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MORPHOLOGICAL INDICES: DISTINGUISHING SINGLE AND TRIPLETS-BEARING BOER AND ETAWA GRADE GOATS IN LOMBOK BARAT

Indeks Morfologi: Membedakan Kambing Boer dan Etawah Beranak Tunggal dan Kembar Tiga di Lombok Barat

Abyadul Fitriyah*, Yuni Mariani, Ni Made Andry Kartika, Nefi Andriana Fajri, Alimuddin, Ria Harmayani

Fakultas Peternakan, Universitas Nahdlatul Wathan Mataram, Jl. Kaktus 1-3 Kota Mataram, NTB 83125

*Email: abyadulfitriyah@gmail.com

ABSTRACT

This study aimed to identify female goats with the potential to give birth to triplets by examining morphological characteristics correlated with FSH and LH hormone levels in the blood. It included four triplet-bearing Boer goats and four triplet-bearing Etawah grade goats, each with 12 kids, and four single-bearing Boer goats and four single-bearing Etawah grade goats, each with four kids. Morphological indices of body sizes, including weight, height slope, length index, width slope, depth index, foreleg length, and hormone levels, were observed. A t-test and descriptive analysis were conducted. The average body size of Boer goats was larger than Etawah grade goats, but there were no significant morphological differences between triplet-bearing Boer and Etawah grade goats. However, single-bearing Boer goats had a significantly higher height slope than single-bearing Etawah grade goats. FSH levels significantly increased in the blood of triplet-bearing Boer goats compared to single-bearing Boer goats. Morphological indices and hormone levels can help select goats likely to give birth to triplets.

Keywords: *Boer goat, Etawah goat, Morphological indices, Single-Bearing, Triplet-Bearing*

ABSTRAK

Penelitian ini bertujuan untuk mengidentifikasi kambing betina yang berpotensi melahirkan anak kembar tiga dengan memeriksa karakteristik morfologi yang berkorelasi dengan kadar hormon FSH dan LH dalam darah. Penelitian ini melibatkan empat kambing Boer yang melahirkan anak kembar tiga dan empat kambing Etawah yang melahirkan anak kembar tiga, masing-masing dengan 12 anak, dan empat kambing Boer yang melahirkan tunggal dan empat kambing Etawah yang melahirkan tunggal, masing-masing dengan empat anak. Indeks morfologi ukuran tubuh, termasuk berat, kemiringan tinggi, indeks panjang, kemiringan lebar, indeks kedalaman, panjang kaki depan, dan kadar hormon, diamati. Uji-t dan analisis deskriptif dilakukan. Rata-rata ukuran tubuh kambing Boer lebih besar daripada kambing Etawah, tetapi tidak ada perbedaan morfologi yang signifikan antara kambing Boer yang melahirkan anak kembar tiga dan kambing Etawah. Namun, kambing Boer yang melahirkan tunggal memiliki kemiringan tinggi yang secara signifikan lebih tinggi daripada kambing Etawah yang melahirkan tunggal. Kadar FSH meningkat secara signifikan dalam darah kambing Boer yang melahirkan anak kembar tiga dibandingkan dengan kambing Boer yang melahirkan tunggal.

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Indeks morfologi dan tingkat hormon dapat membantu memilih kambing yang kemungkinan besar akan melahirkan anak kembar tiga.

Kata kunci: Beranak Tunggal, Beranak Kembar Tiga, Indeks Morfologi, Kambing Boer, Kambing Etawah

INTRODUCTION

In order to improve genetic quality, goat breeding and selection are essential. An ideal goat breed is characterized by optimal body shape, as determined by morphological indices. Goat productivity is significantly influenced by litter size or twin births type. Breeders often prefer goats capable of producing twins, as twin births not only fetch higher market prices but also increase meat consumption and enhance farmer welfare. The genetic factors influencing twinning can serve as valuable criteria for assessing an animal's genetic potential, highlighting the need for further research in this area. Morphological measurements are effective indicators of livestock traits and productivity (Kumar et al., 2018).

Research indicated a positive correlation between body weight and size of livestock and birth type (Kurniawati et al., 2019). The occurrence of twins in goats are attributed to various factors, including abnormalities in the secretion of reproductive hormones such as FSH, LH, and estrogen, or abnormal zygote cell division.

The South African-bred Boer goat is well known for producing large amounts of meat. After 120 days, a well-chosen adult Boer buck can weigh between 100 and 120 kilograms, with a 29 kg weaning weight (Tarigan et al., 2018). According to Athey et al. (2020), Boer goats typically gain between 203 and 245 grams per day after birth, with a birth weight that ranges from 3.9 to 4.0 kilograms. Because of these qualities, Boer goats are being used in crossbreeding programs in several nations, including Indonesia to utilized and enhance genetic traits (Sulastri, 2006; Cai et al., 2022).

The Etawah Grade goat is notable for its distinct physical features, such as a crest on the forehead and nose, black or brown hair on the head and neck, wattles, small horns, and long, outwardly curved ears. These goats typically have a chest circumference of 15 to 50 cm and a body height of 60 to 120 cm. They have a lifespan of up to 12 years and a fertility period ranging from 2 to 8 years (Mulydi, 2022). It is noteworthy that Etawah Grade goats, with a gestation period of 150-154 days, can yield triplets in a single pregnancy. Four months is when sexual maturity is reached, but for best results, breeding usually starts at twelve months (Wiyanto and Putra, 2020).

There is still much to learn about the possible effects of applying the hereditary characteristic of twinning in goats to increase domestic meat production. The purpose of this study is to collect baseline data regarding the impact of twinning on female goat productivity and reproductive performance, with a focus on Boer and Etawah goats breeds. The selection index method, which utilizing linear body size measurements in livestock breeding. Body size is a reliable indicator of livestock productivity and should reveal information about the genetic potential of the animals. By using morphological identification correlated with blood levels of the hormones FSH and LH, the purpose of this study is to identify female goats who may become triplet mothers. This identification enhances goat breeding by promoting the development of desired reproductive traits and superior genetic potential.

MATERIALS AND METHODS

Ethical approval

The Nahdlatul Wathan Mataram University Animal Ethics Committee with the Number 015/PDKN/LPPM/UNW/VII/2022 approved the experimental protocols.

Study period and location

Six months, from May 2022 to October 2022, were dedicated to the research and data collection period. Desa Omde, Kecamatan Kediri, Lombok Barat, Nusa Tenggara Barat as the study's location (Figure 1).

Figure 1. The study's location (temperature, humidity, and qualitative evaluation of performance)

Animals

This study included four groups of goats: (1) four Boer goats each bearing triplets with totaling 12 kids; (2) four Boer goats each bearing a single kid with totaling four kids; (3) four Etawah grade goats each bearing triplets with totaling 12 kids; and (4) four Etawah grade goats each bearing a single kid with totaling four kids.

Feeding

All goats, including the Etawah Grade Goats, were fed a diet that was identical in terms of its nutritional makeup. The nutrients included in the feed are listed in Table 3 and included field grass, mango (Mangifera indica), banana (Lannea coromandelica), gamal (Gliricidia sepium) leaves, Ketapang (Terminalia catappa), Turi (Sesbania grandiflora), Jackfruit (Artocarpus heterophyllus), and Lamtoro (Leucaena leucocephala). The diet was fed at 7 a.m. and 4 p.m. and consisted of fresh forage equal to 10% of the goats' daily body weight (4-5 kg for moms and 1-2 kg for kids). Water was available to them at all times.

Experimental design

Quantitative performance was evaluated on all Boer goats and Etawah grade goats, moms and kids alike, utilizing physical characteristics such as weight, length, wither height, chest width, depth, and circumference; also including hip height and width. The morphological indices for the body sizes were weight (W), Slope of Height (HS), **Index of Length (LI), Slope of Width (WS)**, depth index (DI), **Front leg length (FL)**, balance (B), and cumulative index (CI) of the Boer and Etawah Grade Goats. In addition, the ELISA technique was used to measure the concentrations and patterns of these reproductive hormones by analyzing the levels of the hormones FSH and LH in the lab. Additionally, measurements of the temperature and humidity of the feed were made, and the nutritional content of the feed was examined.

Measurements

1. Quantitative performance measurement

Utilizing a digital thermometer, a measuring stick, a measuring tape, and a scale with a precision of 0.01 centimeters each, the following qualitative performance metrics are measured:

a. A body weight scale capable of holding 100 kg is used to measure body weight (Dias et al. 2020).
b. The measurement of body length is obtained by measuring the distance in centimeters between the tuber humerus and tuber ischiadicus.
c. The measurement of wither height is made in centimeters, starting from the distance (in centimeters) between the back of the olecranon and the highest point of the spinosus vertebrae thoracalis.
d. Measurement of chest circumference: cm, taken directly behind the olecranon.
e. The measurement of chest depth is the length of time (in centimeters) between the top withers and the bottom breastbone.
f. The measurement of chest width is the distance (in centimeters) behind the shoulder blades, in the space between the left and right ribs.
g. The measurement of hip height is the distance in centimeters from the top of the tuber coxae to the ground.
h. The measurement of hip width is derived from the centimeters between the outer corners of the groin or the distance between the tuber coxae.
i. Rump height, measured from the top of the rump to the bottom of the real dastern using a measuring stick (cm) (Dige et al. 2022; Sonjaya 2013).
j. To take the body temperature, a rectal thermometer was inserted into the rectum and left there for about a minute. According to Hereng et al. (2019), the thermometer will show a figure that corresponds to the temperature of the goats' bodies.

2. The morphological index calculation

The goats' physical dimensions was ascertained by calculating the morphological index using the following formula, which was suggested by Salako (2006) and Alderson (1999):

a. Weight (W) is equal to Body length (cm) x Chest circumference (cm) x [(Width (cm) + (Width (cm)) / 2].
b. Wither height (cm) – Rump height (cm) = Height Slope (HS)
c. Body length (cm) / Wither height (cm) equals the length index (LI).
d. Hip width (cm) / Chest width (cm) equals the width slope (WS)
e. Depth Index (DI) = Wither height (cm)/ Chest depth (cm)
f. Foreleg Length (FL) = Chest depth (cm)-Wither height (cm)

To determine the livestock's reproductive hormone secretion and concentration pattern (FSH and LH), blood specimens were obtained from the goats' jugular veins using a tube containing anticoagulant (Ma et al. 2018). Goat blood is extracted and vortexed for ten minutes at 3,000 rpm. The resulting red serum is then removed and kept in a plastic 1.5 ml tube (evendof), which is then kept at -200C until every LH and FSH hormone (via RIA kit) are analyzed using the ELISA technique (Yin et al. 2018).

3. Measurements of feed and nutrient intake

The kinds and caliber of feed components used in animal rations are examined in the Nutrition and Animal Feed Science Laboratory at the University of Mataram's Faculty of Animal Husbandry were analyzed (by means of proximate analysis) as follows:

a. The feed was dried at 60˚C in an oven and then again at 105˚C to determine the dry matter (DM) (Despal et al., 2022).
b. The following procedures were used to test the content of Ash: The porcelain dish is first dehydrated in an oven set at 105°C for approximately an hour. It is then cooled for 15 minutes in a desiccator before being weighed (Hasrianti et al. 2022).
c. Using the Kjeldahl technique to measure crude protein (CP), and the Soxhlet method was used to extract ether extract (EE) (Despal et al., 2022).
d. The feed was broken down in an alkaline and base solution before the crude fiber (CF) was examined. The previously mentioned proximate component (DM, ash, CP, EE, and CF) was examined in accordance with AOAC (2005). The Despal et al. (2022) equation was used to compute the total digestible nutrient (TDN).

Monitoring the humidity and temperature both inside and outside the cage each three hours, beginning at 6 a.m. for first day and at nine in the morning, for the second, the temperature and humidity were recorded. Over the course of a month, these measurements were made. The height of the cattle's hips was used to measure the air inside the cage, and the building's roof was used to measure the air outside.

Data analysis

To compare the birth of triplets and singles of Boer goats with Etawah grade goats, as well as the offspring from both breeds, a 0.05 significance level t-test was utilized (Mishra et al., 2019). Descriptive analysis of the data was also performed. The t-test formula was as follows:

Note: $$t = \frac{\overline{X}_1 - \overline{X}_2}{S\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

In the first data set, x̄1 represents the average value, and in the second, x̄2 represents the average value.

The first data set's number of data is n1, and the second data set's number of data is n2.

S stands for standard deviation or variance.

RESULTS AND DISCUSSION

Results

The data provided in Figure 2 compares the average reproductive performance and physical characteristics of single-bearing and triplet-bearing Boer goats. The variables included are body mass (kg), body length (cm), height at withers (cm), chest circumference (cm), chest depth (cm), chest width (cm), hip height (cm), hip width (cm), rump height (cm), temperature (°F), age (years), follicle-stimulating hormone (FSH) (mIU/ml), and luteinizing hormone (LH) (mIU/ml).

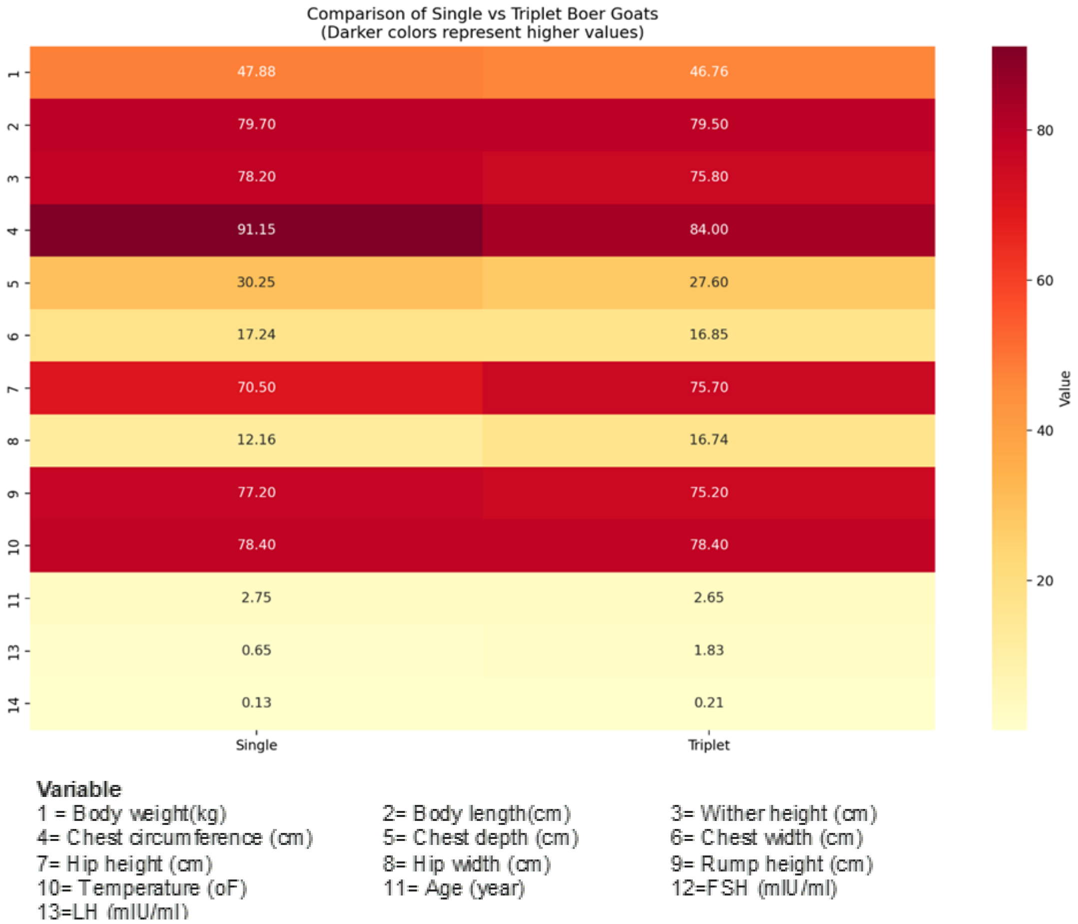

Figure 2. The heatmap of Single vs Triplet Boer Goats

Based on Figure 2.; 1). Single Boer goats tend to have larger chest measurements (circumference, depth, and width), 2). Triplet Boer goats have higher and wider hips, 3). Body weight, length, and wither height are similar between the two groups, 4). Triplet goats have significantly higher FSH levels, which might be related to their multiple birth status, 5). Other measurements like temperature, age, and LH levels are similar between the groups.

These differences could be due to genetic factors or developmental differences related to single vs. triplet births. The larger chest in single goats might indicate better lung capacity or heart function, while the wider hips in triplet goats could be an adaptation for carrying multiple fetuses. The higher FSH levels in triplet goats might be associated with their increased fertility.

Body Weight: Single-bearing goats have an average body weight of 47.88 kg, while triplet-bearing goats weigh slightly less at 46.76 kg. The body weight of single-bearing goats and triplet-bearing goats is not significantly different, as indicated by the p-value greater than 0.05. This implies that the number of offspring doesn't significantly affect on the body weight of the goats. The body weight is similar between the two groups.

Body Length: The average body length is 79.70 cm for single-bearing goats and 79.50 cm for triplet-bearing goats. P>0.05 indicates that there is no substantial difference. Similar to body weight, body length does not indicate a slight difference between the two groups, demonstrating that the birth type does not affect the body length of the goats.

Wither Height: Single-bearing goats have a wither height of 78.20 cm compared to 75.80 cm for triplet-bearing goats. The p-value (P>0.05) indicates not much of a difference. The height at the withers is not influenced by whether the goat is single-bearing or triplet-bearing.

Chest Circumference: There is a significant difference in chest circumference. Single-bearing goats have a larger chest circumference (91.15 cm) compared to triplet-bearing goats (84.00 cm), with a significant p-value (P≤0.05). This could imply that single-bearing goats have more robust body structures, possibly due to less energy and nutrient allocation to multiple fetuses.

Chest Depth and Width: A significant difference is also observed in chest width. Both chest depth (30.25 cm vs. 27.60 cm) and chest width (17.24 cm vs. 16.85 cm) are greater in single-bearing goats, with significant p-values (P≤0.05), indicating notable differences in chest dimensions.

Hip Height: Triplet-bearing goats have a higher hip height (75.70 cm) compared to single-bearing goats (70.50 cm), with a significant p-value (P≤0.05).

Hip Width and Rump Height: Single-bearing goats have a smaller hip width (12.16 cm) compared to triplet-bearing goats (16.74 cm), and a higher rump height (77.20 cm vs. 75.20 cm), both with significant p-values (P≤0.05).

Temperature and Age: Both groups have the same average temperature (78.40°F) and similar ages (2.75 years for single-bearing and 2.65 years for triplet-bearing), with p-values (P>0.05) indicating no significant differences.

Follicle-Stimulating Hormone (FSH): Triplet-bearing goats have significantly higher FSH levels (1.83 mIU/ml) compared to single-bearing goats (0.65 mIU/ml), with a significant p-value (P≤0.05). This suggests that higher FSH levels may be associated with the ability to bear triplets, as FSH is crucial for follicular development and ovulation.

Luteinizing Hormone (LH): LH levels are slightly higher in triplet-bearing goats (0.21 mIU/ml) compared to single-bearing goats (0.13 mIU/ml), but the p-value (P>0.05) indicates that this difference is not statistically significant.

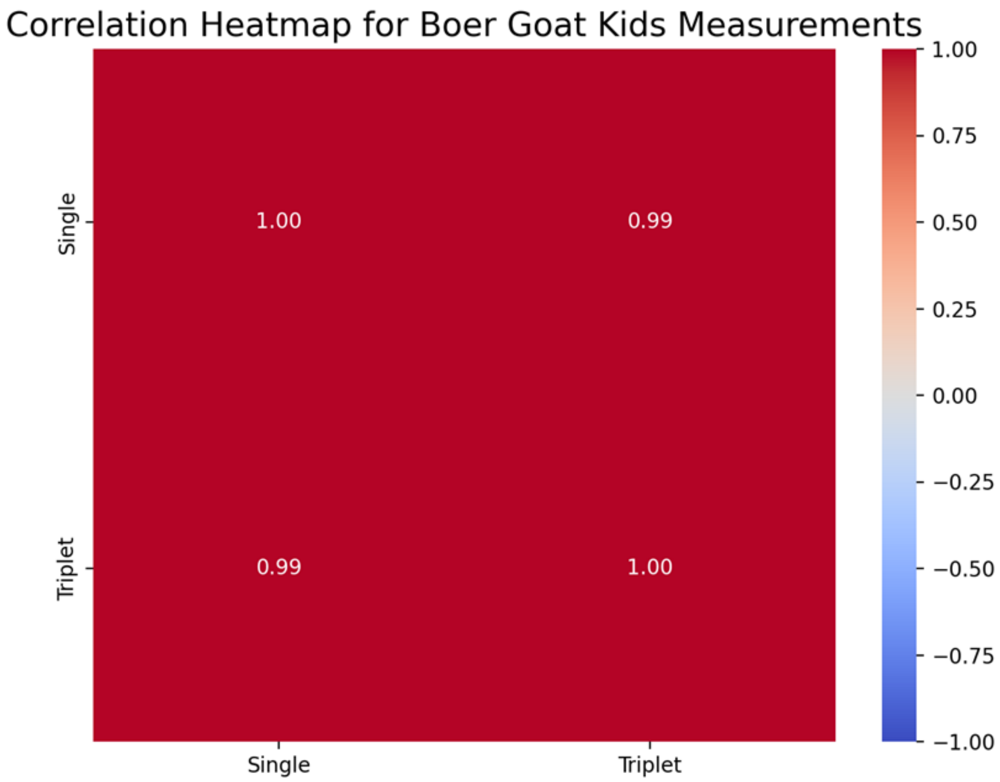

Figure 3. The The heatmap of Single vs Triplet Boer Goats kids

Figure 3 and 4 shows a visual comparison of various measurements between single and triplet Boer goat kids. The graph also indicates some small values for measurements that might represent different data types (e.g., hormone levels) not easily comparable on the same scale as body measurements. Statistical significance of these differences is not shown.

Based on Figure 3, the correlation matrices are not meaningful or not significant. This is different from what is shown in the graph, although the difference is not significant.

This graph provides a visual comparison of various measurements between single and triplet Boer goat kids. Here's a brief interpretation of the results: 1). Body weight (kg): Single kids appear to be slightly heavier than triplets, 2). Body length (cm): Single kids are slightly longer than triplets, 3). Wither height (cm): Interestingly, triplets seem to have a slightly greater wither height than singles, 4). Chest circumference (cm): Single kids have a larger chest circumference compared to triplets, 5). Chest depth (cm): Single kids have a slightly greater chest depth than triplets, 6). Heart girth (cm): Single kids have a larger heart girth compared to triplets.

The graph also shows some measurements with very small values, which might represent different types of data (e.g., blood parameters or hormone levels) that were originally in the dataset but are not easily comparable on the same scale as the body measurements. This graph doesn't show the statistical significance of these differences.

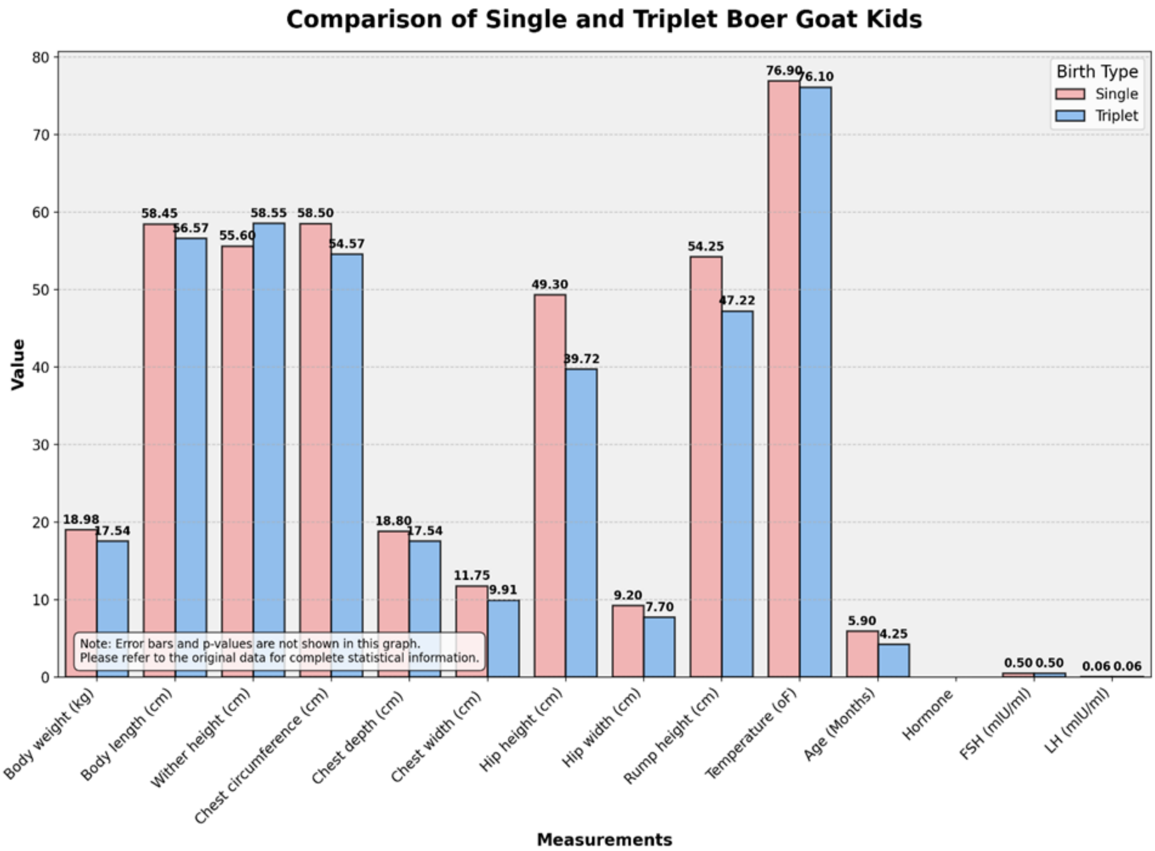

Figure 4. The comparison of single and triplet Boer goat kids

Figure 5 compares the reproductive performance and physical characteristics of single-bearing and triplet-bearing Etawah goats.

The data provided in Figure 5 compares the average reproductive performance and physical characteristics of single-bearing and triplet-bearing Etawah goats.

Figure 5 shows a significant difference ($P < 0.05$) in body weight and FSH hormone levels between single-bearing and triplet-bearing Etawah grade goats. The goats with triplet births had higher body weight and FSH hormone levels compared to those with single births. Specifically, the body weight was 40.83±10.10 kg for triplet-bearing goats versus 37.20±4.67 kg for single-bearing goats, and the FSH level was 1.53±0.08 mIU/ml for triplet-bearing goats versus 0.72±0.09 mIU/ml for single-bearing goats.

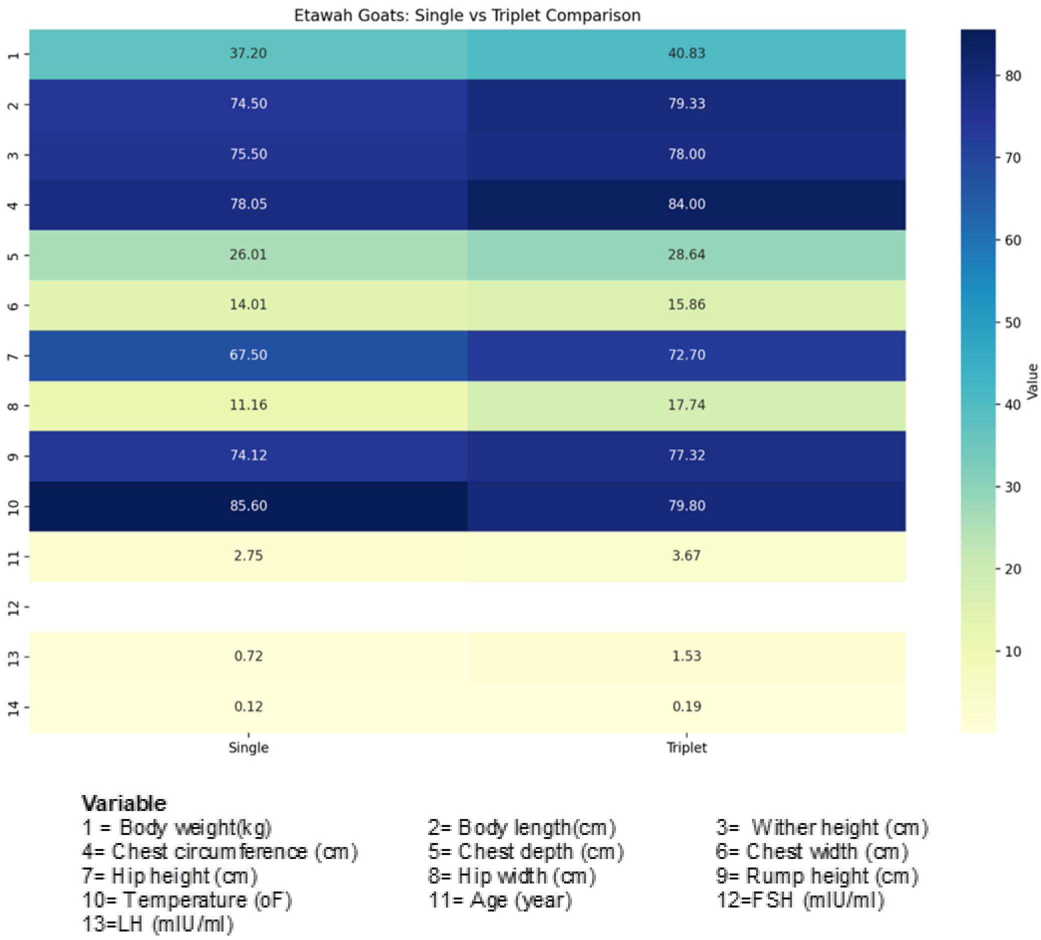

Figure 5. The heatmap of Single vs Triplet Etawahh Goats

Based on Figure 5.; 1). Triplet Etawahh goats are generally larger than single Etawahh goats, with significant differences in body weight, chest circumference, and hip measurements, 2). The most striking difference is in hip width, which could be an adaptation for carrying multiple fetuses, 3). Triplet Etawahh goats have a lower body temperature, which is an interesting finding that might warrant further investigation, 4). The age difference is significant, with triplet goats being older on average. This could potentially influence some of the other measurements, 5). The higher FSH levels in triplet goats might be associated with their increased fertility and ability to produce multiple offspring. These differences could be due to genetic factors, developmental differences related to multiple births, or adaptations for carrying multiple fetuses

Figure 5 indicates that there are no significant differences in body length, height at withers, chest depth, and chest width between single-bearing and triplet-bearing Etawah cross goats of similar age. The measurements for these traits are as follows: body-length (74.50±3.54 cm vs. 79.33±4.93 cm), height at withers (75.50±0.71 cm vs. 78.00±3.46 cm), chest-depth (26.01±2.25 cm vs. 28.64±2.48 cm), and chest-width (14.01±3.10 cm vs. 15.86±3.40 cm). However, there are significant differences ($P \leq 0.05$) between single-born and triplet-born Etawah goats in terms of body weight, chest measurement, hip-height, hip-width, and FSH hormone levels. The measurements for these traits are: body weight (37.20±4.67 kg vs 40.83±10.10 kg), chest measurement (78.05±4.24 cm vs 84.00±3.46 cm), hip-height (67.50±3.12 cm vs. 72.70±3.21 cm), hip-width (11.16±2.12 cm vs. 17.74±2.09 cm), and FSH hormone levels (0.72±0.09 mIU/ml vs. 1.53±0.08 mIU/ml).

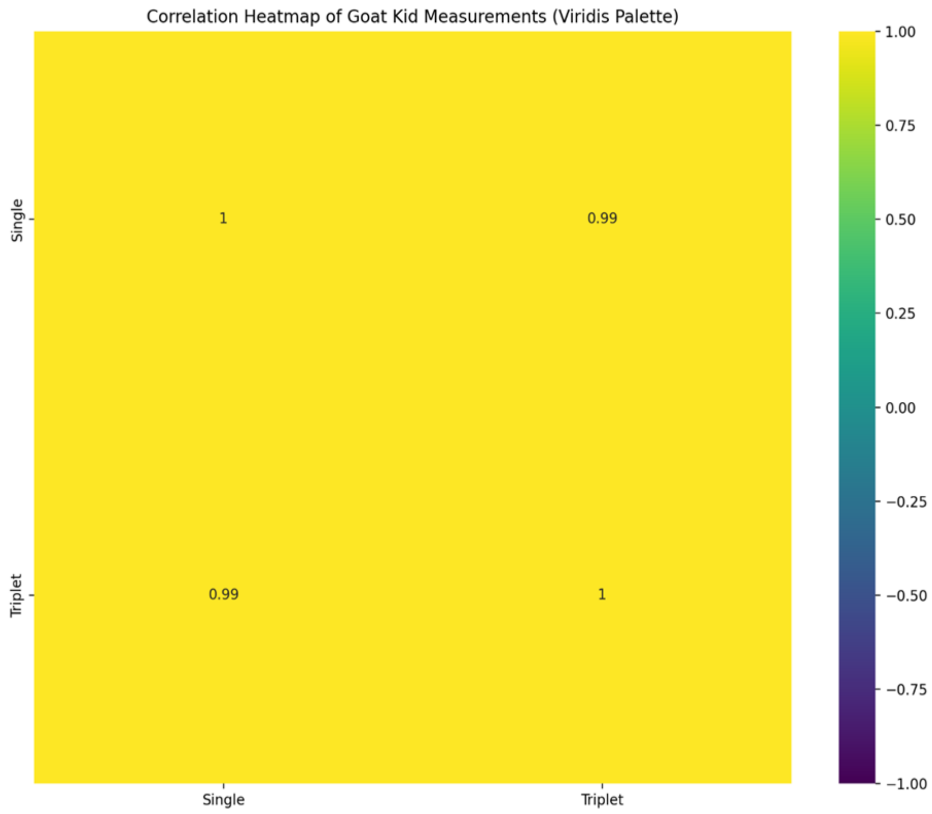

Figure 6. The heatmap of Single vs Triplet Etawahh Goats Kids

The correlation heatmap shows the correlation between the measurements for Single and Triplet goat kids. The correlation coefficient is 1, which indicates a perfect positive correlation. This means that the relative differences in measurements between Single and Triplet kids are consistent across all variables.

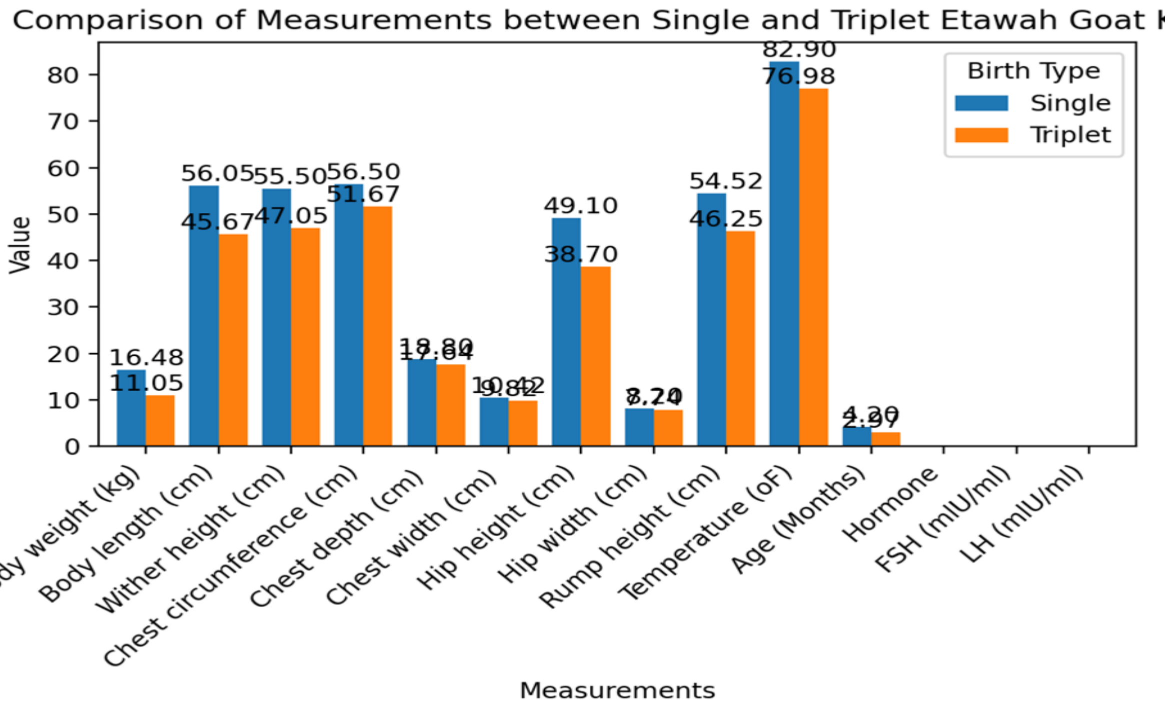

Figure 7. The comparison of single and triplet Etawah goat kids

Figure 7 shows that single goat kids generally have larger body measurements across all variables compared to triplet kids. Significant differences are noted in body weight, body length, and hip height. Chest measurements show smaller differences compared to other parameters.

Based on Figure 7. Single goat kids consistently have higher measurements across all variables compared to Triplets kids. The most significant differences appear to be in body weight, body-length, and hip-height. Chest-width and hip-width show the smallest absolute differences between Single and Triplets kids.Body weight: Single kids (16.48 kg) are significantly heavier than Triplet kids (11.05 kg). Wither height and Hip height: Single kids have greater heights in both measurements. Chest measurements (circumference, depth, and width) show smaller differences between Single and Triplet kids compared to other measurements.

The data suggests that Single kids generally have larger body measurements compared to Triplet kids, which could be due to factors such as nutrition distribution during gestation or competition for resources among multiple fetuses, more nutrients available per fetus during gestation for Single kids, less competition for resources in the womb for Single kids, and potentially longer gestation periods for Single kids.

Table 1 shows that the morphological indices for weight, height slope, length index, and width slope in Boer goats with single and triplet births were significantly different (P≤0.05). The average height slope index is equal to 1 in single-bearing goats and less than 1 in triplet-bearing goats.

Tabel 1. Morphological index of Boer goats with singlet and triplet offspring

Variable	Type of Birth		p-value	Significance
	Single	Triplet		
Weight (W)	106790.81	112157.01	P≤0.05	Significant
Slope of Height (HS)	1	0.6	P≤0.05	Significant
Index of Length (LI)	0.9680	1.048812	P≤0.05	Significant
Slope of Width (WS)	0.7053	0.993471	P≤0.05	Significant
Depth Index(DI)	0.3868	0.364116	P>0.05	Not Significant
Front leg length (FL)	47.95	48.2	P>0.05	Not Significant

In Table 1, the average height slope index is more than 1, and there is no significant difference (P>0.05) between the morphological index of Boer goat kids born as singles and triplets.

Table 2. Morphological index of Boer goat kids born single and triplet

Variable	Boer goat kids (Birth)		p-value	Significance
	Single	Triplet		
Weight (W)	34107.77	49325.15	P≤0.05	Significant
Slope of Height (HS)	1.35	1.33	P>0.05	Not Significant
Index of Length (LI)	1.051259	1.00041	P>0.05	Not Significant
Slope of Width (WS)	0.855814	0.87790	P>0.05	Not Significant
Depth Index(DI)	0.338129	0.361277	P>0.05	Not Significant
Front leg length (FL)	36.8	31.01	P>0.05	Not Significant

Table 3 shows that the morphological indices for weight, Slope of Height, Index of Length, and Slope of Width in single-bearing and triplet-bearing Etawah Grade goats were significantly different (P≤0.05). Additionally, the average Slope of Height index was greater than 1 in single-bearing goats and less than 1 in triplet-bearing goats.

Table 3. Morphological index of Etawah goats with singlet and triplet offspring

Variable	Birth Type		p-value	Significance
	Single	Triplet		
Weight (W)	73178.31	111950.49	P≤0.05	Significant
Slope of Height (HS)	1.38	0.68	P≤0.05	Significant
Index of Length (LI)	0.986755	1.017051	P≤0.05	Significant
Slope of Width (WS)	0.796574	1.118537	P≤0.05	Significant
Depth Index(DI)	0.344503	0.3671795	P>0.05	Not Significant
Front leg length (FL)	49.49	49.36	P>0.05	Not Significant

Table 4 shows the morphological index of Etawah grade goat kids between single and triplet birth types does not differ significantly (P >0.05), and the average height slope index is less than 1.

Table 4. Morphological index of Etawah grade goat kids born single and triplets

Variable	Etawah grade goat kids (Birth)		p-value	Significance
	Single	Triplet		
Weight (W)	299483.14	20718.77	P≤0.05	Significant
Slope of Height (HS)	0.98	0.8	P>0.05	Not Significant
Index of Length (LI)	1.00991	0.97067	P>0.05	Not Significant
Slope of Width (WS)	0.786948	0.788187	P>0.05	Not Significant
Depth Index(DI)	0.338739	0.374920	P>0.05	Not Significant
Front leg length (FL)	18.80	29.41	P>0.05	Not Significant

Weight (W): The weight of single-born kids is significantly higher than that of triplet-born kids, as indicated by the p-value of ≤0.05. This suggests that single-born kids may have better growth conditions in utero compared to triplets.

Slope of Height (HS), Index of Length (LI), The width slope (WS), Index of Depth (DI), Length of Foreleg (FL): These morphological indices show no significant difference between single and triplet births, as all p-values are greater than 0.05. This indicates that these physical characteristics are relatively consistent regardless of birth type.

Discussion

Observational Findings on Goat Production Performance

Boer goats typically have larger bodies than Etawah grade goats. Significant variations in hip and chest measurements were observed between single-bearing and triplet-bearing Boer and Etawah grade goats (Adi et al., 2021). Additionally, the study revealed that Boer goats exhibited higher average daily weight gain compared to Etawah grade goats in both single-bearing and triplet-bearing groups. These findings suggest that Boer goats may have superior growth potential compared to Etawah grade goats in a commercial production setting. Further research is needed to explore the underlying factors contributing to these performance differences between the two breeds.

This suggests that genetics play a role in hip size, which positively correlates with body weight and chest circumference. The hip (height and breadth) and chest (circumference, depth, and width) measurements of triplet-bearing Boer and Etawah grade goats were substantially greater (P≤0.05) than those of single-bearing goats. These results suggest that genetic factors play a significant role in determining the growth potential of Boer and Etawah grade goats. Additionally, the mode of delivery may also impact the development of these physical characteristics. Further investigation into the specific genes and environmental factors influencing hip and chest size could provide valuable insights for breeders looking to improve the performance of their goats in a commercial setting. Ultimately, understanding these underlying factors could lead to more efficient breeding practices and increased productivity in goat farming operations. For example, researchers could study the expression of genes related to bone development in Boer and Etawah grade goats to better understand how they contribute to hip and chest size. Additionally, comparing the growth patterns of goats born via natural birth versus caesarean section could reveal the impact of delivery method on physical characteristics. However, it is important to consider that genetic factors are not the only determinants of bone development and body size in goats. Environmental factors such as nutrition, housing conditions, and overall management practices also play a significant role in shaping the physical characteristics of goats (Adi et al., 2021). Therefore, solely focusing on gene expression may not provide a comprehensive understanding of how to improve goat performance in commercial settings.

A comprehensive understanding of the variables affecting goat development necessitates taking into account both hereditary and environmental factors. Researchers may learn a lot about how to maximize the health and productivity of goats by examining the interplay between genetics and environmental variables. To maintain the general welfare and profitability of goats in commercial operations, genetic selection combined with appropriate management practices will ultimately be required. The reason for this could be that triplet-bearing Etawah goats, especially in their reproductive age range of two to five years, have hip bones that grow more quickly than average. According to Cho et al. (2020), spirulina maintains calcium balance and supports puberty by increasing the action of parathyroid hormone, which also works with FSH and LH. So, the hip bone of a sexually mature individual reaches its full potential in terms of strength and growth.

This can have significant implications for the overall health and reproductive success of the goat, as well as its ability to produce high-quality offspring. In addition, genetic selection for traits such as increased milk production, meat quality, and disease resistance can further enhance the profitability of goat farming operations. By combining genetic selection with proper management practices, goat farmers can maximize the potential of their herds and ensure long-term success in the industry.

Boer and Etawah grade goat kids show no significant differences in body size between single-born and triplet-born at similar ages. Reproductive hormone levels influence body dimensions like chest and hip size, influencing female goats' femininity and fertility. Chest and hip measurements can determine femininity.

These physical characteristics are important considerations for goat farmers looking to improve their breeding programs and overall herd performance (Bertolini et al.2018). By selecting traits that contribute to better meat quality and reproductive success, farmers can ensure the long-term sustainability of their operations. Additionally, monitoring hormone levels and body measurements may provide valuable insights into the selection of goats that have the potential to produce triplets. For example, a goat farmer may choose to breed a female goat with larger chest and hip measurements in order to increase the likelihood of producing offspring with desirable traits. By focusing on these physical characteristics, farmers can selectively breed goats that are more likely to have successful pregnancies and higher fertility rates. This targeted approach can lead to improved herd performance and increased profitability for the farmer.

Gajarajulu et al. (2016) and Kiapour et al. (2020) highlighted that hip bones form part of the pelvic structure, closely associated with the abdominal and uterine cavities. A larger abdominal and uterine cavity is necessary for triplet-bearing female goats, correlating with reproductive hormone levels in the blood. Sulastri et al. (2020) discovery that twin-bearing Saburai goats had a wider hip (18.75 ± 1.02 cm) than parturient Saburai goats (12.23 ± 2.41 cm) lends credence to this. According to Poddar et al. (2018), female Black Bengal goats had an inner pelvic diameter of 12.09 ± 0.12 cm, which was larger than the males' diameter of 11.47 ± 0.26 cm. According to Sutiyono et al. (2006), body length and hip width in goats can predict the type of parturition. According to Steininger and Braun (2012), cows have a wider pelvis than bulls, reflecting functional differences. The hip bone, comprising the ilium, ischium, and pubis, varies in size between sexes (Ghosh et al. 2013; Bartolotta et al. 2021).

Numerous studies align with the findings of this research. For instance, Sulastri et al. (2020) discovered that the hip width of twin-bearing Saburai goats (18.75 ± 1.02 cm) was significantly larger ($P \leq 0.05$) compared to parturient Saburai goats (12.23 ± 2.41 cm). Similarly, Poddar et al. (2018) reported that the inner pelvic diameter of female Black Bengal goats (12.09 ± 0.12 cm) exceeded that of their male counterparts (11.47 ± 0.26 cm). Sutiyono et al. (2006) further suggested that body length and hip width are predictive indicators of parturition type in goats. Anatomically, the hip bone's dimensions differ between bulls and cows, with cows possessing a broader pelvis (Steininger and Braun, 2012). The hip bone comprises three sections: the ilium, ischium, and pubis. The ilium, a triangular bone, is positioned craniolaterally in the pelvis, while the ischium forms the caudal part of the pelvic floor, and the smaller pubic bone constitutes the cranial section (Ghosh et al., 2013; Bartolotta et al., 2021).

These studies show that there are significant differences in pelvic dimensions between male and female goats, as well as between goats with the potential to produce triplets. Variations in pelvic size and shape may play a significant role in predicting litter size in these animals. Understanding these anatomical differences may help in developing better management practices to ensure successful breeding. Further research into the relationship between pelvic dimensions and litter size may provide valuable insights for livestock practices.

The bigger hip width seen in goats that were carrying triplets in this study matches what was found in studies of Saburai and Black Bengal goats, which were 12.23 ± 2.41 cm and 12.09 ± 0.12 cm, respectively (Sulastri et al., 2020; Poddar et al., 2018). Poddar et al. (2018) state that the hip width of Black Bengal goats was discovered by measuring the space between the coxae nodules. Regression analysis showed that factors such as age, body weight, hip height, and hip breadth have a significant impact on the size of the litter in female Black Bengal goats. Goats with a litter size bigger than 1.65, a tuber coxa distance greater than 11.38 cm, and a neck length greater than 22.78 cm had a three times higher chance of producing twins (Haldar et al., 2014).

While measuring Saburai and Black Bengal goats, they came in at 12.23 ± 2.41 cm and 12.09 ± 0.12 cm, which is in line with the wider hip width seen in goats that are pregnant with triplets in this study (Sulastri et al., 2020; Poddar et al., 2018). According to Poddar et al. (2018), measuring the distance between the coxae nodules allowed researchers to determine the hip width of Black Bengal goats. Regression analysis demonstrated that factors like age, body weight, hip height, and hip breadth have a significant impact on the size of the litter in female Black Bengal goats. Twins are three times more likely to be born in goats with a litter size greater than 1.65, tubercle spacing greater than 11.38 cm, and neck length greater than 1.65. These findings suggest that hip width and other physical characteristics play a significant role in determining litter size in Black Bengal goats. The study highlights the importance of considering these factors when breeding goats to increase the likelihood of twins being born. By understanding the relationship between hip width and litter size, researchers and breeders can make more informed decisions to improve goat productivity and overall health. Further research in this area could provide valuable insights into goat reproductive biology and help optimize breeding strategies for increased efficiency.

The study found no discernible variation in body length between Boer and Etawah grade goats that were single-bearing and those that were triplet-bearing. Body length is a crucial metric for estimating meat production and predicting the likelihood of twin births in female goats and sheep. The correlation between a female goat's body length and her abdominal area allows for the estimation of multiple births. Cattle with extended body lengths possess larger abdominal cavities, which support the survival of multiple offspring (Aitken-Palmer et al., 2017). According to Kurniawati et al. (2019), the type of parturition affects the body dimensions of Bligon goats, such as body length and hip height; single-bearing Bligon goats exhibit smaller and lower body weights than twin-bearing ones.

Figures 2, 3, and 4 display the observational data on the productivity levels of the Boer goats, specifically their reproductive performance. Similarly, Figures 5, 6, and 7 display the reproductive performance statistics for goats of Etawah grade. According to this study, goats born as triplets and singletons differ significantly in age. In particular, the age of Etawah Grade goats was 4.20±1.41 versus 2.97±1.03), while the age of Boer goat babies was recorded as 5.90±1.99 vs. 4.25±1.09).

Although it had no effect on the morphological index, it was discovered that the age of the goats correlated with their body size. The age of the goats was strongly correlated with an increase in body size. In contrast to goats born in triplets, certain single-born goats did not exhibit a significant difference (P > 0.05) in body size, especially when it came to chest circumference, chest depth, chest width, and hip width. The youngsters' continued growth is responsible for this lack of a discernible difference, as their body sizes and growth rates fluctuate. It is expected that variations in body size will become increasingly noticeable after weaning.

Additionally, the researchers found that the gender of the goats also played a role in their body size development. Male goats tended to have larger body sizes compared to female goats of the same age. This difference was particularly evident in measurements such as shoulder height and overall weight. The researchers hypothesized that hormonal differences between male and female goats could be influencing their growth patterns. Further studies will be needed to explore this potential factor and its impact on the goats' overall development.

Goat youngsters' body temperatures (in degrees Fahrenheit) likewise showed a positive correlation with age, but mother goats' body temperatures showed the reverse pattern. The body temperatures of mother goats, ages 2-4, ranged from 75°F to 85°F, according to Torrao et al. (2011). The results of this study support earlier studies, showing that mother goats' body temperatures varied from 78.40°F to 85.50°F. Furthermore, there was no discernible variation in the blood levels of hormones (FSH and LH) between the triplet and singlet births of Boer and Etawah goat kids.

This suggests that in these goat breeds, litter size may not have a significant impact on hormonal regulation during pregnancy and birth. Additionally, the study found that the body temperatures of the goat kids were consistently higher than those of the mother goats, indicating a potential difference in metabolic activity between the two groups.

These findings shed light on the physiological differences between mother goats and their offspring, highlighting the complex interactions that occur during pregnancy and birth. For example, a Boer goat may give birth to triplets, each with their own unique hormonal regulation during pregnancy and birth. The higher body temperatures of the goat kids compared to their mothers may suggest increased metabolic activity in the offspring, potentially influencing their growth and development. However, studies have shown that in some cases, mother goats may actually have higher metabolic rates than their offspring due to the energy demands of lactation. Additionally, certain breeds of goats may exhibit different metabolic responses during pregnancy and birth, further complicating our understanding of the physiological differences between mother goats and their offspring. Factors such as diet, environmental conditions, and genetic predispositions may all play a role in determining metabolic rates in both mother goats and their kids (Cai. et al., 2022; Daramola, 2021)

Morphological Index of Single-Bearing and Triplet-Bearing Boer Goats

In livestock competitions, the morphological index is a useful tool in addition to body size, especially when choosing animals with excellent reproductive quality. This is especially important when determining which animals are more likely to give birth to triplets.

A high morphological index often indicates better fertility and overall health in livestock, making these animals more desirable for breeding purposes (Sintayehu et al., 2021). By selecting animals with a higher morphological index, breeders can increase the chances of producing offspring with similar traits, ultimately improving the quality of their herd.

This study found that there was no significant difference (P > 0.05) between the morphological indices of Etawah goats and Boer goats that gave birth to triplets. There was a comparison between Boer and Etawahh goats' weight (112,157.01 vs. 111,950.49), slope of height (0.60 vs. 0.68), index of length (1.048812 vs. 1.017051), slope of width (0.993471 vs. 1.118537), depth index (0.364116 vs. 0.3671795), and front leg length (48.2 vs. 49.36). These results suggest that despite some variations in specific morphological indices, both Boer and Etawah goats have the potential to produce triplets at similar rates. This information can be valuable for goat breeders looking to improve the reproductive efficiency of their herds. By understanding the morphological characteristics associated with successful triplet births, breeders can make more informed decisions when selecting breeding pairs, ultimately leading to a more consistent and high-quality herd. Further research in this area could help to refine these findings and provide even more specific guidelines for goat breeders seeking to optimize their breeding programs.

In their 2020 study, Wiyanto and Putra found that the goats' weight slope was 47,477.46 and their height slope was 1.94. The morphological index values they found for Etawah Grade were lower than those found in this study. However, the width slope was larger at 0.9645 and the foreleg length was 26.34.

The height slope index is used to evaluate the type of livestock; a lower number indicates higher quality (Timothy et al., 2014). The height slope index should be as close to zero as possible, and the wither and rump heights should ideally form a parallel, straight line. The foreleg length measurement should be taken into consideration when evaluating the height slope index.

This study found that the height slope index values were 1.38 for single-bearing Etawah goats, 0.68 for triplet-bearing Etawah goats, 0.60 for triplet-bearing Boer goats, and for single-bearing Boer goats it was 1. The average slope index for goat kids is larger than or equal to one for both Boer and Etawah goats. This indicates that the height slope index tends to be higher in single-bearing goats compared to triplet-bearing goats. The findings suggest that there may be a relationship between litter size and the height slope index in goats. Further research could explore this relationship and its potential implications for goat breeding and management practices. Overall, maintaining a low height slope index is important for ensuring the structural soundness and overall quality of goats in breeding programs.

The width slope index was 0.70 vs. 0.99 for Boer goats bearing singlets and triplets and 0.79 vs. 1.11 for Etawah Grade goats bearing singlets and triplets. According to Hafiz (2009), cattle are classified as fat and long-legged if their depth index is greater than 0.5 and as fat and short-legged if it is less than 0.5. The goats in the study were classified as large, long-legged breeds.

A goat's leg length can be determined using the length index. A value above 1 indicates long legs, and a value below 1 indicates short legs. According to the study's findings, goats of the Boer and Etawah in Lombok Barat Regency are classified as having long legs because their length indices are close to 1. This suggests that these breeds may have a genetic predisposition for longer legs, which could have implications for their agility and ability to navigate rough terrain. The region in which these goats are raised is characterized as being rocky and dry, despite the fact that Lombok Barat Regency is a relatively fertile area.

Types and Quality of Feed Ingredients for Goat Rations

Animal growth and development can be assessed and supported by a number of other variables, like cage temperature and humidity, as well as quantitative performance measures and morphological indices, such as nutrition (Ferrara et al., 2003; Nie et al., 2020).

Animals need nutrients that meet their body's needs in order to grow as best they can. According to Athifa et al. (2022), growth and reproduction are necessary for livestock productivity. Proper nutrition is essential for supporting the growth and development of animals, as it provides the necessary building blocks for tissue growth and repair. In addition to nutrition, environmental factors such as temperature and humidity can also play a significant role in determining the growth rates of animals. Studies have shown that optimal environmental conditions can enhance the overall health and productivity of livestock, ultimately leading to improved growth and reproduction outcomes.

The feed utilized in this study consisted of field grass and leaves from Gamal, Ketapang, Turi, Jackfruit, mango, banana, and Lamtoro. The feed ingredients were selected and analyzed according to the needs of the research goats for growth and reproduction, as shown in Table 5. Leaves and greens are a vital component of a goat's diet, providing the necessary nutrients, energy, and fiber to support their growth, health, and reproductive success.

Table 5. Feed ingredient types and quality for animal rations (%)*

Ingredients	DM	Ash	CF	CFb	CP	Carbohydrate
Gamal (*Gliricidia sepium*)	16.6	8.74	12.5	13.2	22.3	26.7
Turi (Vegetable hummingbird)	20.1	7.55	8.46	13.6	18.9	31.4
Ketapang (Indian almond)	35.1	13.0	4.30	15.8	11.8	20.1
Jackfruit	26.9	12.0	1.42	17.3	8.62	33.7
Mango	32.6	6.11	2.36	30.2	12.2	16.5
FG1	16.5	16.4	1.86	19.5	18.9	26.8
FG2	18.2	11.5	2.74	21.7	11.8	34.1
Banten (*Lannea coromandelica*)	32.6	8.21	3.55	8.19	14.7	32.7
Lamtoro (River tamarind)	29.5	6.17	6.21	17.1	23.7	17.3

*Outcomes of the Proximate Analysis at the University of Mataram's Faculty of Animal Husbandry's Nutrition and Animal Feed Science Laboratory (2022)
DM stands for dry matter; CP for crude protein; CFb for crude fiber; CF = crude fat;
FG1 = Field grass and shrubs found in rice paddies
FG2 = Garden-variety field grass

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Leaves from various plants can play a significant role in goat production and reproduction by providing essential nutrients, promoting health, and enhancing productivity.

Gamal leaves are not specifically mentioned in the provided source. However, the addition of functional feed supplements (FFS) to the diets of lactating Holstein cows has been shown to significantly increase milk production and improve milk composition, including protein yields (Shaker et al., 2022) Turi leaves are high in calcium and phosphorus, enhancing milk yield and quality. Ketapang leaves contain tannins for parasite control and overall health. Jackfruit leaves are fiber-rich, aiding digestion and supporting growth and reproductive performance. "Mango leaves are rich in minerals like nitrogen, potassium, phosphorus, iron, sodium, calcium, magnesium, and vitamins A, B, E, and C. These nutrients play a crucial role in various bodily functions such as immune system health and energy metabolism (Vivek et al., 2021; Enas et al., 2022).

Overall, a diverse diet of different types of leaves is crucial for the overall health and productivity of goats. By providing a variety of leaves such as gamal, turi, ketapang, jackfruit, and mango, goat farmers can ensure that their animals receive the necessary nutrients to thrive. These leaves not only support muscle development, milk production, and digestion but also play a role in parasite control, immune system boosting, and reproductive health. Therefore, incorporating a mix of these leaves into the goats' diet can lead to improved growth, development, and overall well-being. However, if a goat farmer were to only provide one type of leaf, such as gamal, in their goats' diet, it could lead to nutritional deficiencies and health issues. For example, gamal leaves are high in protein but low in calcium and phosphorus, which are essential for bone development and overall health. Therefore, relying solely on gamal leaves could result in stunted growth, weak bones, and other health problems for the goats.

Table 5 provides a comprehensive overview of the nutritional composition of various feed ingredients. This information is crucial for formulating balanced diets for goats, ensuring they receive adequate protein, energy, and fiber for optimal growth and reproduction. Each ingredient has its strengths, and the choice of feed should be based on the specific nutritional needs of the goats.

Based on Table 5, gamal stands out with a high crude protein content of 22.3% and an equal carbohydrate content of 22.3%, making it an excellent protein source. Similarly, Turi offers a protein content of 18.9% and a carbohydrate content of 31.4%, making it suitable for both energy and protein needs. In contrast, ketapang has a lower protein content of 11.8% but a higher dry matter content of 35.1%, indicating less water content. Jackfruit, with a protein content of 8.62% and high carbohydrates at 33.7%, serves more as an energy source. Mango has a higher protein content than ketapang and jackfruit at 12.2%, with low carbohydrates at 16.5% and a significant crude fat content of 30.2%. Lamtoro leaves also feature low carbohydrates at 17.3% but boast a high protein content of 23.7%. Conversely, Banten is characterized by a high carbohydrate content of 32.7% and moderate protein at 14.7%. FG1 offers a balanced nutritional profile with 18.9% protein and 26.8% carbohydrates, similar to FG2, which also has 18.9% protein and 26.8% carbohydrates.

Although the nutritional content of the feed can vary significantly, livestock can support reproduction through their diet. A lack of adequate food can disrupt growth and reproduction and may even lead to the death of livestock. For this reason, feed is essential to the growth and development of animals. The leaves of plants like Gamal, Turi, Ketapang, Jackfruit, Mango, and Lamtoro are some of the basic feed and forage given to Boer goats and Etawah grade goats. These plants are rich in nutrients such as protein and carbohydrates, which are crucial for the health and reproduction of livestock. By providing a balanced diet that includes these essential feeds, farmers can ensure that their goats are healthy and able to reproduce successfully.

The surrounding environment

Figures 8 and 9 depict the temperature and humidity levels for the environments where Boer goats and Etawahh grade goats were housed, based on field observations.

Table 6. Air temperature where goats are kept (oC)

Observation Time	Boer goats and Etawah grade goats	
	Inside the Cage	Outside the Cage
Morning (6-9 a.m.)	27.50±0.85	27.05±1.65
Mid-day (12 a.m.)	26.30±0.70	26.60±1.30
Afternoon (3-6 p.m.)	27.45±0.90	28.75±1.95
Evening (9 p.m.)	27.50±0.80	26.00±2.20
Mid-night (12-3 a.m)	28.85±1.40	27.90±2.05
Average	27.52±0.93	27.26±1.82

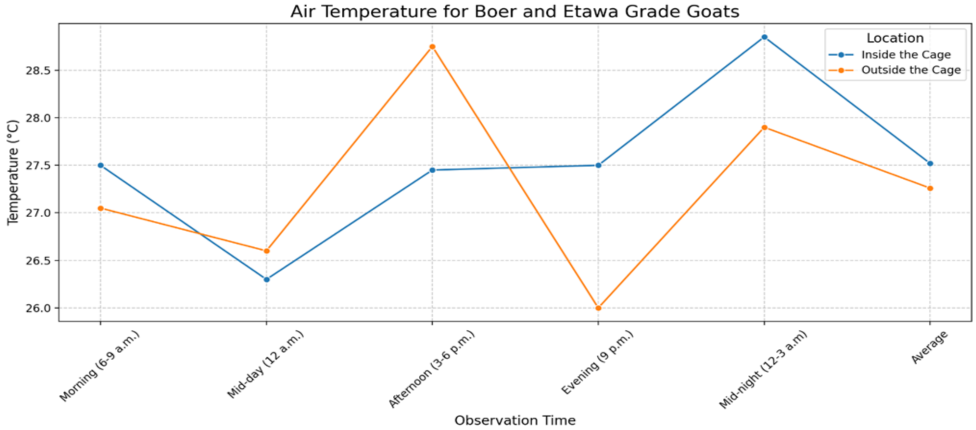

Figure 8. Air temperature inside and outside the cage throughout the day

Based on Table 6 and Figure 8:1). Daily Change: Midday is usually the coolest time of day for both areas; however, temperatures do vary throughout the day. 2). Cage Effect: The goats' cage appears to have a moderating effect on temperature, keeping them cooler in the hotter afternoon and better able to hold onto heat in the evening (3). Peak Variations: The afternoon hours are when there is the biggest temperature differential between the inside and outside of the cage, with the cage offering noticeably colder temperatures (4). Warmth at Night: It's interesting to note that the goats may benefit from the cage's increased warmth around midnight on colder evenings (5). As a Whole: Although there is a modest change in temperature, it is only slightly hotter (by 27.52°C) within the cage than it is outside (by 27.26°C). This demonstrates how the cage, which provides warmer conditions at night and cooler conditions during the day as needed, effectively regulates the goats' body temperatures. The slight difference in average temperature between the inside and outside of the cage indicates the goats' capacity to adapt to their surroundings comfortably both during the day and at night. The capacity of the cage to control temperature may eventually be advantageous to the goats' general health and welfare. For instance, goats can stay cool and prevent heat stress on hot summer days by having a break from the intense heat in their cage. Similar to this, the cage providing a slightly warmer environment for them to sleep in and keep comfortable on chilly evenings may improve the goats' quality of life.

Table 7. The humidity of the location where the goats are kept (%)

Observation Time	Boer goats and Etawah grade goats	
	Inside the Cage	Outside the Cage
Morning (6-9 a.m.)	72.9	65.95
Mid-day (12 a.m.)	69.5	63.4
Afternoon (3-6 p.m.)	61.4	62.5
Evening (9 p.m.)	71.2	70.5
Mid-night (12-3 a.m)	75.65	75.4
Average	70.13	67.55

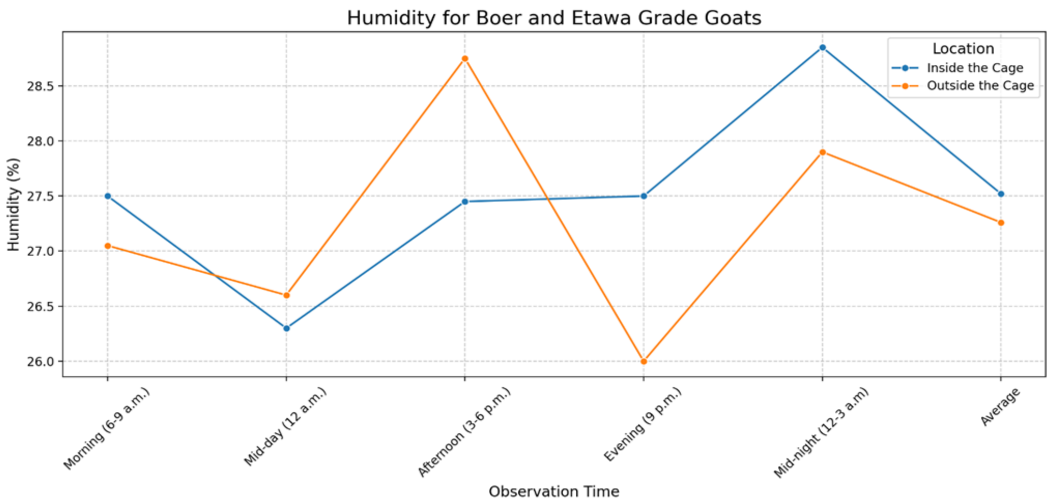

Figure 9. Diurnal humidity inside the cage and outside the cage

Based on table 7 and Figure 9: 1). Daily humidity levels inside and outside the cage follow similar patterns (2). There's a noticeable drop in humidity at midday for both locations (3). The largest difference is observed in the afternoon, where it's more humid outside the cage (4). Daily Variation: Humidity levels fluctuate throughout the day, with the lowest levels generally occurring at midday for both locations (5). Cage Effect: The cage seems to have a moderating effect on humidity: it keeps the humidity lower during the humid afternoon and it maintains slightly higher humidity during the drier midday period (6). Peak Differences: The largest humidity difference between inside and outside the cage occurs in the afternoon, where the cage provides significantly less humid conditions (7). Nighttime Similarity: Interestingly, humidity levels are very similar inside and outside the cage during nighttime and early morning hours (8). On average, the humidity outside the cage (27.26%) is slightly higher than inside (27.52%), but this difference is minimal. Overall, the cage effectively regulates humidity levels throughout the day, providing a comfortable environment for the inhabitants. The peak differences in humidity between inside and outside the cage suggest that the structure is most effective at managing humidity during the afternoon. The nighttime similarity in humidity levels indicates that the cage may not be as necessary for maintaining consistent humidity during the evening and early morning hours. Despite the slight difference in average humidity levels, the cage overall does a good job at keeping conditions stable and comfortable for its inhabitants.

As stated by Julianti 2022 and Arifanti et al. 2022. According to Tables 6 and 7, the temperature outside and within the goat cage are both reasonably dry (Climate Type E), which is defined by higher daily air temperatures and lower daily humidity. The animals' open enclosures did not have much of a temperature differential between the inside and outside. The temperature and humidity inside the cage varied from 26.30oC to 28.85oC and 61.4% to 75.65%, respectively. However, the average temperature outside the cage varied between 26.0oC and 28.75oC, while the humidity ranged from 62.5% to 75.4%. Both inside and outside the cage, the temperature was lower at noon than it was at other times of the day. This consistent temperature and humidity level inside and outside the goat cage indicates that the enclosure is well-suited for the animals' needs. The slight difference in temperature and humidity between the inside and outside of the cage suggests that the enclosure provides adequate protection from the elements without creating a drastic change in climate. The fact that the temperature was lower at noon highlights the importance of providing shade and shelter for the animals during the hottest part of the day.

According to Chanachai et al. (2022), temperature has a detrimental impact on mammalian activity, while precipitation has a favourable effect. This supports their observations that there is more mobility during the rainy season compared to the dry season. The study site's Type E, rather dry environment, could have a negative impact on animal development. The research site's maximum humidity levels were recorded between midnight and daybreak, both inside and outside the cage. These findings suggest that animals may seek refuge during the hottest part of the day to avoid the negative effects of the dry environment. Providing shade and shelter can help mitigate these impacts and promote healthier animal development. Additionally, the higher humidity levels during the night and early morning may offer some relief for the animals from the dry conditions during the day. Overall, understanding and addressing these environmental factors is crucial for ensuring the well-being of the animals in the research site.

Negative climatic conditions have little of an impact on goat growth rates, but humidity and air temperature do affect animal growth and development (Castilho et al., 2015; Lecina-Diaz et al., 2018). This is because goats have a genetic predisposition to withstand heat better than other animal species. This genetic adaptation allows goats to thrive in hot and dry climates, making them well-suited for research sites with challenging environmental conditions. However, it is still important to monitor and manage humidity levels to prevent any potential heat stress or other health issues in the goats. By prioritizing the well-being of the animals and taking into consideration their unique genetic traits, researchers can ensure the success of their studies and the overall welfare of the goat population in the research site.

Moving forward, these findings have important implications for goat management practices. Understanding the effectiveness of the cage in maintaining consistent humidity levels throughout the day can help farmers make informed decisions about when to utilize the structure for the benefit of their animals. By recognizing the peak differences in humidity and adjusting care routines accordingly, farmers can ensure that their goats are always kept in a comfortable and healthy environment. Additionally, this research highlights the importance of monitoring environmental conditions and adjusting as needed to optimize the well-being of the animals. Overall, these findings provide valuable insights that can improve goat management practices and contribute to the overall health and happiness of the herd.

CONCLUSION

We concluded that goats with the possibility of having triplets can be identified by morphological indices, namely the height slope, hip and chest sizes, and the blood's concentration of follicle stimulating hormone (FSH). There is a positive correlation between these parameters and body weight and chest circumference. The elevated hormone levels in the blood could potentially be attributed to the livestock's consumption of basalt feed.

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