

Non genetic analysis on reproductive traits of Garut sheep

Khoffatuzzahro Khoffatuzzahro¹, Raziah S. Wahyuni¹, Efani Gustia¹, Febby R.N. Rury², Asep Gunawan^{1*}

¹Department of Animal Production and Technology, Faculty of Animal Science, IPB University, Bogor 16680, West Java, Indonesia.

²Unit of the Margawati Garut Sheep and Goat Development Center, Garut 44111, West Java, Indonesia.

ARTICLE INFO

Received: 23 September 2025
Accepted: 05 November 2025

*Correspondence:

Corresponding author: Asep Gunawan
E-mail address: agunawan@apps.ipb.ac.id

Keywords:

Garut sheep, Non genetic, Reproductive traits

ABSTRACT

The influence of non-genetic factors on the reproductive traits of sheep is used as the basis of information to design the sustainability of Garut sheep development. Reproductive traits is key factor of productify and efficiency of Garut Sheep. The aim of this study was to analyze non genetic factors on reproductive traits of Garut sheep in Unit of the Margawati Garut Sheep and Goat Development Center (UPTD BPPTDK) Margawati. Reproductive traits data from 4,246 Garut lambs were collected at UPTD BPPTDK Margawati during the period 2021–2024. The reproductive traits analyzed included litter size, preweaning mortality, and pregnancy rate. These data were obtained from 1,703 Garut ewes, 53 Garut rams, and 2,490 Garut lambs. Non genetic factors examined included year, type of birth, seasons, and parity. The reproductive traits data were analyzed using Univariate General Linear Model (GLM). Year had significantly ($P < 0.01$) impact on preweaning mortality rates and pregnancy rates and had significantly ($P < 0.05$) effects on litter size. Parity significantly ($P < 0.01$) influenced pregnancy rates. Type of birth significantly ($P < 0.01$) affected preweaning mortality rates. Season did not have a significant effect ($P > 0.05$) on litter size, preweaning mortality, and pregnancy rate. All non genetic factors except seasons affects on reproductive traits in Garut sheep. It can be concluded that analyzing non-genetic factors affecting the reproductive traits of Garut sheep can provide valuable insights for improving management practices and developing more effective sheep breeding programs.

Introduction

Sheep constitute an essential segment of Indonesia's livestock sector, supporting both meat production and the rural economy. In Indonesia, sheep are generally classified into three main groups: Javanese Thin-Tailed Sheep, Garut Sheep (also known as Priangan Sheep, native to West Java), and Javanese Fat-Tailed Sheep. Among these, Garut sheep a native germplasm of West Java have been selectively developed into a leading livestock commodity. Their primary advantages include high fecundity and strong adaptability to local environmental conditions (Dudi *et al.*, 2023). Garut sheep exhibit rapid reproduction and are recognized for their prolificacy, often giving birth to more than one lamb per parturition. This reproductive trait supports accelerated population growth within a short timeframe. According to data from the Indonesian Central Statistics Agency (BPS, 2024), the total sheep population in Indonesia has reached 9,219,176 head, with West Java accounting for 6,971,877 head, or approximately 75.62% of the national total. This reflects the dominant role of West Java, particularly Garut sheep, in the country's sheep farming industry.

Garut sheep regarded as superior local genetic resources in Indonesia, productive traits are focused on the quality of meat, besides their easy adaptability to local environmental conditions. Garut sheep have a good quality of meat which contains high levels of polyunsaturated fatty acids (PUFA) relative to thin-tailed and fat-tailed sheep. This component is among the most sought after meat attributes for consumers (Gunawan *et al.*, 2018). However sometimes population growth within a short timeframe. According to data from the Indonesian Central Statistics Agency (BPS, 2024), the total sheep population in Indonesia has reached 9,219,176 head, with West Java accounting for 6,971,877 head, or approximately 75.62% of the national total. This reflects the dominant role of West Java, particularly Garut sheep, in the country's sheep farming industry productivity is influenced by both genetic and non-genetic factors.

Non-genetic, or environmental factors influence gene expression that can impact the phenotypical variation in the animal or the expression of some attributes can vary due to the environmental changes experienced by populations (Virolainen *et al.*, 2022). Therefore some key environmental variables that impact reproductive traits are year, parity, type of birth, and lambing season (Ajafar *et al.*, 2022). It has been noted that ewes have better litter sizes within their second or third parity compared to their first parity (Pollesel *et al.*, 2020). Garut sheep typically have an average litter size of 2.1 lambs a parturition, and therefore they are considered to be prolific (Lusi *et al.*, 2022). Unfortunately, Garut sheep have relatively high mortality among twins at up to 15.38% (Somanjaya, 2017). Improving the productivity of Garut sheep, reproductive efficiency must be improved by improving reproductive management (Ashari *et al.*, 2018). Reproductive efficiency can be evaluated in terms of pregnancy rate, which declines as more age-based reproductive efficiency factors are considered.

Reproductive traits are key drivers of efficiency, productivity, and profitability in livestock production (Mamutse *et al.*, 2023). Breeding for improvement of reproductive traits relies on quantifying the effects of non-genetic factors (Uttam *et al.*, 2023). However, there is a considerable knowledge gap regarding the effects of environmental factors on the reproductive traits of Garut sheep. Given the need for an assessment of these non-genetic factors to support efforts for developing and improving the genetic quality of this useful breed is needed.

Materials and methods

Breed Description and Data Collection

Garut sheep are a native Indonesian breed, with much phenotypic variation. For example coat color variations include solid white, solid black, and solid brown to various combinations of colors. This breed is characterized by two distinct ear lobe morphotypes: short ear lobes/

rumpung (<4 cm) and long ear lobes /ngedaun hiris (4–8 cm). Typically, this breed has a convex facial profile which is a distinctive morphological credential. Rams exhibit horns of variable length. Data were collected from the recorded reproductive performance data of 4,246 Garut sheep at the Unit of the Margawati Garut Sheep and Goat Development Center for the period from 2021–2024. The reproductive traits analyzed included litter size, preweaning mortality, and pregnancy rate, based on records from 1,703 heads Garut ewes, 53 heads Garut rams, and 2,490 head Garut lambs. From the recapitulated data on livestock population structure, several non-genetic factors were identified and analyzed, including year, season, parity, and type of birth.

Definition of variable

Litter size is the number of offspring born per ewe during a single parturition (Notter *et al.*, 2017).

Preweaning mortality is the count of the lamb deaths that died until the lamb is weaning (100 days).

Pregnancy rate refers to the proportion of ewes that become pregnant within in a given breeding cycle (Putri *et al.*, 2021).

Analysis of data

The reproductive traits analyzed included litter size, preweaning mortality, and pregnancy rate.

Preweaning mortality rate (%) = (No. of Lambs That Died Before Weaning)/(Total No of lambs born) × 100%.

Pregnancy rate (%) = ((No of Pregnant Ewes)/(No of Mated Ewes) × 100%).

Data recording from Microsoft Excel and then processed using SPSS software. Data analysis in this study used the General Linear Model (GLM) to determine the effect of non-genetic factors (year, season, parity, and birth type) on reproductive traits (litter size, preweaning mortality, and pregnancy rate) (Mamutse *et al.* 2023). The model was as follows:

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$$

Y_{ij} : the reproduction traits or observation;

μ : mean;

α_i : the effect of non-genetic factor;

ε_{ij} : the random error associated with the observation.

The further tests of comparison of means were done using Tukey's method.

Results

Reproductive performance

Reproductive performance in Garut sheep, characterized by traits such as litter size, preweaning mortality, and pregnancy rate, plays a pivotal role in determining the biological and economic efficiency of sheep production systems. The litter size of Garut sheep in this study was 1.47 ± 0.02 lambs. The pre-weaning mortality rate of Garut sheep in this study was $12.53 \pm 0.62\%$. Pregnancy rates of Garut sheep in this study was $72.45 \pm 1.08\%$. The results descriptive analysis reproductive traits of Garut sheep including litter size, preweaning mortality, and pregnancy rate are presented in Table 1.

Table 1 Descriptive statistics of reproductive traits.

Variable	N	Mean±SE	Min	Max
Litter size	1703	1.47 ± 0.02	1	3
Mortalitas pra sapih (%)	1703	12.53 ± 0.62	0	100
Pregnancy rate (%)	1626	72.45 ± 1.08	0	100

SE= Standar error; Min= Minimal; Max= Maximal



Fig 1. Characteristics of Garut Sheep a) Garut ram. b) Garut ewe. c) Garut lamb.

Reproductive traits of Garut sheep as affected by non-genetic factor

Year had significant effect ($P < 0.05$) on reproductive traits litter size, and a had highly significant effect ($P < 0.01$) on pre weaning mortality and pregnancy rate. The year 2021 has the lowest litter size and pregnancy rate values, and has the highest preweaning mortality value. Based on the results of the study, the value of litter size, preweaning mortality, and pregnancy rate changes along with better maintenance management every year.

Type of birth had highly significant ($P < 0.01$) on preweaning mortality, triplets had the highest preweaning mortality rate compared to the single-birth type. Twins and triplets showed higher preweaning mortality values than single-birth type.

Parity had highly significant effect ($P < 0.01$) on pregnancy rate, Parity 6 and 7 showed the lowest pregnancy rate. The highest pregnancy rate was shown in parity 0. Parity had no effect ($P > 0.05$) on litter size and preweaning mortality

Season did not have a significant effect ($P > 0.05$) on litter size, preweaning mortality, and pregnancy rate. The value of litter size, preweaning mortality, and pregnancy rate had the same value in the rainy season as well as the dry season.

Table 2. Non genetic analysis on reproductive traits of Garut sheep.

Factor	Reproductive traits		
	LS±SE	M±SE(%)	PR±SE(%)
Year			
2021	1.40 ± 0.03^b	18.55 ± 1.55^a	56.40 ± 2.26^b
2022	1.43 ± 0.03^{ab}	8.19 ± 1.03^b	74.48 ± 2.83^a
2023	1.51 ± 0.03^a	12.97 ± 1.20^b	80.57 ± 1.72^a
2024	1.51 ± 0.03^a	11.27 ± 1.13^b	80.39 ± 2.25^a
Type of Birth			
1	-	5.92 ± 0.80^c	-
2	-	11.60 ± 1.10^b	-
3	-	33.07 ± 2.27^a	-
Parity			
0	-	-	81.67 ± 2.24^a
1	1.51 ± 0.03	16.45 ± 1.46	75.59 ± 2.20^{ab}
2	1.50 ± 0.04	12.96 ± 1.34	72.46 ± 2.41^{ab}
3	1.42 ± 0.03	9.73 ± 1.39	67.51 ± 3.05^{ab}
4	1.46 ± 0.04	10.84 ± 1.61	72.99 ± 3.38^{ab}
5	1.48 ± 0.04	12.58 ± 1.86	57.76 ± 4.61^{ab}
6	1.44 ± 0.06	12.65 ± 2.44	53.36 ± 6.70^b
7	1.34 ± 0.07	10.00 ± 3.12	
8	1.45 ± 0.14	6.89 ± 5.72	
Season			
Wet	1.47 ± 0.02	11.41 ± 0.89	71.31 ± 1.65
Dry	1.47 ± 0.02	11.40 ± 0.87	73.46 ± 1.45

M= Preweaning mortality; PR= Pregnancy rate; LS= Litter size; SE= Standar error; Means with different superscripts in the same column indicate significant differences ($P < 0.05$)

Discussion

The year of birth had a significant effect on litter size ($P < 0.05$), notably increasing from 2021 to 2024. The litter size of Garut sheep in this study was lower than that of other sheep breeds, such as thin-tailed sheep with a litter size of 1.82 lambs, fat-tailed sheep with 1.61 lambs, Adilo sheep with 1.52 lambs, and Afec sheep - Asec sheep at 181 lambs (Jayadi and Jan, 2024; Abuzahra *et al.*, 2024; Deribe *et al.*, 2014; Najmuddin and Nasich, 2019). Some similar results have been reported for other sheep breeds, such as Saint Croix Hair Sheep and Doyogena Sheep, in which year of birth also significantly affected litter size (Dávila *et al.*, 2015; Habtegiorgis *et al.*, 2022). The increase in litter size over the years may be the result of improvement in husbandry and feeding management, but may also represent other contributing influences, such as disease outbreak (Assan, 2020). In 2021, selection based on breeding females was not solely based on body weight, but included the history of female and offspring birth years, both of which were also related to improved fertility rates and litter sizes. In general, birth-types of dams shows repeatability across parities, which supports selective breeding practices. Also during this year adjustments were made to their feeding and improvements to both the quantity and quality of feed.. Pratama and Siswoyo. (2024) stated that the quantity of feed offered to female sheep provided adequate nutrition to enhance ovulation rates, and in turn the number of offspring per litter. Nonetheless, identification of inefficiencies related to livestock record-keeping during 2021 and 2022 may have affected data integrity specifically, for the recording of the total litter size. It was important to report on all aspects of sheep production to promote management practice evaluations and to guide and highlight productivity challenges (Pari, 2018). Therefore, the benefits of good and improved data record-keeping may have contributed to the reported annual increase in total litter size..

Parity and season did not affect litter size significantly ($P > 0.05$). These results are consistent with Mamutse *et al.* (2023), who found that in small ruminants managed in intensive systems, litter size is not affected by seasonal variation. Undoubtedly the ubiquitous availability of feed and nutrition, regardless of rainy or dry seasons, eliminated any effect of season (Assan, 2020). In addition, since the Garut ewes did not vary by birth type in litter size construction over parity due to proportioned distributions. Therefore, factors such as good management and health practices employed contributed to the consistency in breeding performance over seasons and across parities

Prewaning mortality was significantly affected by the year of birth ($P < 0.01$) during the period from 2021 to 2024, with the highest pre-weaning mortality of 18.55% for the year of birth 2021 and decreases each year thereafter (2022–2024). Similar year effects for pre-weaning mortalities have been reported in other sheep breeds namely Dorper, Menz, and Avikalin sheep (Besufkad *et al.*, 2024; Gowane *et al.*, 2018). Prewaning mortality in this research was lower than Yankasa sheep, which was 33% (Butswat *et al.*, 2021). This annual variability of pre-weaning mortality could suggest yearly changes in either multiple ewes management or health, climatic, or recordkeeping by the farmers (Assan, 2020). Higher mortality In 2021 may have contributed by disruptions of feed supply by administrative health management of ewes from the COVID-19 pandemic. The nutritional deficiencies within ewes have likely reduced milk production during this period, and therefore possibly lead to lamb nutrients reducing pre-weaning mortality. Improvements were made in feed management from 2021 to 2024 by firstly quality, then quantity, and subsequently final both improvements collectively. In 2024, management improvement to ewes that birthed three or more lambs followed best management practices to remove one lamb, and provide separate out for rearing the lamb separately to ensure lamb was consistently obtaining an input of milk as required. According to Setiawan *et al.* (2023), competition for milk between multiple lambs can reduce nutrient intake, decrease immunity, and increase the chance of mortality. Therefore, specific interventions such as lamb separating lambs, represent efforts to increase lamb

survival and subsequently pre-weaning mortality.

Prewaning mortality was also higher in twin and multiple births compared to singletons, which corroborates findings from Fesseha *et al.*, (2023), who found that triplet births exhibited the highest mortality due to reduce birth weights and the limited supply maternal milk supply. Increased competition for suckling in the event of multiple births may lead to increased nutritional deficiencies and increased mortalities. Twins have the lowest birth weight compared to singletons (Sveinbjörnsson *et al.*, 2021). Low birth weight in lambs is a major factor contributing to pre-weaning mortality (Kenyon *et al.*, 2008). It is suspected that lambs with lighter birth weights have lower competitiveness compared to lambs with heavier birth weights (Morel *et al.*, 2008). An increase in birth weight is accompanied by a decrease in preweaning mortality (Everett-Hincks & Dodds., 2008).

In contrast, parity and season had no significantly effect on pre-weaning mortality ($P > 0.05$). This lack of effect is likely due to uniformity in birth type distribution across parity levels (Yolanda *et al.*, 2022) and consistent feed quality and composition provided throughout the year, regardless of season. Consequently, milk production and lamb nutritional intake remained relatively stable across parities and seasons, resulting in no observable variation in preweaning mortality.

The year factor had a highly significant effect on the pregnancy rate of Garut sheep ($P < 0.01$). From 2022 to 2024, pregnancy rates were notably higher compared to 2021, which recorded the lowest value across the observed period. The pregnancy rate in 2021 was also lower than reported by Nurrochman *et al.* (2023) with pregnancy rates of Garut which was 64.26%. Variations in pregnancy rates across years may be attributed to differences in environmental conditions and management practices. Notably, changes in feed management began in 2021 with the introduction of molasses mineral blocks (MMB) to meet the macro and micro-mineral requirements of the flock. Adequate mineral supplementation plays a critical role in reproductive success; deficiencies in selenium and vitamin E have been linked to spermatozoa mortality, thereby reducing fertility (Widhyari *et al.*, 2015). In addition, zinc (Zn), a key trace mineral, supports reproductive function by regulating the secretion of gonadotropin-releasing hormone (GnRH); its deficiency may impair reproductive performance. Fluctuations in pregnancy rates from year to year can attributed to yearly variation in climatic conditions (Gunawan *et al.*, 2011). The increasing pregnancy rates from 2021 to 2024 likely demonstrate ongoing improvements in ewe management and the success of selection strategies implemented during that time frame. The selection strategy used likely included both body condition and reproductive history.

Parity was also found to affect pregnancy rates ($P < 0.01$), consistent with results performed by Fadillah (2014), that reproductive performance is affected by parity level. Ewes in parity levels 1 to 3 demonstrated optimal reproductive capacity, while those in parity 6 and 7 exhibited the lowest pregnancy rates. This decline is likely due to age-related reductions in muscle tone, bone strength, and tissue function, which negatively impact reproductive ability (Murti, 2014). Interestingly, parity 0 representing ewes bred for the first time showed the highest pregnancy rate, consistent with results from Khan *et al.* (2024), who found a high conception rate among primiparous females. The overall trend of declining pregnancy rate with increasing parity underscores the need for early replacement of older breeding stock to maintain reproductive efficiency.

Season did not significantly affect pregnancy rate ($P > 0.05$). This finding differs from that of Arroyo (2011), who observed increased estrus activity and fertilization rates in Peliubey ewes during the rainy season, likely due to higher humidity. However, at the present study site, environmental conditions and nutritional adequacy were maintained consistently throughout the year, which likely mitigated seasonal effects. The application of nutritional flushing implemented before and after parturition played a role in enhancing reproductive outcomes. Flushing, through improvements in feed quality and quantity, provides additional nutrients that support reproductive hormone synthesis. Adequate nutrition during

the flushing phase promotes follicular development and maturation via the action of follicle-stimulating hormone (FSH) and luteinizing hormone (LH), ultimately facilitating ovulation (Rohmah *et al.*, 2017). The results suggested that the consistent implementation of flushing strategy on a year-round basis accounts for the lack of seasonal variation in pregnancy rates.

Conclusion

All non genetic factors except seasons affect reproductive traits. Year, parity, and birth of type influence the reproductive traits by affecting litter size, pregnancy rate and preweaning mortality in Garut sheep at UPTD BPPTDK Margawati. Identification of non-genetic factors as an effort to strengthen the breeding system at UPTD BPPTDK Margawati with precision, accuracy, realtime updates, and sustainability. It can be concluded that analyzing non-genetic factors affecting the reproductive traits of Garut sheep can provide valuable insights for improving management practices and developing more effective sheep breeding programs.

Acknowledgments

Acknowledgement and appreciation to the Margawati Garut Sheep and Goat Development Center for granting us permission to use their animals in this study.

Conflict of interest

The authors have no conflict of interest to declare.

References

- Abuzahra, M., Wijayanti, D., Effendi, M., Mustofa, I., Eid, L., 2024. Estimate the effect of non-genetic factors on the reproductive traits of Afec-Assaf strain in Bani Naim Farm, Palestine. *J. Ilmu Ternak Vet.* 29, 9–15.
- Ajafar, M.H., Kadhim, A.H., Al-Thuwaini, T.M., 2022. The reproductive traits of sheep and their influencing factors. *Rev. Agric. Sci.* 10, 82–89.
- Arroyo, J., 2011. Reproductive seasonality of sheep in Mexico. *Trop. Subtrop. Agroecosyst.* 14, 829–845.
- Ashari, M., Suhardiani, R.A., Andriati, R., 2018. Analisis efisiensi reproduksi domba ekor gemuk di Kabupaten Lombok Timur. *J. Ilmu Teknol. Peternak.* Indones. 4, 207–213.
- Assan, N., 2020. Aspects of litter size (birth type) in goats and sheep production. *Sci. J. Zool.* 9, 138–151.
- Besufkad, S., Aschalew, A., Getachew, T., Goshme, S., Bisrat, A., Abebe, A., Zewdie, T., Alemayehu, L., Kebede, A., Gizaw, S., 2024. Survival analysis of genetic and non-genetic factors influencing lamb survival of different sheep breeds. *Small Rumin. Res.* 232, 1–8.
- Butswat, I., Osinowo, O., Adegbola, T., Mbat, S., 2021. Influence of birth weight, year and parity on preweaning mortality in Yankasa sheep. *Niger. J. Anim. Prod.* 22, 120–124.
- BPS, 2024. Badan Pusat Statistik: Populasi Domba menurut Provinsi (Ekor). <https://www.bps.go.id/id> (Accessed 25 July 2025)
- Dávila, S.F., Barragán, B.H., Rivas, P.G., Gonzáles, D.B., Armijo, A.S.V., Torres, J.L.R.A., 2015. Environmental factors and ram influence litter size, birth, and weaning weight in Saint Croix hair sheep under semi-arid conditions in Mexico. *Trop. Anim. Health Prod.* 47, 825–831.
- Deribe, G., Abebe, G., Tegegne, A., 2014. Non-genetic factors influencing reproductive traits and pre-weaning mortality of lambs and kids under smallholder management, Southern Ethiopia. *J. Anim. Plant Sci.* 24, 413–417.
- Dudi, D., Rahmat, D., Herawati, E., 2023. Efek diluar genetik pada sifat pertumbuhan prapah domba Garut pemeliharaan intensif. *J. Anim. Husb. Sci.* 7, 58.
- Everett-Hincks, J.M., Dodds, K.G., 2008. Management of maternal behaviour to im-

- prove lamb survival in easy care sheep systems. *J. Anim. Sci.* 86, 259–270.
- Fadillah, R., Suharyati, S., Hartono, M., 2014. Pengaruh paritas terhadap persentase estrus dan kebuntingan pada sapi Bali. *J. Ilm. Peternak. Terpadu* 2, 35–38.
- Fesseha, H., Gebremichael, G., Kebede, I., Beriso, T., 2023. Study on incidence of lamb morbidity and mortality and associated risk factors in the mixed crop-livestock production system of Gewata District, Kaffa zone, southwestern Ethiopia. *Anim. Dis.* 3, 11.
- Gowane, G.R., Swarnkar, C.P., Prince, L.L.L., Kumar, A., 2018. Genetic parameters for neonatal mortality in lambs. *Livest. Sci.* 210, 85–92.
- Gunawan, A., Anggreli, D., Listyarini, K., Abuzahra, M., Jakaria, Yamin, M., Inounu, I., Sumantri, C., 2018. Identification of single nucleotide polymorphism and pathway analysis of Apolipoprotein A5 (APOA5) related to fatty acid traits in Indonesian sheep. *Trop. Anim. Sci. J.* 41, 165–173.
- Gunawan, A., Sari, R., Parwoto, Y., Uddin, M.J., 2011. Non-genetic factors affecting reproductive performance and preweaning mortality in artificially and naturally bred Bali cattle. *J. Indones. Trop. Anim. Agric.* 36, 83–90.
- Habtegiorgis, K., Haile, A., Getachew, T., Jimma, A., Gemiyo, D., 2022. Litter size and lamb survivability in Doyogena sheep. *Heliyon* 8, e11576.
- Jayadi, S., Jan, R., 2024. Study fenotip dan litter size bibit domba ekor gemuk di Kabupaten Lombok Timur. *i-SAPI J.* 1, 1–7.
- Kenyon, P.R., Morris, S.T., Burnham, D.L., West, D.M., 2008. Effect of nutrition during pregnancy on hogget pregnancy outcome and birthweight and liveweight of lambs. *N.Z. J. Agric. Res.* 51, 77–83.
- Khan, M., Ahmad, E., Oneeb, M., Husnain, A., Yousuf, M.R., 2024. Factors influencing pregnancy rate and loss after laparoscopic artificial insemination with frozen-thawed semen in Lohi sheep under sub-tropical conditions. *Reprod. Domest. Anim.* 59, 1–7.
- Lusi, D., Yurmiati, H., Ramdani, D., 2022. Pengaruh sistem pemeliharaan terhadap produktivitas induk domba Garut. *J. Prod. Ternak Terapan* 3, 73–79.
- Mamutse, J., Susanto, A., Purwantini, D., Sumaryadi, M.Y., Subagyo, Y., Sodik, A., 2023. Non-genetic factors affecting reproductive traits of Saanen goats. *J. Agric. Rural Dev. Trop. Subtrop.* 124, 129–135.
- Morel, P.C.H., Morris, S.T., Kenyon, P.R., 2008. Effects of birth weight on mortality in triplet-born lambs. *Aust. J. Exp. Agric.* 48, 984–987.
- Murti, T.W., 2014. Ilmu Manajemen dan Industri Ternak Perah. Pustaka Reka Cipta, Bandung.
- Najmuddin, M., Nasich, M., 2019. Produktivitas induk domba ekor tipis di Desa Sedan, Kecamatan Sedan, Kabupaten Rembang. *Ternak Trop. J. Trop. Anim. Prod.* 20, 76–83.
- Notter, D.R., Mousel, M.R., Lewis, G.S., Leymaster, K.A., Taylor, J.B., 2017. Evaluation of Rambouillet, Polypay, and Romanov–White Dorper × Rambouillet ewes mated to terminal sires in an extensive rangeland production system: Lamb production. *J. Anim. Sci.* 95, 3851–3863.
- Nurrochman, T.R., Falahudin, A., Somanjaya, R., 2023. Perubahan status energi pada induk domba Garut. *Trop. Livest. Sci. J.* 2, 21–28.
- Pari, A.U.H., 2018. Pemanfaatan recording untuk meningkatkan manajemen ternak kerbau. *J. Sain Peternak.* Indones. 13, 20–28.
- Pollesel, M., Tassinari, M., Frabetti, A., Fornasini, D., Cavallini, D., 2020. Effect of does parity order on litter homogeneity parameters. *Ital. J. Anim. Sci.* 19, 1189–1195.
- Pratama, R., Siswoyo, P., 2024. Evaluasi hasil IB domba lokal. *J. Cakrawala Ilm.* 3, 9.
- Putri, C.D., Ismudiono, Poetranto, E.D., 2021. The effect of different artificial insemination time periods on the pregnancy rate of Sapudi ewes. *World Vet. J.* 11, 469–473.
- Rohmah, N., Ondho, Y., Samsudewa, D., 2017. Pengaruh pemberian pakan flushing dan non flushing terhadap intensitas birahi dan angka kebuntingan induk sapi potong. *J. Sain Peternak.* Indones. 12, 290–298.
- Setiawan, D., Santosa, S.A., Candrasari, D.S., 2023. Profil Kambing Kejobong. *J. Ilm. Ilmu-Ilmu Peternak.* 26, 124–137.
- Somanjaya, R., Heriyadi, D., Hernaman, I., 2017. Performa domba lokal betina dewasa pada berbagai variasi lamanya penggembalaan di daerah irigasi Rentang Kabupaten Majalengka. *Indones. J. Appl. Sci.* 7, 37–43.
- Sveinbjörnsson, J., Eythórsdóttir, E., Örnólfsson, E.K., 2021. Factors affecting birth weight and pre-weaning growth rate of lambs from the Icelandic sheep breed. *Small Rumin. Res.* 201, 1–5.
- Uttam, V., Patel, D., Purohit, P., Sunwasiya, D.K., Pathak, A., Shetkar, M., Sagolsem, S., 2023. Non-genetic factors in Indian cattle. *Pharma Innov. J.* 12, 1541–1544.
- Virolainen, S.J., VonHandorf, A., Viel, K.C.M.F., Weirauch, M.T., Kottyan, L.C., 2022. Gene–environment interactions and their impact on human health. *Genes Immun.* 24, 1–11.
- Widhyari, S.D., Esfandiari, A., Wijaya, A., Wulansari, R., Widodo, S., Maylina, L., 2015. Penambahan Zn dalam pakan terhadap kualitas spermatozoa. *J. Ilmu Pertanian.* Indones. 20, 72–77.
- Yolanda, Y., Suwarno, N., Arifin, J., 2022. Hubungan bobot lahir dengan bobot sapih domba Garut jantan dan betina pada berbagai tipe kelahiran di UPTD-BPPTDK Margawati Garut. *J. Produksi Ilmu Terapan* 4, 12–27.