Evaluation of the effect of feeding *Brachiaria humidicola* supplemented with Azolla sp. on the growth performance of Saanen doeling (*Capra aegagrus hircus)*

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Abstract. This study evaluates the effect of integrating *Brachiaria humidicola* and Azolla sp., a protein-rich water fern, on the growth performance of Saanen doelings. The study was conducted at Pasir Akar Farm, Universiti Sultan Zainal Abidin, Terengganu, Malaysia; the research involved nine 6-month-old Saanen doelings. They were divided into three feeding groups: Control (C) with 100% *B. humidicola*, Treatment 1 (T1) with 90% *B. humidicola* and 10% Azolla, and Treatment 2 (T2) with 80% *B. humidicola* and 20% Azolla. Each group had three replicates. Growth performance was assessed through body measurements (length, wither height, chest circumference), Body Condition Score (BCS), average daily gain, and feed conversion ratio (FCR), using regular weight measurements and feed intake records. Data analysis via one-way ANOVA revealed that Treatment 2 achieved the highest growth performance, with a BCS of 3.87, surpassing T1 at 3.70 and C at 3.67. T2 also recorded the lowest average feed intake at 19.14 kg, compared to T1 at 21.40 kg and C at 23.50 kg, indicating the most efficient FCR. Significant differences ($p < 0.05$) in live weight were noted between T1 and T2 during weeks 3 to 5. Thus, an 80:20 ratio of *B. humidicola* to Azolla sp. enhances Saanen doelings' growth performance.

1 Introduction

The demand for goat milk and meat has been steadily increasing in Malaysia, prompting the establishment of numerous commercial dairy goat farms [1]. However, local production has yet to keep pace with this rising demand, leading to significant imports of goat products. Among the various breeds available, the Saanen goat stands out due to its exceptional growth

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potential and high milk production capabilities. Originating from the Saanen Valley in Switzerland, Saanen goats are known for their large body size, typically maturing at a live weight of up to 55 kg and a height of approximately 80 cm [2]. They are often referred to as dual-purpose animals because they provide both milk and meat, making them a valuable asset in mixed farming systems [3]. Saanen goats are particularly favored in dairy production due to their docile temperament and adaptability to intensive management systems. Their milk is highly regarded for its digestibility and nutritional benefits, which align with Malaysian dietary preferences and cultural practices [1]. Given these attributes, the Saanen breed was chosen for this study to evaluate the effects of integrating *Brachiaria humidicola* and Azolla sp. on the growth performance of Saanen doelings.

In tropical regions, ruminant livestock mainly rely on natural pastures and low-quality grasses, which become scarce during the dry season. Thus, feeding ruminants conserved forages is crucial as they are available year-round and provide consistent nutritional value [4]. Forages are essential in ruminant nutrition as they supply essential energy, protein, and minerals [5]. In Malaysia, the challenging land topography leads to a need for more natural pastures, posing a significant constraint on ruminant production. Farmers increasingly depend on concentrates instead of roughages, resulting in higher production costs. Globally, forages remain the primary feed source for ruminants, with various types like *B. humidicola* used as pasture or feed. Farmers commonly use it to feed livestock like goats and cattle through meadows, native grazing ranges, and grass silage. This tropical grass is well-suited to diverse climates and soil conditions. The total dry matter (DM) yield plays a crucial role in determining the carrying capacity of a pasture, and farmers should also consider the digestibility and biomass production of the forage for optimal benefits [6]. Forage quality can result in adequate growth, lower productivity, and significant economic losses, impacting the livelihoods of cash-strapped farmers worldwide [7]. While *B. humidicola* is helpful, it alone cannot meet the protein needs of ruminants. Supplementing a *B. humidicola* diet with *Azolla microphylla* can enhance goat growth performance by providing additional protein [8]. The high cost of imported supplements and pellets, which must be sourced from overseas, makes local alternatives like Azolla sp. a viable and cost-effective protein source for ruminants in Malaysia.

Azolla sp. is among the world's most minor yet economically significant floating plants. They are unique due to their rapid growth, capable of doubling their area in 5 to 10 days [8, 9]. Azolla is an aquatic plant with high nutritional value and productivity, making it suitable as animal feed [8, 9,10]. It is an excellent source of vitamins, essential minerals, and protein for livestock [8, 9]. Often referred to as the aquatic fern, Azolla hosts the symbiotic blue-green algae Anabaena Azolla, which fixes atmospheric nitrogen. This nitrogen-fixing pteridophyte thrives in various marine environments, including paddy fields. Farmers have increasingly favored Azolla for its potential as animal feed. With the rising demand for meat and milk and dwindling fodder supplies, there is a growing need for sustainable feed supplements [9,10].

Therefore, this research aims to enhance local dairy production by optimizing feeding strategies that leverage the breed's natural advantages while contributing to sustainable agricultural practices. The study specifically focuses on assessing growth parameters such as body measurements, Body Condition Score (BCS), average daily gain, and feed conversion ratio (FCR). By measuring these parameters, we aim to provide insights that can help farmers improve the health and productivity of their Saanen goats, ultimately supporting the broader goal of meeting local demand for goat products.

2 Materials and Method

2.1 Study Site

This study was conducted at UniSZA Pasir Akar Farm. The Pasir Akar Farm is in Jerteh, Terengganu, Malaysia (coordinates: 5°38'37 "N 102°28'16" E). This farm belongs to Universiti Sultan Zainal Abidin (UniSZA) and is an educational and practical facility for students. It encompasses a variety of livestock, including chickens, beef cattle, dairy goats, and sheep. The climate in this region is characterized by high humidity levels, generally ranging from 80% to 95%, along with warm temperatures, with an average annual temperature of approximately 26.9°C. During certain months, particularly from November to February, humidity levels can rise to nearly 90% due to the rainy season.

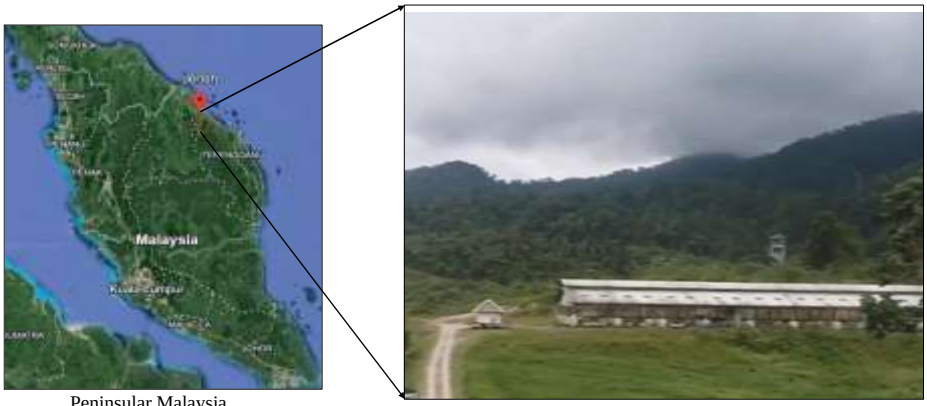

Fig. 1. Location of the study site.

2.2 Ethical Approval

Ethical approval is a mandatory prerequisite for conducting experiments. An application was submitted to the Animal and Plant Research Ethics Committee at Universiti Sultan Zainal Abidin (UAPREC) to obtain this approval. The process was completed when the approved series number UAPREC/008/008 was received.

2.3 Experimental Design

2.3.1 Collection of Plant Samples

Samples of *Brachiaria humidicola* were harvested using the stem-cutting method, while samples of *Azolla microphylla* were collected from the cultured tanks using a sieve. Both samples were thoroughly washed under tap water to remove any debris and remaining soil before proceeding to the preparation of the feeding treatment.

2.3.2 Preparation of Animal Samples

A total of nine Saanen doelings, approximately six months old, were used in this study. They were randomly divided into three groups of three animals, with body weights ranging from 20 to 30 kg. Each group was fed *B. humidicola* supplemented with *A. microphylla* at three different levels of feeding treatment for five weeks to collect data on growth performance.

2.3.3 Preparation of Feeding Treatments

The feed given to the nine Saanen doelings consisted of a mixture of *B. humidicola*, supplemented with concentrate pellets, and *A. microphylla*. The goats were divided into three groups, each receiving one of three feed treatments: Control (C), Treatment 1 (T1), and Treatment 2 (T2). The Control group received 100% *B. humidicola* grass and 0% *A. microphylla*, T1 received 90% *B. humidicola* grass and 10% *A. microphylla*, and T2 received 80% *B. humidicola* grass and 20% *A. microphylla*.

2.3.4 Feeding Treatments Experiment

The prepared feed treatments were given to the nine Saanen doelings in varying ratios based on their body weight. Table 1 shows the feeding treatments given to the goats. The goats were fed twice daily, at approximately 9 a.m. and 5 p.m. The feed intake of the goats was recorded daily, and their feed consumption was calculated weekly to meet their daily demand. The feeding troughs were constantly cleaned before adding new feed to ensure they were clean and fungus-free. During the feeding adaptation period, each goat was weighed weekly in the morning before feeding to determine the average daily gain (ADG). The feeding experiment was then conducted continuously for five weeks.

Table 1. Experimental Design of Feeding Treatments.

Group of Animals	Feeding Treatments	Calculation Average Feed of Saanen Doeling (Weight: 3kg ± 0.5)	
C	100% of *B. humidicola*	3000g of *B. humidicola*	
T1	90% of *B. humidicola* + 10% of fresh *Azolla micropylla*	*B. humidicola* = 90 % x 3000g = 2700g	Azolla = 10% x 3000g = 300g
T2	80% of *B. humidicola* + 20% of fresh *Azolla micropylla*	*B. humidicola* = 80% x 3000g = 2400g	Azolla = 20% x 3000g = 600g

2.4 Data Collection for Growth Performance

2.4.1 Feed Intake

The weekly feed intake of each goat was recorded, and the average feed intake was calculated by dividing the total amount of feed by the number of goats. Feed intake was calculated using the following formula:

$$\text{Feed intake} = \text{feed given (kg)} - \text{Remaining feed (kg)} \quad (1)$$

2.4.2 Body Weight and Body Weight Gain

The body weight of all Saanen doeling was individually measured using a weighing scale. The weight, recorded in kilograms (kg), was collected at 7-day intervals over five data collection periods. The difference in body weight between the beginning and end of each period was used to determine the average weekly live weight growth. Body weight gain was calculated using the following formula:

$$\text{Body Weight Gain} = \text{Final weight (kg)} - \text{Initial weight (kg)} \quad (2)$$

2.4.3 Body Measurement

Throughout this study, body measurements were collected. These measurements included body length, wither height, and chest girth, which were estimated using measuring tape. Body length was measured from the end of the shoulder joint (scapula bone) to the end of the sitting bone. Wither height was measured perpendicularly from the highest point of the withers to the ground. Chest girth was measured by wrapping the measuring tape around the chest, just behind the shoulders to the withers. All body measurements were recorded in centimeters (cm).

2.4.4 Average Daily Gain (ADG)

Average daily weight gain was calculated by dividing the total weight gain by the number of days. The ADG was calculated using the following formula:

$$\text{ADG} = \text{Final weight (kg)} - \text{Initial weight (kg)} / \text{Days} \quad (3)$$

2.4.5 Feed conversion ratio (FCR)

The Feed Conversion Ratio (FCR) is a crucial criterion for evaluating an animal's growth performance. FCR measures how efficiently the animal's body converts feed into weight gain. A lower FCR indicates higher efficiency in converting feed into weight gain. It is calculated by dividing the total feed intake for each week by the body weight gain of each goat. Below is the formula for FCR:

$$\text{FCR} = \text{Total feed intake (kg)} / \text{Body weight gain (kg)} \quad (4)$$

2.4.6 Body Condition Score (BCS)

Body Condition Scoring (BCS) is a systematic method used to assess the fat reserves and overall body condition of ruminants, such as goats, sheep, and cattle. BCS is crucial for managing animal health, nutrition, and reproductive performance. It helps farmers make informed decisions regarding feeding strategies and overall herd management. BCS systems typically range from 1 to 5, with each score representing a specific level of body fat and muscle condition. The Body Condition Score (BCS) measurement was conducted in accordance with the methods outlined in the study by Getwiler [11].

2.5 Data Analysis

The growth performance data were analyzed using one-way analysis of variance (ANOVA) in Minitab version 22.0 statistical software. This analysis aimed to determine the mean, standard deviation, and significant differences ($p < 0.05$) among groups receiving different treatments. Additionally, post-hoc tests, such as Tukey's HSD (Honestly Significant Difference) test, were conducted following ANOVA to identify specific group differences when significant effects were detected. This comprehensive approach ensures a robust statistical evaluation of the data, allowing for a clear understanding of the impact of the treatments on growth performance. This revision clarifies that further testing is involved and specifies the type of post-hoc test used after ANOVA. The significance of differences was evaluated by comparing mean values between treatment groups, with a p-value of less than 0.05 ($p<0.05$) considered statistically significant, indicating differences unlikely to be attributed to chance. This statistical approach, employing ANOVA alongside Standard Deviation and p-values, effectively identified significant variations in.

3 Results and Discussion

The results present data on several key performance indicators, including feed intake, weight gain, body measurements (such as body length, wither height, and chest girth), Body Condition Score (BCS), average daily gain (ADG), and feed conversion ratio (FCR). This information is organized for three different feeding treatments, allowing for a comparative analysis of how each treatment affects the animals' growth and overall performance. These metrics are essential for evaluating the efficacy of the feeding strategies and their impact on animal health and productivity.

3.1 Feed Intake

Feed intake refers to the amount of feed consumed by an animal or group of animals when they have unlimited access. It is crucial for animal productivity, as daily feed intake directly impacts growth and health. Generally, goats consume between 1.8% and 2.0% of their body weight in dry matter (DM) daily, as reported by Ayumi et al. [12]. However, this intake can vary based on factors such as breed, age, physiological state (e.g., pregnancy or lactation), and feed quality [13]. In this study, different feeding treatments using *Brachiaria humidicola* and *Azolla microphylla* showed varying effects on feed intake among treatments. Figure 2a illustrates the weekly feed intake for Saanen doelings across these treatments. Throughout the study, Treatment 2 (T2) consistently demonstrated the most efficient feed intake, indicating a positive response to the supplementation. This suggests that T2, which contains the highest Azolla percentages, may optimize nutrient absorption or palatability, enhancing the overall growth performance of Saanen doeling. The findings of this study parallel with the studies by Kamaruddin et al. [9] and Roy et al. [14] that reported Azolla supplementation in the basal diet of Saanen doelings enhances growth performance by improving nutrient absorption and feed efficiency. Meanwhile, Figure 2b shows the average feed intake among treatments over the entire study period.

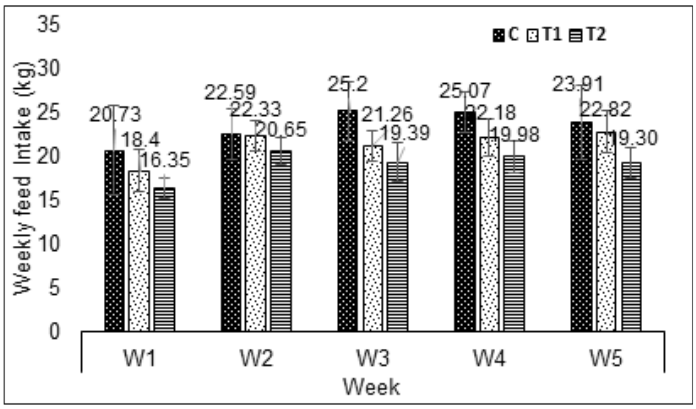

Fig. 2a. Weekly feed intake of Saanen doeling under different treatment conditions.

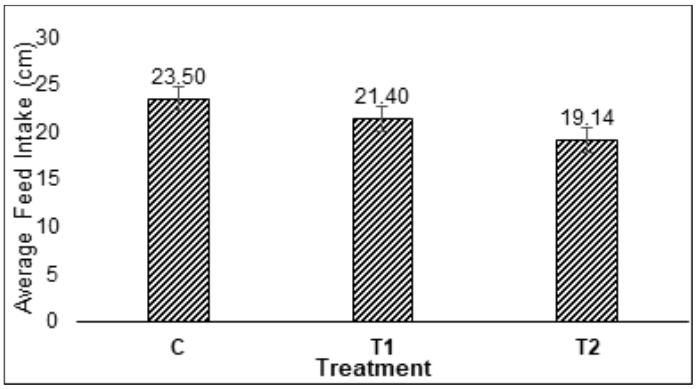

Fig. 2b. Average feed intake across treatments throughout the entire study period.

The results indicate that Treatment 2 (T2) had the lowest average feed intake at 19.14 kg, followed by Treatment 1 (T1) at 21.40 kg and Control (C) at 23.50 kg. This suggests that animals may convert feed into body mass more efficiently with lower intake, particularly when the feed is nutritionally rich and highly digestible. Reduced feed intake in T2 does not necessarily indicate poorer performance; rather, it may reflect improved feed conversion ratios. The higher Azolla supplementation in T2 likely enhances nutrient density or palatability, enabling goats to consume less while still achieving effective growth. Previous studies have shown that Azolla can significantly improve the nutritional profile of animal feed due to its high protein content and digestibility, which can lead to better growth performance even with reduced feed intake [9,14-16]. This aligns with the observed data, where T2 goats efficiently convert less feed into body mass, suggesting enhanced feed utilization and conversion efficiency.

3.2 Weight gain

Figure 3a illustrate the different treatments and the weekly live weight gain of Saanen doeling at five intervals: Initial – Week 1 (I-W1), Week 1 – Week 2 (W1-W2), Week 2 - Week 3 (W2-W3), Week 3 - Week 4 (W3-W4), and Week 4 - Week 5 (W4-W5). The figure shows that the control group (C) had a modest increase in weight with some week-to-week variation. Specifically, W2-W3 showed the lowest weight increase (0.33 kg), while W4-W5 showed the highest (0.8 kg). In Treatment 1 (T1), the weight gain during W2-W3 was similarly low (0.53 kg), comparable to the control group but slightly higher. Treatment 2 (T2) demonstrated

the most consistent and highest weight gains across the weeks, significantly improving ($p<0.05$) weight gain, especially during W3-W4 and W4-W5 compared to C and T1. The most substantial weight gain occurred during W3-W4 (1.17 kg), which surpassed the other treatments. This suggests that the dietary supplementation used in T2 is particularly effective during this period, possibly due to optimal nutrient absorption or a synergistic effect with other dietary components, as reported in the study by Toradmal et al. [16]. However, in the subsequent interval, W4-W5, T2 experiences a decrease in weight gain to 0.8 kg. This reduction could be attributed to factors such as nutrient saturation, where the goats might have reached a point where additional nutrients no longer significantly enhance growth, as reported in the study by Kamaruddin et al. [9]. Biological adaptation to the diet or changes in environmental conditions could also contribute to this decline [17]. Figure 3b illustrates the average live weight gain of Saanen doeling at different levels of treatment throughout the study period.

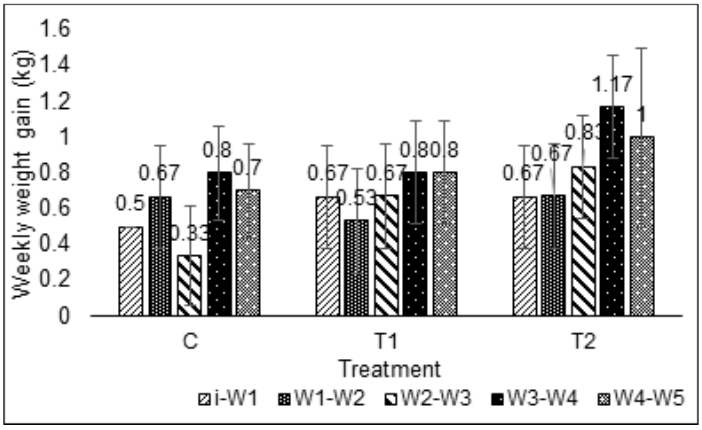

Fig. 3a. Weekly live weight gain of Saanen doeling at five intervals per week.

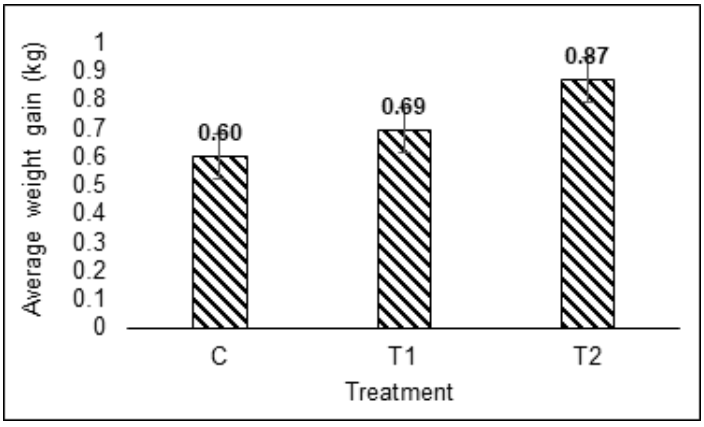

Fig. 3b. Average live weight gain of Saanen doeling at different treatment levels.

Figures 3a and 3b show that Treatment 2 (T2) achieved the highest average weight gain at 0.87 kg, followed by Treatment 1 (T1) at 0.69 kg and Control (C) at 0.60 kg. This indicates that the experimental diet in T2, consisting of 80% *B. humidicola* and 20% *A. microphylla*, provided optimal nutritional content exceeding the maintenance requirements for goats. The high crude protein content in T2 contributed to consistent growth and less fluctuation, highlighting the beneficial impact of the Azolla supplement. Both *B. humidicola* and *A.*

microphylla are known for their high protein levels (9% and 27%, respectively) [9, 14,16,17]. While excessive protein can negatively affect animal health by reducing weight gain and disrupting metabolism [17], the 20% inclusion rate of Azolla in T2 resulted in the highest daily weight gain. In contrast, a 30% inclusion rate reduced feed efficiency. These findings align with a study by Roy et al. [14] who reported daily weight gains of 140-330 grams in heifers with Azolla meal supplementation. High-quality feed containing essential nutrients such as energy, crude protein, fiber, fat, and vitamins typically leads to improved body weight gain [9, 14, 16, 18].

3.3 Body Measurement

Body measurements are crucial for assessing growth and evaluating animal performance. Key measurements include body length, wither height, and chest girth, each closely related to body weight and overall growth performance. Body length refers to the distance from the shoulder to the base of the tail. It provides an indication of the animal's size and growth potential, often correlating with body weight. A longer body length generally suggests better growth and development [19]. Wither height is the height from the ground to the highest point of the shoulder. This measurement reflects skeletal growth and is used to assess an animal's maturity and development. It can indicate how well an animal is growing in terms of bone structure [19]. Chest girth measures the circumference around the chest, just behind the front legs. This is a key indicator of body condition and fat reserves, providing insights into the animal's health and nutritional status. A larger chest girth often correlates with greater body weight [19]. A study by Toradmal et al. [14] demonstrated that feeding Azolla to Osmanabadi goats significantly increased these parameters, enhancing growth performance such as body weight, height, length, and chest girth. This suggests that dietary interventions can positively impact physical development and productivity in livestock

3.3.1. Body Length

Figure 4a illustrates the changes in body length of Saanen doelings from week 1 to week 5 across different treatment groups. The intervals are Initial – Week 1 (I-W1), Week 1 – Week 2 (W1-W2), Week 2 – Week 3 (W2-W3), Week 3 – Week 4 (W3-W4), and Week 4 – Week 5 (W4-W5). The Control group showed the smallest improvements in weeks 2 and 3 (1.33 cm), while weeks 1 and 5 showed the most improvement (2 cm). Gains were relatively consistent, peaking at 2 cm in week 5. For Treatment 1 (T1), body length gains varied from 1 cm to 2.33 cm, with the highest gain in week 2, indicating a positive response to the 10% Azolla sp. supplementation. Gains were more consistent than in the Control group, with notable increases in weeks 2 and 3. Treatment 2 (T2) exhibited the most significant improvements, ranging from 2 to 3 cm. The highest growth (3 cm) was observed in week 5, highlighting the substantial benefit of the 20% Azolla sp. supplementation. Gains remained consistently strong throughout the weeks, with notable peaks in weeks 1 and 5 (2.67 cm and 3 cm).

Figure 4b displays the average body length gain of Saanen doeling across different treatments throughout the study period. T2 showed the highest average gain at 2.47 cm, followed by T1 at 1.87 cm and C at 1.67 cm. This indicates that T2 significantly contributed to body length growth due to its appropriate crude protein content. Although Azolla can be advantageous for animal growth and performance, regulating its use is crucial to avoid hindering potential growth [15].

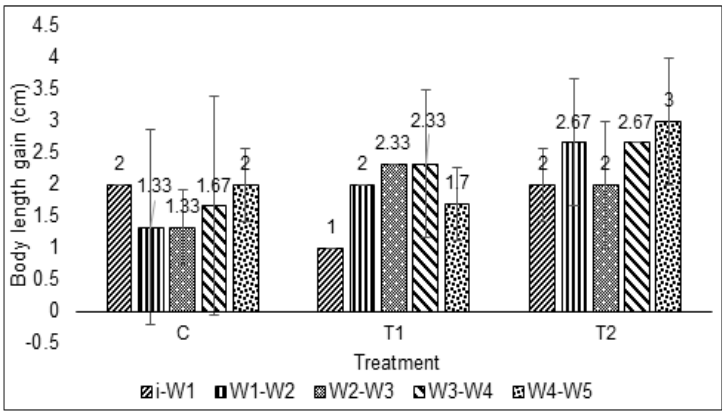

Fig. 4a. Changes in the body length of Saanen doeling across the different treatments.

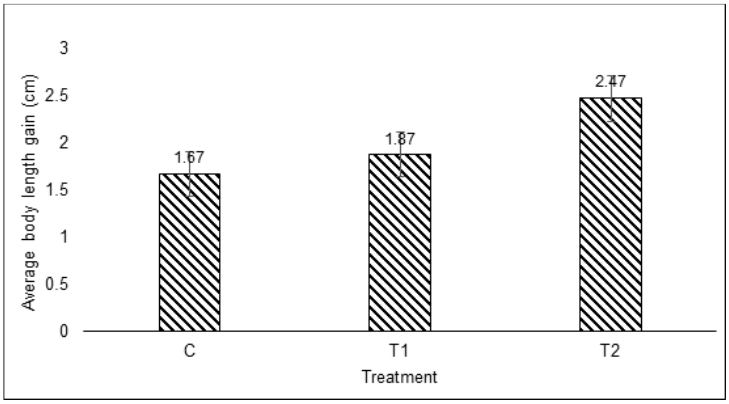

Fig. 4b. Average body length gain of female Saanen goats across different treatments.

3.3.2 Wither Height

Figure 5 illustrates the weekly changes in wither height of Saanen doeling across different treatments over five intervals: Initial - Week 1 (I-W1), Week 1 - Week 2 (W1-W2), Week 2 - Week 3 (W2-W3), Week 3 - Week 4 (W3-W4), and Week 4 - Week 5 (W4-W5). The Control group experienced the smallest gain in W2-W3 at 1.17 cm, while the highest gains were observed in I-W1 and W4-W5 at 1.67 cm. The growth pattern displayed variability, peaking at 1.67 cm during weeks with more pronounced gains. Treatment 1 (T1) showed more consistent wither height gains compared to the Control group, particularly in the second and fourth weeks (1.83 cm). This suggests a positive response to the 10% Azolla sp. supplementation during these periods.

Treatment 2 (T2) demonstrated the most significant wither height gains, ranging from 1.5 cm to 2 cm, with the highest growth of 2 cm observed in the fifth week. This indicates a substantial positive impact from the 20% Azolla sp. supplementation, with consistently high gains throughout the study. The results underscore T2's effective contribution to wither height growth, supported by its appropriate crude protein content. Studies have shown that increased crude protein in goat diets enhances wither height and overall performance, making it a key indicator of animal health and productivity [16 -17, 20-21].

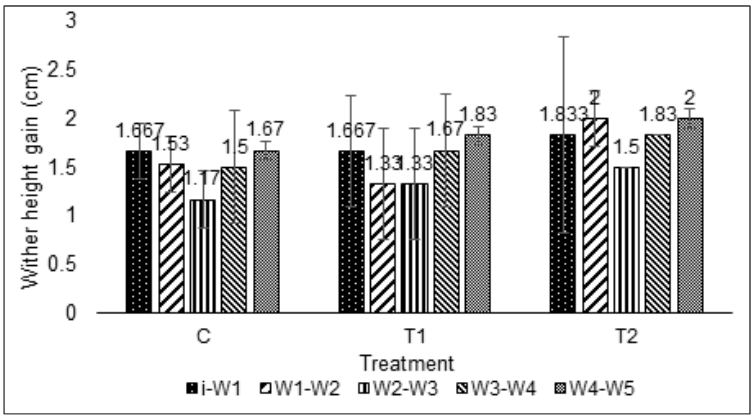

Fig. 5. Changes in the wither height of Saanen doeling goats each week under different treatments.

3.3.3 Chest girth

Figure 6a represents the weekly chest girth gains of Saanen doelings across different treatments at five intervals: Initial – Week 1 (I-W1), Week 1 – Week 2 (W1-W2), Week 2 – Week 3 (W2-W3), Week 3 – Week 4 (W3-W4), and Week 4 – Week 5 (W4-W5). In the Control group, chest girth gains were modest and varied weekly, with consistent improvements and a notable increase in the fourth and fifth weeks. Treatment 1 (T1) exhibited chest girth gains ranging from 1 cm to 2.33 cm, with the highest gain observed in W2-W3 and W3-W4 (2.33 cm). This indicates a positive response to the 10% Azolla sp. supplementation during these periods. Treatment 2 (T2) demonstrated the highest chest girth gains, ranging from 2 cm to 3 cm. The most significant growth (3 cm) occurred in the fifth week, highlighting a strong positive effect of the 20% Azolla sp. supplementation. Gains were consistently robust across the weeks, with the lowest gain observed in the first week (2 cm).

Figure 6b illustrates the average chest girth gain of female Saanen goats across different treatments throughout the study period. Treatment 2 exhibited the highest average chest girth gain at 2.47 cm, followed by T1 at 1.87 cm and C at 1.67 cm. These findings suggest that Treatment 2 effectively promotes chest girth growth, indicating efficient feed utilization. A study by Kumari et al. [16] noted a strong positive relationship between chest girth and weight in migratory goats. Besides, the higher levels of crude protein in the diet improve growth, feed intake, feed efficiency, heart girth, and body condition score in growing goats [9, 16,18, 22-23]. However, there was a decrease in W2-W3 in Treatment 2, which might be attributed to factors such as temporary dietary adjustments or environmental stressors affecting growth during that interval.

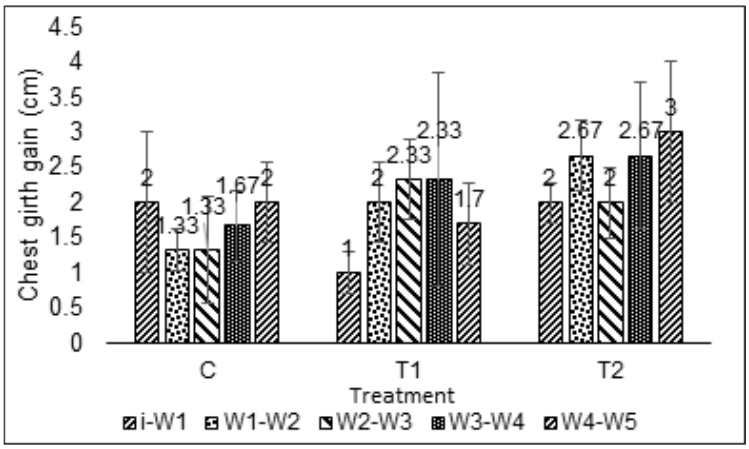

Fig. 6a. Weekly chest girth gains of female Saanen goats across different treatments.

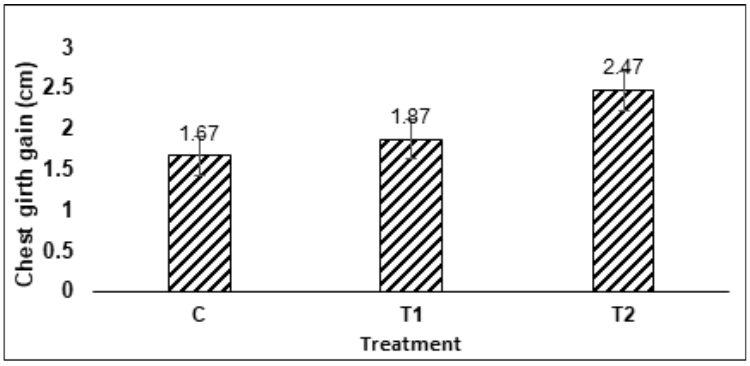

Fig. 6b. Average chest girth gain of female Saanen goats throughout the study period.

3.4 Body Condition Score

A study by Ghosh et al. [24] highlighted that body condition scoring (BCS) assesses the amount of muscle and fat surrounding the vertebrae to optimize goat comfort, reproductive health, feeding programs, and production outcomes. Feeding various treatments of *B. humidicola* supplemented with *A. microphylla* resulted in differing effects on the body condition score (BCS) of Saanen doeling before and after the study.

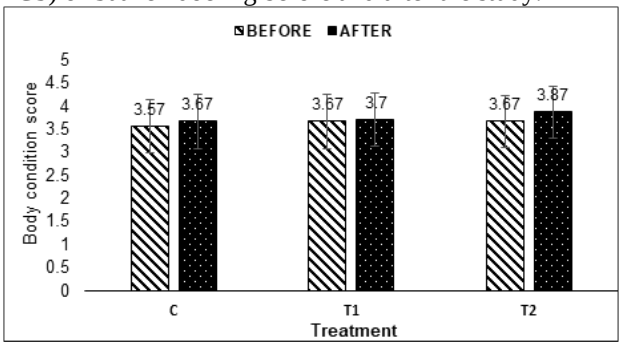

Fig. 7. Comparison of body condition score (BCS) of female Saanen goats before and after the treatment.

Figure 7 compares the Body Condition Score (BCS) of Saanen doeling before and after the study across different treatments. The analysis indicates that Treatment 2 achieved the highest BCS after the study, with a score of 3.87, followed by Treatment 1 at 3.70 and the control group at 3.67. This suggests that goats receiving Treatment 2 had better nutritional intake compared to those on the other treatments. This finding aligns with the report by Wang et al.[25], which states that goats with superior performance and nutrition generally exhibit higher body condition scores.

As noted by Karisha et al. [18], incorporating Azolla into goat feed enhances growth rates due to its rich content of essential amino acids and minerals. Healthy goats typically have a BCS ranging from 2.5 to 4.0, while scores of 1.0, 1.5, or 2.0 may indicate potential management or health issues [11]. Thus, Figure 7 shows that all animals across the various treatments maintained good BCS, with Treatment 2 achieving the highest score of 3.87. This indicates that goats in Treatment 2 likely consumed adequate feed to meet their nutritional needs for optimal productivity. To assess whether a goat's feeding program effectively supports its survival, growth, milk production, and pregnancy, evaluating the Body Condition Score (BCS) is essential [26-28].

3.5 Average Daily Gain

Average Daily Gain (ADG) is a key metric for predicting weight growth in goats, measuring the average weight gain per day over a specific period. A higher ADG indicates faster growth, which is advantageous for meat production. Figure 8a illustrates the weekly ADG of Saanen doeling under different treatments. The Control group showed modest gains with some variability throughout the weeks. Treatment 1 (T1) experienced a significant increase in Week 3 (0.16 kg), suggesting a beneficial effect of 10% Azolla supplementation during that time. However, Treatment 2 (T2) exhibited the highest ADG, with a notable peak of 0.19 kg in Week 5. The data consistently indicated that T2 had the highest ADG across all weeks. Figure 8b presents the average daily gain over the entire study duration. Results show that Treatment 2 achieved the highest ADG at 0.17 kg, followed by T1 at 0.14 kg, and Control at 0.10 kg. This superior performance in T2 suggests that goats fed a diet of 80% *B. humidicola* and 20% *A. microphylla* received optimal nutrition, making it the most effective treatment. These findings align with previous studies by Kamaruddin et al. [9], Kumari et al. [14] and Karisha et al. [18].

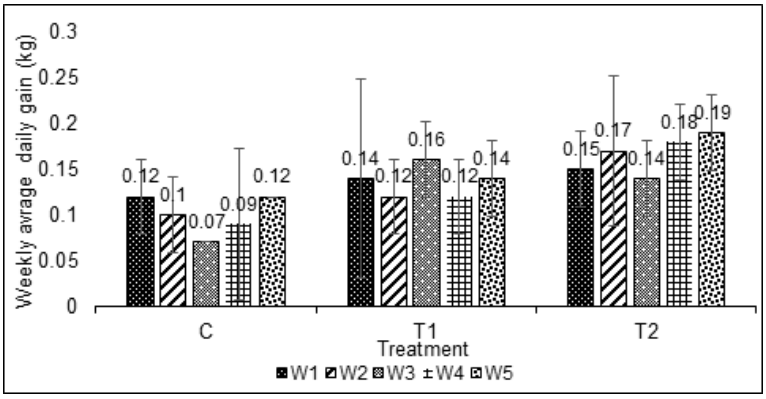

Fig. 8a. Weekly average daily gain of female Saanen goats.

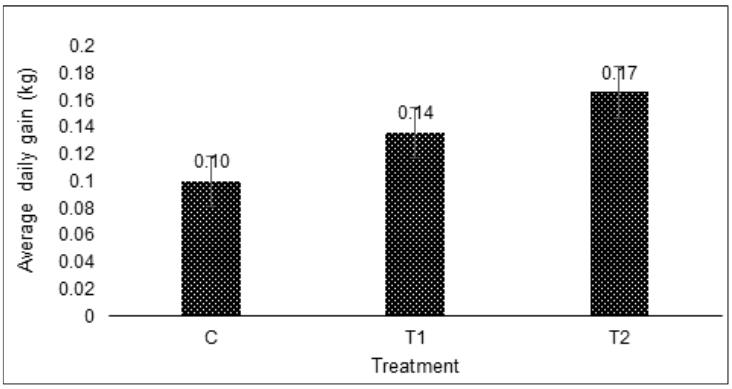

Fig. 8b. Average daily gain of female Saanen goats.

3.6 Feed Conversion Ratio

This study evaluated the effects of supplementing *B. humidicola* with *A. microphylla* on the feed conversion ratio (FCR) in Saanen doelings, a critical metric for assessing animal growth performance. FCR measures how efficiently livestock convert feed into desired outputs [12]. As shown in Figure 9a, the weekly FCR values for Saanen doeling varied across different treatments. The control group exhibited significant fluctuations, with FCR values ranging from 2.79 to 5.12, peaking in week 2 (5.12) and dropping to 2.79 in week 3, indicating inconsistent feed efficiency. In contrast, Treatment 1 (T1) showed more stable FCR values than the control, ranging from 2.25 to 4.23, with the highest value in week 2 (4.23) and the lowest in week 4 (2.25), reflecting moderate fluctuations. Treatment 2 (T2) had the most consistent and lowest FCR values, ranging from 1.84 to 3.76, with the minimum in week 1 (1.84) and a peak in week 4 (3.76). The trend of decreasing FCR values suggests improved feed efficiency over time, with Treatment 2 consistently demonstrating the best feed conversion rates compared to the other treatments.

Figure 9b highlights the differences between treatments and the average FCR of Saanen doeling throughout the study. Treatment 2 achieved the lowest average FCR at 2.72 kg, followed by T1 at 3.33 kg, and the control group at 4.41 kg. The control group's higher FCR indicates less efficient feed conversion compared to the supplemented treatments. Although T1 showed better feed efficiency than the control, Treatment 2's lower FCR suggests that goats receiving 80% *B. humidicola* and 20% *A. microphylla* had the most effective feed utilization for weight gain. These findings align with previous studies [9, 12, 16,18].

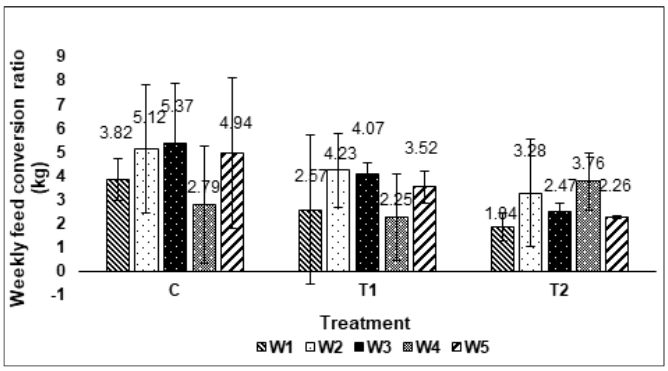

Fig. 9 Weekly feed conversion ratio of Saanen doeling.

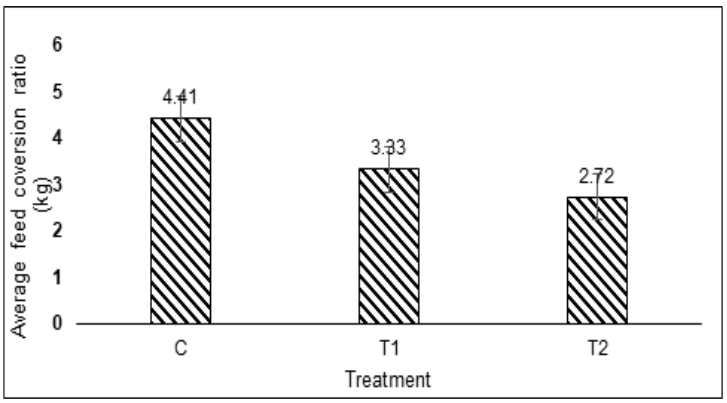

Fig. 10. Average feed conversion ratio of Saanen doeling.

4 Conclusion

This study evaluated the effect of feeding Saanen doelings a diet supplemented with Azolla sp. alongside *Brachiaria humidicola*. The findings indicate that integrating Azolla sp. significantly enhances the growth performance of Saanen doelings, as reflected in improved feed conversion ratios and overall weight gain. The combination of the nutrient-rich Azolla sp. with the tropical grass *B. humidicola* provides a balanced diet that supports better feed utilization and efficiency. The results suggest that utilizing this feeding strategy can lead to healthier, more productive goats, which is particularly beneficial for sustainable livestock management in tropical regions. Future research should explore the long-term effects of this dietary regimen and its economic viability for goat farmers. Overall, the study underscores the potential of innovative feeding practices to improve the productivity of Saanen doelings and contribute to sustainable animal husbandry.

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