namely the number of kids triple effect on the long lambing interval. Non-genetic factors affected the reproductive performance of Garut sheep.

Keywords: *Litter size, Parity, Garut sheep, Productivity*

Introduction

Sheep farming is a significant source of revenue for rural communities, especially in regions like Nusa Tenggara, Sumatra, and West Java. Smallholder farmers can engage in sheep breeding more easily than with large livestock like cattle because it requires comparatively less capital. Sheep can reproduce quickly, which facilitates population growth in a comparatively short amount of time. Year after year, Indonesia's sheep population keeps growing. Although regional differences exist in population growth rates, data indicates a consistent upward trend. One of Indonesia's biggest breeding grounds for sheep is Java Island, particularly West Java. With a national sheep population of 15.615,300 heads, including various sheep breeds such as arrow sheep, and an annual slaughter rate of 1,581,373 heads (Directorate General of Livestock and Animal Health Services., 2023).

Garut sheep are recognized as one of the important local genetic resources in Indonesia. They have good meat quality and strong adaptation to the local environment. Development programs for Garut sheep often focus on improving genetics and husbandry management to achieve optimal results. The productivity of Garut sheep is influenced by genetic and non-genetic factors. Genetic factors, such as genomic technology, allow us to be more specific in identifying genes or genetic markers associated with reproductive productivity. Marker-Assisted Selection (MAS) (Wijayanti *et al.*, 2023), Genotyping (Bolormaa *et al*., 2017), Genome-Wide Association Study (GWAS) (Gholizadeh and Esmaeili-Fard, 2022) are some of the methods used. However, non-genetic factors must also be considered.

Non-genetic factors such as nutrition, reproductive management, health, environment, and farmer skills play an important role in determining sheep reproductive productivity. Parity and type of birth are also classified as non-genetic factors that affect livestock reproduction, as seen from litter size, lambing interval, birth weight, and weaning weight. Female sheep tend to have a larger litter size in the second or third birth compared to the first birth (Pollesel *et al*., 2020). Low parity is associated with longer lambing intervals and lower birth weights. Higher parity is generally associated with shorter intervals between lambings and higher birth weight, though this can decrease at high parity (Dwyer, 2003; Pesántez-Pacheco *et al*., 2019). The aim of this study was to determine the effects of parity and birth type on reproductive performance such as litter size, lambing interval, and doe productivity (birth weight and weaning weight).

Materials and Methods

Animal Management

The study was carried out at the UPTD Margawati Sheep and Goat Breeding Development Centre (BPPTDK) in Sukanegla Village, Garut Kota District, Garut Regency. There were 327 ewes used, with a history ranging from one to five parities. The average body weight of a Garut sheep was 44 kg to 48 kg. The same environmental conditions apply temperatures ranging from 16 to 26^{o}C, a high altitude of 1000 m above sea level, 2020 mm of rainfall per year, and an air humidity of 85% to 95%. CV Trisila Agri Perkasa provided feed with the following specifications: minimum PK content of 14%, minimum TDN content of 60%, maximum moisture content of 14%, and no urea.

A natural mating system is used in mating management. Small flocks of animals are housed in stilt pens. Every sheep is cared for in the same way during husbandry. Eight ewes and one male mate.

Data Collection

Litter size, lambing interval, birth weight, weaning weight, parity, and type of birth were recorded with a total of 327 ewes. Litter size was obtained from the number of offspring obtained from each birth. The lambing interval was obtained from the lambing interval after the first birth of the mother. Birth weight was obtained from the first measurement of lambs at birth, and weaning weight was obtained from the measurement of the first day after weaning or when the lamb was separated from the mother for the first time. In addition, the productivity of the mother is differentiated into birth types (single, double, and triple).

Statistical analysis

The general linear model (GLM) procedure of the statistical package for service solution were used (SPSS ver 21). Data on litter size, lambing interval, doe productivity (birth weight dan weaning weight) were analyzed using a mixed model.

$$Yij = \mu + Bi + Gj + Eij$$

Where:

Yij= litter size, lambing interval, doe productivity record of the ij ewe.

μ = overall mean.

Bi= effect of the i_{th} parity number (i = 1-5)

Gj= effect of the j_{th} type of birth (j = 1-3).

Eij= random error term.

Parity and birth type were the independent variables in the model. The statistical analysis took into account the number of livestock in the flock (which was then converted to the number of livestock in ruminants) as a source of variance. In order to more accurately estimate the effects of the principal factors, a model devoid of interactions was ultimately adopted, as most interactions in unbalanced models are meaningless. The value was expressed as mean ± standard error (SE). It was determined that $p<0.01$ and $p<0.05$ were statistically significant.

Results and Discussion

Litter size

In the reproductive traits of Garut sheep, it was found that overall parity affects the number of litter sizes ($p<0.05$) ((Table 1 and Table 2). More specifically, parity 3 carries the most influence compared to other parities in determining the number of litter sizes. The highest number of litter sizes occur at the fifth parity, which is 2.21 (Kabalin *et al*., 2022). Previous research on Afec-Assaf demonstrated a significant difference between the fourth parity and litter size, with the first parity having the fewest litters (Abuzahra *et al*., 2024). Lamb dorper litter size was significantly influenced by ewe parity ($p<0.001$) and ewe lambing year ($p<0.05$) (Abebe *et al*., 2023). Litter size is substantially lower in first litters compared to subsequent litters (Pollesel *et al*., 2020). This is due to the fact that after the first or second birth, fertility rates typically rise, which raises the litter size. Higher-parity sheep may be more hormonally adapted, increasing the likelihood of multiple or even more ovulations (Hameed Ajafar *et al*., 2022; Laclef *et al*., 2023). As a result, a litter will have more kids. Multiple-time sheep are frequently in better condition when it comes to their capacity to produce more ovum and better-quality ovulation. This could lead to the fertilization of more ovum and the subsequent production of more embryos.

Table 1. Descriptive statistic for by the factor for litter size, lambing interval, birth weight, and weaning weight in Garut sheep

Reproductive traits	Descriptive statistic parameter				
	n	Mean	SD	Min.	Max.
Litter size (head)	327	1.87	0.78	1.00	4.00
Lambing interval (day)	327	241	1.62	1.00	4.00
Birth weight (kg)	327	2.72	0.64	1.00	4.00
Weaning weight (kg)	327	12.86	3.70	1.00	4.00

Note: SD: standard deviation

Table 2. Means ± standard error by the factor for litter size, lambing interval, birth weight, and weaning weight in Garut sheep

Fix factor	Sample	Litter size (head)	Lambing interval (day)	Birth weight (kg)	Weaning weight (kg)
		(Mean±SE)			
Overall	327	1.87*±0.78	241**±1.62	2.72**±0.64	12.86±3.70
Parity					
Parity 1	201	1.83 ^{bc}±0.76	370^{A}±0.01	2.59^{C}±0.60	12.60±3.72
Parity 2	94	1.94^{b}±0.84	320^{C}±0.94	2.98^{B}±0.72	13.90±3.71
Parity 3	24	2.00^{a}±0.72	244 ^{DE}±0.10	2.77^{CD}±0.51	12.24±3.36
Parity 4	6	1.67^{c}±0.51	366^{B}±0.90	3.11^{A}±0.64	12.52±4.00
Parity 5	2	2.00^{a}±0.01	287 ^{D}±0.01	2.24^{E}±0.01	11.23±1.01

Note: SE: standard error; between columns with different superscripts within the same column indicates significant differences p<0.01 (A, B) and p<0.05 (a, b) level; *: p<0.05; **: p<0.01

Type of birth also greatly affects the number of litter sizes in sheep (p<0.01), as in Table 2 that the triple birth type produces the most litter size compared to the first birth type. Sheep that have experienced several births have experience in the birthing process, so their bodies are better prepared and able to handle pregnancy better. This may contribute to the increase in litter size. Sheep that have given birth before tend to be more reproductively mature. They have reproductive organs that are better prepared and function more optimally compared to first-time lambs (Campbell *et al*., 2014; Pettigrew *et al*., 2019). Single births result in smaller litter sizes (only one litter), and they frequently happen to younger sheep or those giving birth for the first time. Genetics, nutrition, and health conditions can also influence the propensity to singletonize. This can increase the likelihood of more litters being born (Ng *et al.*, 2023; Wijayanti *et al*., 2022; Zhou, 2020). Litter size increases with multiple births. It is more common in breeds of sheep that are genetically predisposed to produce twins as well as in mature sheep with higher parity. In many farming practices, twins are the most advantageous birth type because they boost productivity (Wijayanti *et al.*, 2023).

Multiple births significantly increase litter size. Births of triplets or more usually occur in very fertile and healthy sheep, often at high parity and under optimal nutritional conditions. While multiple births increase productivity, there are also higher risks associated with ewe and kid health, including potentially higher kid mortality and additional burden on the ewe in terms of care and lactation. Overall, birth type plays a direct role in determining litter size, with twins and multiples contributing the most to increased litter size in sheep populations. However, it is also important to note that while parity can influence litter size, other factors such as genetics, nutrition, and farm management also play a significant role in determining litter size in sheep (Wijayanti *et al.*, 2023). To improve litter size and overall productivity in sheep breeding programs, further research and targeted management strategies should be implemented.

Lambing interval

The lambing interval is an important factor in determining the reproductive effectiveness of an ewe flock. Parity had a significant effect on lambing interval (p<0.01), with an average of 241 d (Table 2). Furthermore, parity 1 demonstrated a significant difference from the other parities, with the longest lambing interval of 370 d. Based on the longest lambing interval recorded after the first parity, 284 d, which was significantly longer than the lambing interval after the second through seventh parities (Kabalin *et al*., 2022). With a lambing interval duration of 244 days, parity 3 had the shortest interval. The female's body changes significantly after her first calving, particularly in terms of physiological adjustments made for giving birth and lactation. Due to the animal's body's incomplete adaptation to the hormonal and metabolic changes that take place during pregnancy and after delivery, this healing process may take longer in the first parity (Ungerfeld and Sanchez-Davila, 2012). In addition, greater stress during the first calving process can affect the reproductive system, including a delay in the return of the estrous cycle, thus prolonging the reproductive interval (Sezenler *et al*., 2016; Sinclair *et al*., 2020).

Table 3. Type of birth by the factor for litter size, lambing interval, birth weight and weaning weight in Garut sheeps

Variable	Type of birth		
	Single	Double	Triple
	(Mean±SE)		
Litter size (head)	1.00^{c}±0.01	2.00^{b}±0.01	3.00^{a}±0.01
Lambing interval (day)	297.05^{b}±1.7	277.23^{c}±1.5	327.41^{a}±1.7
Birth weight (kg)	3.26^{A}±0.51	2.43^{B}±0.41	2.09^{C}±0.35
Weaning weight (kg)	16.42±2.34	10.68± 2.31	9.86±2.09

Note: SE: standard error; between columns with different superscripts within the same line indicates significant differences p<0.01 (A, B) and p<0.05 (a, b) level.

Based on Table 3, type of birth significantly influenced the length of lambing interval (p<0.05). The ewes with triple birth type had the longest lambing interval (327.41 d) compared to single (297.05 d) and double birth types (277.23 d). This is because more than two births place a greater physiological burden on the ewe. This can lead to an extended period of postpartum anestrus (infertile period after giving birth), which can affect the lambing interval. Previous findings showed that the overall lambing interval was 9.36 mo (Abebe *et al*., 2023). This small variation suggests that genetic factors may play a role in determining the time interval between

subsequent births. When comparing the results of lambing interval with this study, which is only 327.41 d faster than that of the previous study in local sheep (9.01 mo) (Abebe *et al*., 2023). Environmental factors, management practices, and local conditions can affect the duration between births.

Ewe Productivity

Birth weight. Based on the results of the study, it was found that overall parity had a significant effect on birth weight of 2.72 kg (Table 1 and Table 2). The 4th parity (3.11 kg) showed the highest birth weight compared to other parities (Table 2). In multiparous sheep (sheep that have given birth more than once), the birth weight of lambs tends to be higher. The body of the sheep is more adapted to the gestation process, and the uterus can provide better nutrition for the growth of the foetus. Lambs that have given birth for the first time (primiparous) usually give birth to lambs with a lower birth weight than lambs that have given birth several times. This may be because the sheep's body has not fully adapted to pregnancy and the birthing process. Ewes with two lambs exhibit significantly more suckling behavior than ewes with one lamb in the first 3 d after parturition (Wang *et al*., 2021), affecting birth weight. Hormones such as progesterone and estrogen that are important for fetal development are usually more stable and regular at higher parities, thus supporting optimal fetal development (Wang *et al*., 2024).

According to the differences in type of birth (Table 3), there was a significant difference in birth weight. The single birth had the highest birth weight (3.26 kg) when compared to the double and triple births (2.43 kg and 2.09 kg). Single-born lambs typically weigh more than twins or multiple births. This is because single lambs receive more nutrients from their mothers than foetuses who share the placenta in multiple births (Abecia and Palacios, 2018). Lambs carrying triplets had the smallest birth weight (2.09 kg); this may be because lambs carrying triplets may be under higher physiological stress, which could reduce the ability of the mother to provide adequate nutrition for all foetuses. Lambs born to ewes with multiple pregnancies only showed a slightly greater average daily weight gain than lambs with single pregnancies (Pesántez-Pacheco *et al*., 2019; Raoof and Balisany, 2016).

Weaning weight. The results of the analysis showed that overall there was no significant effect of parity differences on weaning weight of Garut sheep (Table 1 and Table 2). However, the birth weight of Garut sheep met the normal limit. The normal birth weight of sheep generally ranges from 2.5 to 5.5 kg (Málková *et al*., 2021). Under ideal environmental and managerial circumstances, disparities might not have a major impact. An important factor in lamb growth is genetics. Weaning weight will be more influenced by genetic factors than by the number of prior births if the sheep has better growth genes (Brien *et al*., 2014). In addition, parity may affect the milk production of the mother; the increase in milk production after a certain parity may not be significant enough to affect weaning weight significantly. Lactation factors and the length of the lactation period are more influential.

Birth type in Garut sheep also had no overall effect on weaning weight ($p>0.05$) (Table 3). Genetic factors also play an important role. Good genetics can allow lambs to grow optimally, regardless of birth type. Overall, although birth type may influence birth weight, factors such as feed management, health, and genetics may be more dominant in determining weaning weight, making weight differences due to birth type insignificant at weaning. The single birth type had a higher weaning weight (16.42 kg) than the double and triple birth types (10.68 kg and 9.86 kg). Foraging behavior was significantly lower in twin-born lambs compared to single-born lambs on day 7 postpartum (Erichsen, 2022). Grooming behaviour was significantly higher in single and twin lambing ewes on postpartum day 0 compared to postpartum day 1 to 7 (Fazio *et al*., 2016). This is what makes the Single birth type have a heavier weaning weight than the others.

Conclusion

Non-genetic factors had a significant influence on the variation in reproductive performance of the sheep included in the study. Specifically, parity 3 had the highest effect on litter size, short lambing interval, and birth weight, while the birth of type factor in triple births had the highest effect on litter size, long lambing interval, and birth weight.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Author’s contribution

The authors confirm their contribution to the paper as follows: Formal analysis, Software,

Investigation, Writing - original draft, Writing - review and editing: DW; Resources: NFFI, ADD; Formal analysis, Software, Writing - review and editing : DW, FA, NF; Data Curation: DW; Supervision, Conceptualization, Validation, Project administration, and Writing - review and editing: DW

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