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Study on relationship between gastrointestinal parasite and growth performance of male and female Saanen goats fed with Pak Chong Napier supplemented with *Azolla microphylla*

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Nematodes are the most significant in terms of prevalence and negative impact on animal health and production. Poor growth, lower productivity, death, and huge economic losses are consequences of their impact. This study aims to determine the relationship between the gastrointestinal parasite and growth performance of male and female Saanen goats fed with Pak Chong Napier supplemented with *Azolla microphylla*. The study was conducted at Kaprima Hulu Seladang Valley Farm in Setiu, Terengganu. 12 male and 12 female Saanen goats were fed with four different feeding treatment formulations. The feeding treatments that were used were Control (100% Pak Chong Napier), T1 (90% Pak Chong Napier + 10% *A. microphylla*), T2 (80% Pak Chong Napier + 20% *A. microphylla*), and T3 (70% Pak Chong Napier + 30% *A. microphylla*). Each feeding treatment was allocated to three goats with similar body weights and the feeding period was conducted for three weeks. The initial and final body weight and faecal egg count of the goats were measured before and after the feeding treatment. Results show that T2 contributes to the highest percentage reduction of faecal egg count by 38.46% and the highest average daily gain is 0.25±0.01 kg in male Saanen goats. Meanwhile, T1 contributes to the highest percentage reduction of faecal egg count by 32.67% and the highest average daily gain is 0.48±0.05 kg in female Saanen goats. In conclusion, it can be stated that the feeding treatment using Pak Chong Napier supplemented with *A. microphylla* could be able to reduce the presence of gastrointestinal parasites as well as increase the growth performance of female and male Saanen goats.

Keywords: Gastrointestinal parasite, Napier Pak Chong, *Azolla microphylla*, Saanen goat

INTRODUCTION

Dairy goat production is still considered a small entity in Malaysia's livestock sector and there is no local dairy goat breed originating from Malaysia. Breeds such as Saanen, Anglo Nubian, British Alpine, and Toggenburg have been imported into Malaysia since 1950, which started the interest in dairy goat farming (Khandoker et al. 2018). They are raised in a variety of breeding (from extensive to very intensive) and feeding (from grazing diets to entire mixed rations) systems as well as geographical locations. As a result, goats' milk output and body composition are likely to fluctuate more than those of other ruminant species (Cannas et al. 2008). Several variables, including parasite infections, have a detrimental impact on the quality and quantity of dairy goat production. Among them, gastrointestinal (GI) strongyle infection remains one of the most significant restrictions on goat production worldwide (Cringoli et al. 2008).

In the tropics and subtropics, diseases caused by helminths in small ruminants have remained a serious productivity limitation. This has resulted in higher manufacturing costs and lower productivity in developing countries. In terms of prevalence and negative impact on animal health and production, nematodes are the most significant of helminths. Poor growth, lower productivity, death, and huge economic losses are all consequences of their impacts, all of which have an impact on the livelihood of cash-strapped farmers in developing countries of the world (Adebayo et al. 2019). A suggested diet of Pak Chong Napier supplemented with *Azolla microphylla* seems to be a good formulation to promote the growth performance of male Saanen goats as both plants have a high content of beneficial nutrients.

Haryani et al. (2018) claimed that Napier or elephant grass was initially brought to Malaysia in the 1920s, and various cultivars have been produced since the 1950s. Napier grass is the most common fodder used in dairy and feedlot operations. Napier grass cultivars have been produced all over the world to suit local circumstances, and they come in a variety of habits, production potential, and nutritional value. Napier grass is a fast-growing grass with a high yearly yield that is dependent on climatic and soil conditions. The dry matter may be produced more per unit area by Napier grass than by any other crop. It may be intercropped with legumes and fodder trees, or it can be grown as a stand-alone plant.

Azolla sp. has been claimed to be a rich source of protein, essential minerals, and vitamins for livestock. Also known as the aquatic fern, Azolla hosts a symbiotic blue-green algae Anabaena Azolla, which is in charge of atmospheric nitrogen fixation and assimilation (Chatterjee et al. 2013). It is a nitrogen-fixing pteridophyte that is commonly found in a variety of aquatic environments including paddy fields (Abraham and Aeri, 2012). Because of its inherent potential usefulness for animal feed, Azolla has gained popularity among farmers in recent years. The demand for milk and meat is growing every day, but the fodder supply for livestock is decreasing, prompting the identification of new sustainable feed supplement sources (Kumar et al. 2019).

As a result, research into unconventional feedstuffs might assist to lower feed costs, like how Napier Pak Chong and *A. microphylla* are available in the local area and no import-export affairs are involved. To close the gap between demand and supply and maintain optimum livestock production throughout the year, non-conventional feed resources need to be used as a supplement or replacement for conventional feed without compromising quality. By better balancing nutrients and maximizing feed resource usage, livestock production may be improved significantly. Through this study, the new suggested feed formulation can enhance the growth performance of dairy goats while soaring the production of meat and milk and fulfilling the consumers' demand. Also changing into another rearing system and new good quality feed can lower the chance of parasitic infections.

MATERIALS AND METHODS

Study site

The study was conducted at Kaprima Hulu Seladang Valley Farm, Kampung Seladang, Terengganu, Malaysia (5° 46.0316' N, 102° 37.9862' E). This farm was chosen as it is one of the Saanen goat breeding farms in the Terengganu area.

Plant samples collection

The plant samples used in this study were Pak Chong Napier grass and *Azolla microphylla*. Both plant samples were collected in Kaprima Hulu Seladang Valley Farm, Terengganu. The Pak Chong Napier samples were harvested at average ages of 45 to 60 days using the stem-cutting method. The stem of Pak Chong Napier was cut from the soil at a height of 15-20 cm (6-8 inches) by using a sickle. While Azolla samples were collected from the cultured tanks using a sieve. Both plant samples were thoroughly washed under

tap water to remove any debris and remaining soils and then proceeded to the feeding treatment preparation.

Feeding treatment preparation

The feeding treatment formulation was prepared using the total mixed ratio (TMR) method. The TMR method was formulated using two types of plants which were Pak Chong Napier grass and *Azolla microphylla* which were collected from Kaprima Hulu Seladang Valley Farm, Terengganu. There were four feed treatments prepared which consist of Control (C), Treatment 1 (T1), Treatment 2 (T2), and Treatment 3 (T3). The Control contains 100% of Pak Chong Napier grass and 0% of *A. microphylla*, T1 contains 90% of Pak Chong Napier grass and 10% of *A. microphylla*, T2 contains 80% Pak Chong Napier grass and 20% of *A. microphylla* and T3 contains 70% of Pak Chong Napier and 30% of *A. microphylla.*

Animal samples preparation

There were 24 Saanen goats which consisted of 12 males and 12 females chosen for this study. The goats have an average age of three to four months old for males and two years old for females with body weights from 10 kg - 20 kg and 30 kg - 40 kg, respectively. Intensive rearing systems were used for goat housing in this experiment. All the goats were separated according to their genders and kept in different pens by four treatment groups. There were eight pens involved, four pens were allocated for males and the remaining four were allocated for females. Each pen was occupied by three goats that had similar body weights.

Feeding treatments experiment

The prepared feed treatments were given to the 24 Saanen goats with different ratios according to the goats' body weight. Table 1 shows the feeding treatments that were given to the goats. The feeding experiment started with the diet adaptation period for seven days before the data collection started. The goats were fed twice a day around 9 a.m. and 5 p.m. Feed intake of goats was recorded daily, and feed consumption was determined weekly to meet the daily requirement. Feeding troughs were always cleaned before a new feed was placed to ensure that the new feed was always clean and free of fungus. During the feeding adaptation period, each goat was weighed once a week, in the morning before feeding to calculate an average daily gain (ADG). Then, the feeding experiment was carried out continuously for three weeks.

Table 1. Feeding treatments diet

Group Animal	Allocated Pen	Feeding Treatments
C	1	100% of Pak Chong Napier grass
T1	2	90% of Pak Chong Napier grass + 10% *A. microphylla*
T2	3	80% of Pak Chong Napier grass + 20% *A. microphylla*
T3	4	70% of Pak Chong Napier grass + 30% *A. microphylla*

Fecal egg count data collections

The fecal egg count data collections were collected two times which were before and after the feeding experiment was conducted. The fecal samples were collected from the rectum of all 24 Saanen goats using a clean glove per recta. Approximately 4 grams of fecal samples were removed from the rectum for each goat. The collected sample was put into the zip lock bags and stored in an icebox temporarily before being taken to the laboratory. The samples were taken to the Microbiology and Microscopy Laboratory, Universiti of Sultan Zainal Abidin, Besut Campus.

2 grams of fecal matter were weighed and placed in a jar. Saturated salt (sodium chloride) solution was added to the jar. The solution was prepared by diluting common salt in distilled water until all salt cannot be dissolved anymore. The ratio used between fecal matter to NaCl solution is 1g:15 ml. The mixture of the feces and NaCl were then poured into a mortar through a sieve and ground into a paste using a pestle. The waste produced in the sieve was discarded while the liquid in the mortar was poured back into a clean jar. The jar was spun gently to stir the sediment in it. The sediment was pipetted by a clean pipette and transferred into the two chambers of the McMaster slide.

The McMaster slide was placed onto the microscope stage. The grid lines on the McMaster slide were brought into focus using the low power (4X) objective and the coarse adjustment knob. Then, the objective was turned to 10X and the grid lines were refocused using the fine adjust knob. The eggs in both chambers were counted. After the total number of egg counts from both chambers were acquired, the total was multiplied by 50 to get the approximate count of eggs per gram of feces. This multiplication factor of 50 is influenced by the ratio of feces to the flotation solution of sodium chloride. The procedure was repeated at the end of

the feeding experiments. Equation 1 shows the formulation for the total egg count.

(Chamber 1 + Chamber 2) x 50 = Total Egg Count (EPG) **Eqn. 1**

Growth performance data collection

The growth performance parameters such as body weight, body weight gain, average daily gain and feed conversion ratio were measured for each selected goat starting before, during, and after the feeding experiments were conducted.

Body weight

The body weight of all 24 Saanen goats was weighed individually by using a weighing scale. The body weight was measured in kilograms and the data were collected and recorded at 7 days intervals for three different data collection times.

Average body weight gain

The weekly average live weight gain was calculated from the difference in body weight obtained at the end and the start of the concerned period as shown in Equation 2.

Body Weight Gain = Final weight (g) - Initial weight (g) **Eqn. 2**

Average daily gain (ADG)

Average daily weight gain was estimated by dividing the total body weight gain by the number of days as shown in Equation 3.

ADG = Final weight (g) - Initial weight (g)/Days **Eqn. 3**

Feed intake

Feed intake of each pen was recorded weekly and the average feed intake was calculated by dividing the total amount of feed by the number of goats in the pen.

Feed conversion ratio (FCR)

The feed conversion ratio is one of the important parameters measured in the growth performance of an animal. The FCR is a measure of how efficiently the body of livestock converts animal feed to the desired output. The lower the feed conversion ratio, the higher the weight obtained from the feed. It was calculated by dividing the cumulative feed intake by the body weight gain of each goat for every week as shown in Equation 4.

FCR = Total feed intake (g)/Body weight gain (g) **Eqn. 4**

Statistical analysis

Data from the fecal samples were analyzed by using One-way ANOVA via Minitab version 17.0 statistics software. It was to determine the mean, standard deviation, and significant difference ($p<0.05$) for the fecal egg count and growth performance parameters.

RESULTS

Gastrointestinal parasite and growth performance of male and female Saanen goats

The relationship between gastrointestinal parasite and the growth performance of male and female Saanen goats were measured in this study.

Fecal egg counts of male and female Saanen goats

The results show a decrease in the fecal egg counts before and after feeding treatment experiments for both male and female Saanen goats. Figure 1 shows the results of the fecal egg count of male Saanen goats before and after feeding treatments while Figure 2 shows the reduced percentage of the fecal egg counts of male Saanen goats after the feeding treatments.

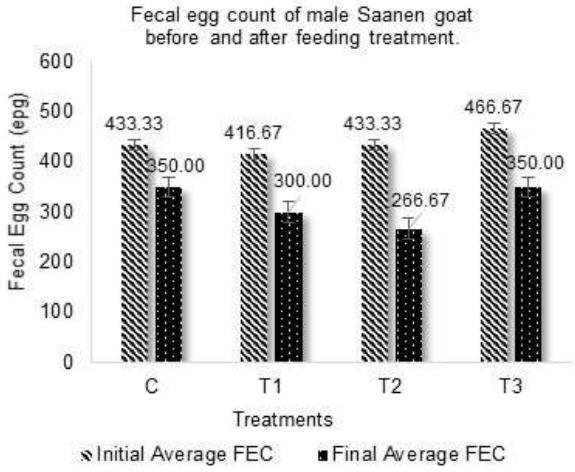

Figure 1. Fecal egg count of male Saanen goat before and after feeding treatment.

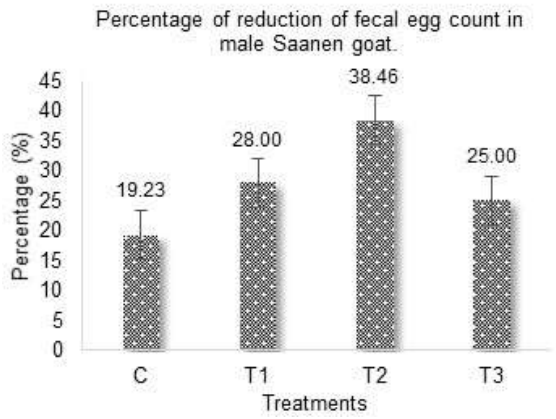

Figure 2. Percentage of reduction of fecal egg count by male Saanen goat after feeding treatment.

Based on the results, Treatment 2 shows the highest reduction of fecal egg counts for the male Saanen goat which is 38.46%, followed by Treatment 1, Treatment 3, and Control which are 28%, 25%, and 19.23 %, respectively.

Figure 3 and Figure 4 show the fecal egg count and percentage of reduced fecal egg count of female Saanen goats, respectively. Results for the female Saanen goats have shown that Treatment 1 has the highest reduction of fecal egg count which is 32.67% followed by Treatment 3 (30.77%), Control (26.09%), and Treatment 2 (24.59%).

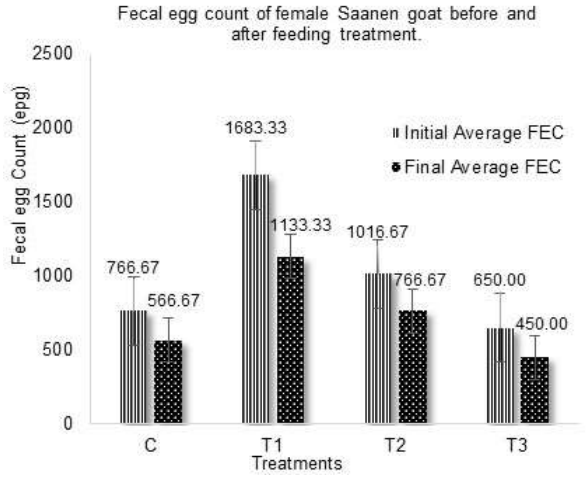

Figure 3. Fecal egg count of female Saanen goat before and after feeding treatment.

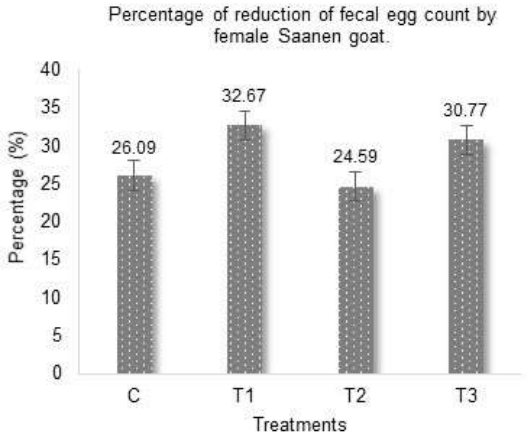

Figure 4. Percentage of reduction of fecal egg count by female Saanen goat after feeding treatment.

Body weight gain and average daily gain (ADG) of male and female Saanen goats.

Figure 5 shows the average body weight of male Saanen goats before and after the feeding treatment. Results show that every feed treatment had an enhancement in the body weight of male Saanen goats after the feeding treatment. However, Treatment 2 contributed the highest body weight gain compared to other feed treatments which are 17.67 kg followed by Treatment T3 (14.83 kg) Treatment 1(18.6 kg), and Control (16.7 kg)

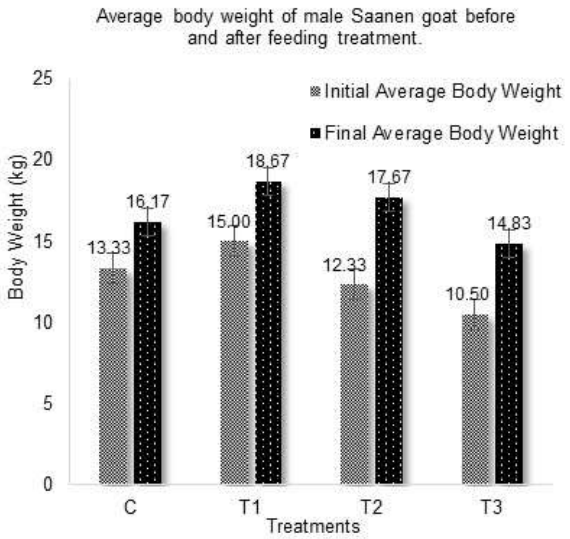

Figure 5. Average body weight of male Saanen goat before and after feeding treatment experiment.

Table 2 and Table 3 show the average mean body weight gain and average daily weight gain for the male Saanen goat, respectively.

Table 2. Average body weight gain of male Saanen goat

Parameter	C	T1	T2	T3
ABWG (kg)	0.95± 0.48	1.22± 0.68	1.78± 1.21	1.44± 2.07

Table 3. Average daily body weight gain of male Saanen goat.

Parameter	C	T1	T2	T3
ADG (kg)	0.13± 0.03^{b}	0.17± 0.03^{ab}	0.25± 0.01^{a}	0.21± 0.06^{ab}

Note: Values are Mean ± SD. Different letters in superscript (^{ab}) within the same row indicate a significant difference ($p<0.05$) among the treatments.

Based on the results, Treatment 2 shows a 1.78 kg increase in body weight after the feeding treatments while there are 1.44 kg was increased for Treatment 3 and 1.22 kg was increased for Treatment 1 and only 0.95 kg was increased for the Control Treatment. Even for daily weight gain, Treatment 2 shows a significant difference ($p < 0.05$) in increasing the body weight gain for the male Saanen goat with 0.25 kg followed by Treatment 3 with 0.21 kg, Treatment 1 with 1.7 kg, and Control only 0.13 kg.

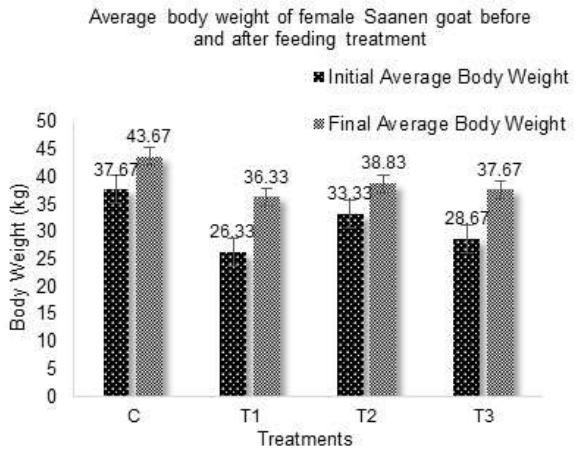

Figure 6. Average body weight of female Saanen goat before and after feeding treatment experiment.

Figure 6 shows the average body weight of female Saanen goats before and after feeding treatment experiments. The results show that Treatment I contributed to the highest body weight gain in the female Saanen goat compared to other feed treatments which is 36.33 kg followed by Treatment 3 with 37.67 kg, Treatment 2 with 38.83 kg, and Control 43.67 kg.

Table 4 and Table 5 show the average mean body weight gain and average daily weight gain for the female Saanen goat, respectively. Based on the results, Treatment 1 shows a 3.33 kg increase in body weight gain. In the daily weight gain, T1 also shows a significantly different ($p < 0.05$) in increasing the body weight gain for the female Saanen goat.

Table 4. Average body weight gain of female Saanen goat.

Treatment	C	T1	T2	T3
ABWG (kg)	2.00± 0.58^{a}	3.33± 1.53^{a}	1.83± 0.44^{a}	2.90 ±2.14^{a}

Note: Values are Mean ± SD. Different letters in superscript (^{ab}) within the same row indicate a significant difference ($p<0.05$) among the treatments.

Table 5. Average daily body weight gain of female Saanen goat.

Treatment	C	T1	T2	T3
ADG (kg)	0.29± 0.08^{b}	0.48± 0.05^{a}	0.26± 0.06^{b}	0.41± 0.07^{a} ^{b}

Note: Values are Mean ± SD. Different letters in superscript (^{ab}) within the same row indicate a significant difference ($p<0.05$) among the treatments.

Feed Conversion Ratio (FCR)

Table 6 and Table 7 show the feed conversion ratio for male and female Saanen goats.

Table 6. The feed conversion ratio of male Saanen goats.

Item	C	T1	T2	T3
FCR	3.1± 0.58^{a}	2.9± 0.48^{ab}	1.63± 0.09^{b}	1.7± 0.53^{b}

Note: Values are Mean ± SD. Different letters in superscript (^{ab}) within the same row indicate a significant difference ($p<0.05$) among the treatments.

Table 7. The feed conversion ratio of female Saanen goat.

Item	C	T1	T2	T3

FCR	5.56± 1.9[a]	2.42± 0.243[b]	5.55± 1.207[a]	3.05± 0.574[ab]

Note: Values are Mean ± SD. Different letters in superscript ([ab]) within the same row indicate a significant difference (*p<0.05*) among the treatments.

As tabulated in Table 6, the different feeding treatments showed a significant difference in the feed conversion ratio of male Saanen goats with a *p-value* is 0.006. In male Saanen goats, Treatment 2 has the lowest FCR with 1.59±0.09 compared to other treatments, C, T1, and T3 with FCR values of 3.19±0.58, 2.8±0.48 and 1.7±0.53, respectively. Meanwhile, in Table 7, the different feeding treatments showed a significant difference in the feed conversion ratio of female Saanen goats with a *p-value* is 0.020. In female Saanen goats, Treatment 1 has the lowest FCR with 2.42±0.24 compared to other treatments, C, T2, and T3 with FCR values of 5.56±1.93, 5.55±1.21 and 3.05±0.57, respectively.

DISCUSSIONS

Gastrointestinal parasite and growth performance of male and female Saanen goats

Fecal egg counts of male and female Saanen goats

Both male and female Saanen showed a decrease in fecal egg count (FEC) after having the new feed formulation. The factor that contributes to the reduction of the FEC was because of the changes in the goat's feeding. The former feeding of *Brachiaria humidicola* was changed to a mixture of both types of grass, Napier Pak Chong and *Azolla microphylla*. According to Income et al. (2021), the ingestion of infective-stage larvae or eggs is how most gastrointestinal helminths infect animals. The reduction of FEC in the goats can probably be ascribed to the presence of condensed tannins in *Azolla sp*. as reported by Bunyeth and Preston (2006) and Brouwer et al. (2019).

Body weight gain and average daily gain (ADG) of male and female Saanen goats.

Treatment 2 with 80% of Pak Chong Napier and 20% of *Azolla microphylla* contributed to the highest body weight gain and average daily gain in males mean while Treatment 1 with 90% of Pak Chong Napier and 10% of *A. microphylla* contributed to the highest body weight gain and average daily gain in female. Both genders favoured different treatments because they have different nutrient requirements. In this experiment, the kids with an average of three to four months are classified as the grower group and female adults with two years of age are considered as breeder or maintenance groups. Both groups required different diet plans. Adult female Saanen weighed from 30 kg – to 40 kg and needed approximately 51 g – 60 g of protein daily while young Saanen weighed from 10kg – to 20kg and needed about 22 g – 38 g of protein per day (Novianti et al. 2021). T1 has a higher protein level due to more portion of Pak Chong Napier which was suitable for adult female Saanen. Meanwhile, T2 has a lesser protein level which is compatible with the nutrient requirements of young male Saanen. According to Almeida et al. (2015), gender did not affect the energy requirements for maintenance. However, it did influence the energy requirements for gain. The energy maintenance requirement comprises basal metabolism (e.g., cellular activity, respiration, blood flow, etc.) plus energy expenditure due to feeding, digestion, and absorption (National Research Council (NRC), 1981; Hynd 2019). The NRC (2007) states that the energy maintenance requirements of intact males are 15% greater than those of females and castrated males. These recommendations are based on the concept that males have more protein the energy requirements for growth differ among male and female goats (Almeida et al. 2015).

Feed Conversion Ratio (FCR)

The lower feed conversion ratio in goats signified that the goats had converted the feed effectively (Mira et al. 2018). Hence, T2 in males and T1 in females were proven to contribute to high body weight gain only with a small amount of feed intake. A similar study by Kumari et al. (2021) shows that the same treatment group, gives the lowest FCR value compared to other groups because it has a higher digestibility and total Dry Matter Intake (DMI). The reduction of FEC in goats can probably be ascribed to the presence of condensed tannins in *Azolla sp*. as reported by Wanapat et al. (1997). According to Min et al. (2003) and McSweeney et al. (2008), moderate levels of tannins (from 4 to 10%) generally result in positive effects against parasites without negative consequences to animal health. Thus, the previous study, reported that tannin-rich sainfoin feed contained 4.06% of condensed tannins, within the lower range reported to improve FEC or blood parameters in ruminants (Min and Hart, 2003; Costes et al. 2018).

CONCLUSION

There is a positive and significant relationship between the gastrointestinal parasite and growth performance of male and female Saanen goats fed with Pak Chong Napier supplemented with *Azolla microphylla*. This study shows that Treatment 2 with 80% Pak Chong Napier and 20% *A. microphylla* contributes to the highest percentage reduction of fecal egg count by 38.46% and the highest average daily gain, 0.25±0.014 in male Saanen goats. Meanwhile, females favour Treatment 1 with 90% Pak Chong Napier and 10% *A. microphylla* contributing to the highest percentage reduction of fecal egg count by 32.67% and the highest average daily gain, 0.43±0.048. Males and females favour different treatments due to different diet plan requirements. Treatment 1 and Treatment 2 shows significant changes in body weight gain in female and male, which might appear due to the better effect of the Azolla feed supplement on growth performance if used at a moderate level. However, more study on the relationship between gastrointestinal parasite and growth performance in a larger sample size of comparable and different goat breeds in various parts of the country is required. Further *in vitro* studies for the reduction of FEC of Saanen goat in *A. microphylla* are needed to clarify whether the formulated feed could reduce or inhibit the parasitic growth in the Gastrointestinal tract in goats.

CONFLICT OF INTEREST

The authors have declared that the present study was performed in the absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

NAK devised the project, the main conceptual ideas, manuscript preparation, and proof outline. NAAKA, NQAMA, NAAR, and INH performed animal treatments, data collection, and data analysis. All authors read and approved the final version.

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