Global Journal of Food and Agricultural Sciences Vol. 10 (10), pp. 001-009, October, 2024. Available online at www.internationalscholarsjournals.org

Full Length Research Paper

Impact of Protein Supplementation on Weight Gain and Dressing Percentage in West African Dwarf Goats Infected with *Haemonchus contortus* and *Trichostrongylus colubriformis*

Linus I. Mhomga[1*], Pius A. Nnadi[2], Samuel N. Chiejina[3], Idika K. Idika[4] and Lucas A. Ngongeh[3]

[1]Department of Animal Health and Production, College of Veterinary Medicine, University of Agriculture, PMB 2373, Makurdi, Benue State- Nigeria,
[2]Department of Animal Health and Production, University of Nigeria, Nsukka;
[3]Department of Veterinary Microbiology and Parasitology, Michael Okpara University of Agriculture, Umudike;
[4]Department of Veterinary Parasitology and Entomology, University of Nigeria, Nsukka.

Accepted 13 July, 2024

The body weight and dressing percentage of West African Dwarf (WAD) goats affected with mixed gastrointestinal (GI) nematode infections were measured as part of a study to determine the impact of protein supplementation. Based on body weight, four groups (A-D) of five worm-free male WAD goats aged 6 to 8 months were created. While groups C and D were fed simply forages, animals in groups A and B were offered forages together with concentrate supplements. *Trichostrongylus colubriformis* (Tc) and *Haemonchus contortus* (Hc) were experimentally infected on Groups A and D, respectively, but not on Groups B or C. The goats were given single doses of 500 L3 in week 1, 1000 L3 in week 2, 2000 L3 in week 3, and 4000 L3 in week 4 of a weekly trickle-escalating infection with the parasites' infective larval stage (L3). Using accepted methods, body weight, faecal egg counts (FEC) per gramme of faeces, and worn burden (Wb) were calculated. Following the animals' painstaking sacrifice, the experiment's dressing percentage was calculated. The outcomes revealed a Day 42 (D42) body weight and worm burden had a significant negative connection ($r_p = -0.76$; $P = 0.01$). BCS on D42 was likewise significant and had a weak negative correlation ($r_s = -0.72$; $P = 0.02$) with worm burden. Groups A and B had a mean dressing % that was substantially higher than groups C and D's (P 0.05). For groups A, B, C, and D, the mean SEM dressing percentages were 59.4 0.6, 60.6 0.7, 56.8 0.4, and 52.4 2.0, respectively. Between groups A and B, there was no statistically significant difference ($P > 0.05$). The number of Hc and Tc faecal eggs on D40 and D42 significantly correlated with the number of D42 worms ($r_p = 0.74$; $P = 0.01$). We came to the conclusion that supplementing lessened the unfavourable effects of infections on body weight, which enhanced dressing percentage.

Keywords: Body weight, dressing percentage, WAD goats, faecal egg counts, worm burdens.

INTRODUCTION

The WAD goat is of major economic importance to rural communities. It serves as a ready source of supplementary income, constitute a major component of the scarce animal protein supply, helps in bush control and provision of organic manure to farmlands, and a source of raw material to leather industry.

Efforts to improve the rather low productivity of the WAD goat through modern intensive rearing and management have been hampered by difficulties in preventing and controlling major infectious diseases. Gastrointestinal parasitism is an important health constraint in goats, which limits their productivity by impairing weight gain (Githigia et al., 2001), depressing milk production, altering body composition leading to condemnation of carcasses and organs (Coop, 1982) and death among kids.

The only modern worm control option available to goat farmers is the use of anthelmintics. However, research has now focused on the alternative control strategies that are sustainable and affordable to small scale goat farmers. Some of the strategies being considered are, manipulation of host nutrition (Van Houtert and Sykes, 1996; Coop and Kyriazakis, 1999), development of parasite resistant genotypes (Mandonnet et al, 1996; Pralomkarn et al., 1997), the use of plants secondary metabolites (Athanasiadou et al., 2003; Min and et al., 2003) and nematode-trapping fungi (Valencia et at., 2008). Previous studies have demonstrated the effects of GI nematodes on haematological and parasitological effects on WAD goats. However, the effects on dressing percentage in WAD goats has not been given due attention. Therefore, this experiment was conducted to determine the effect of experimental mixed nematode infections on the dressing percentage and the body weight of WAD goats.

MATERIALS AND METHODS

Animals and their Management

Twenty healthy male WAD goats aged between 6 - 8 months were sourced from local markets. The animals were identified using a neck tag, weighed to determine their live weights and the body condition scores were assessed. Subsequently, all the animals were drenched with the anthelmintic fenbendazole (Panacur^{R}) at 7.5mg/kg body weight and a coccidiostat diclazuril (Vecoxan^{R}) at 1mg/kg body weight. In addition, they were vaccinated against *peste des petits ruminants* (PPR) and the whole body liberally dusted with insecticide/acaricide powder (6% permethrin) to rid them of ectoparasites. They were also treated prophylactically with oxytetracycline (Tridox)^{R}, at the dose rate of 20mg/kg body weight. Animals were fed twice daily (9.30am and 3.30pm) with cut-and-carry forages harvested from experimental plots inaccessible to other livestock. Groups A and B were supplemented daily with 300 grammes of concentrate mix containing 17.06% crude protein in addition to the forages. The feed was analyzed using AOAC (2000) procedures, while neutral-detergent fibre (NDF) and ash were determined according to Goering and Van Soest (1970). Water was provided ad libitum.

*Correspondence author's E-mail address: mhomga@yahoo.com; Tel: +234 8062430635.

Experimental design.

The goats were assigned to four groups labeled A, B, C and D, with five animals per group. Groups A and B were supplemented while C and D were fed only forage. The experimental animals were acclimatized for four weeks to adapt to their respective diets. Groups A and D were selected and infected with Hc and Tc at the end of the adaptation period, while group B and C were not infected. On the first day (D0) of the infection, a single dose of 500L3 was administered to the infected groups. Doses of 1000 L3, 2000 L3 and 4000 L3 were administered in the second, third and fourth week respectively. Body weights and body condition scores were determined on D0, and then subsequently on a weekly basis while feed intake was determined on a daily basis. At the end of a 42 day period, the animals were humanely sacrificed and both the abomasal and intestinal worms were recovered for worm counts. The carcass was then weighed to calculate the dressing percentage.

Determination of feed consumption.

Left-over forage was carefully recovered every morning from each pen before fresh forage was offered to the animals and weighed. The difference between what was given the previous day and the leftover forage was taken as the forage consumed by all the animals in the group. The same was done for the concentrates for those groups that were fed concentrate.

Body weight and body condition score.

A weighing balance was used to measure the live weights of the animals as described by Nnadi et al. (2007). Animals were weighed on the day of arrival and weekly thereafter till the end of the study. Mean weekly gain in body weight per group was thereafter calculated by subtracting the mean body weight of the previous week from the current one. The body condition scores (BCS) of all the animals were also assessed on arrival and subsequently once weekly (Detweiler et al., 2008).

***Haemonchus contortus* and *Trichostrongylus colubriformis*.**

Infective larvae (L_3) of local strains of Hc and Tc isolated from WAD goats, in Nsukka area and subsequently maintained in worm-free WAD goats (Musongong et al., 2003) was harvested from faecal cultures of donor goats kept at the experimental parasitology animal house. The recovered L3 were stored at 10^0C in a refrigerator and used within two weeks of recovery from cultures. The methods of preparation of larval inoculums and administration of larvae were as described by Fakae et al. (1999). Infected animals were placed on a regime of, escalating infection (Chiejina et al., 2005) for four consecutive weeks. The relative proportions of Hc (40%) and Tc (60%) L3 in the inocula were determined.

Faecal worm egg count and worm burden.

Fresh faecal samples were collected from all infected animals once a week between D0 and D14 and subsequently daily from D15 until patency in all the infected animals to determine prepatent period, using centrifugal flotation in saturated salt (NaCl) solution (Hansen and Perry, 1994). After patency was established (D23), faecal egg counts (FECs) were carried out twice weekly using a combination of salt flotation and a modified MacMaster technique (MAFF, 1971; Hansen and Perry, 1994). The two weekly FECs were averaged and the data expressed as weekly FEC for each goat from which mean weekly group FECs were determined. At termination of the experiment all the infected animals were humanely sacrificed and worms recovered for total and differential worm counts as described by Fakae et al. (1999).

Determination of carcass dressing percentage.

Immediately after slaughter animals were singed and eviscerated. The eviscerated warm carcasses were weighed to determine carcass weight, which was used, together with the appropriate live weight of each animal, to calculate the dressing percentage

Statistical Analysis.

The data collected were analyzed using the statistical package SPSS (version 15.0 for windows). Data on FECs and worm burdens were normalized using $\log_{10}$ (FEC +1) and $\log_{10}$ (wb +10) respectively. Carcass dressing percentage was analyzed using one-way ANOVA. Data on other parameters (body weight, BCS and feed intake) were analyzed by repeated measures analysis of variance (rmANOVA) using General Linear Model (GLIM) (Crawley, 1993) with time as the within subject factor and treatments as between subject factors. Correlations between variables were analyzed by Pearson's Test. Probabilities (P) of 0.05 or less was considered significant.

RESULTS

Body weight

The body weight of goats in supplemented groups (A and B) increased throughout the period of the experiment. However, those of goats in the unsupplemented groups (C and D) remained static during the first 14 days of study, followed by a period of loss in body weight. Comparison between the mean increases in A and B showed that these were comparable (figure. 1). However, at the end of the study, groups A and B gained 14.4% and 18.7% of their initial (D0) body weight, respectively. In contrast, groups C and D lost 9% and 22% of their D0 weight, respectively, over the same period. The effect of diet on body weight gain was significant ($F_{3,16}$ = 5.21, P < 0.011). The mean body weight of A and B were comparable throughout the period of study ($F_{1,8}$ = 1012.6, P > 0.05) as well as between groups C and D ($F_{1,8}$ = 193.8, P > 0.05). However, there was a significant difference between A and D ($F_{1,8}$ = 285.3, P =0.01) and between B and C ($F_{1,8}$ = 614.5, P= 0.009).

Body condition score

There was a strong correlation between diet and BCS as shown in figure 2. Diet had a significant effect on the BCS ($F_{3,16}$ = 1.46, P < 0.001). Groups A and B had comparable BCSs but A was significantly higher than D (P < 0.05). Similarly, the BCS of group B was significantly higher than C (P < 0.05). However, the BCS of groups C and D were comparable (P > 0.05).

Feed intake

The patterns of feed consumption in groups A and B were similar, while those of groups C and D were also similar (figure. 3). Generally, diet had a significant effect on feed intake among the various groups ($F_{3,16}$ = 6.63, P = 0.004). Group A consumed a significantly lower amount of feed than B ($F_{1,8}$ = 4.9, P = 0.04), while the amount of feed consumed by C was significantly higher than D ($F_{1,8}$ = 1.01, P = 0.043). Group B was significantly higher than D ($F_{1,8}$ = 9.56, P = 0.011) but was not significantly different from group C. Group A also consumed a significantly higher amount of feed than D($F_{1,8}$ = 5.46, P = 0.012), but no difference was observed between A and C .

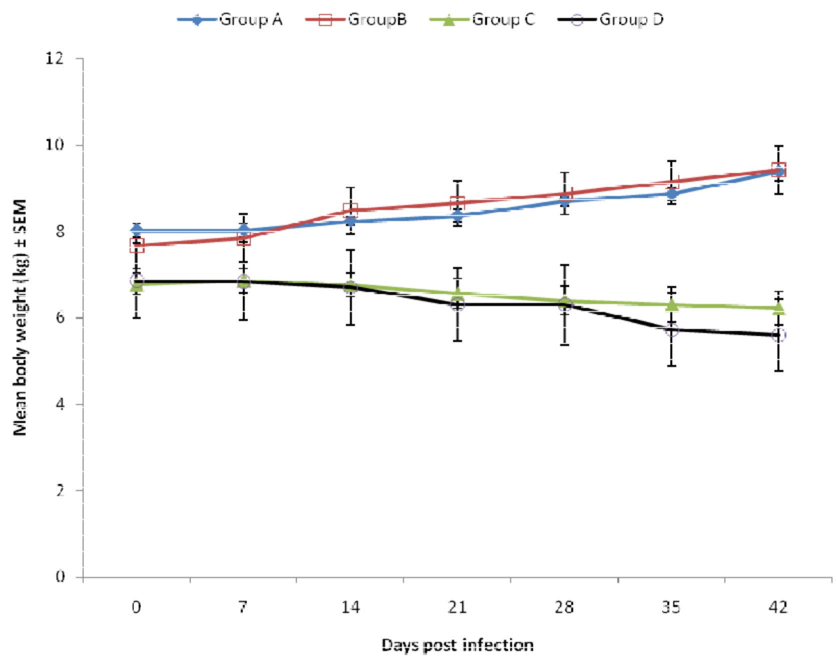

Figure 1. Effect of *H.contortus* and *T. colubriformis* infections on body weight

Legend
Group A – Infected supplemented
Group B – Uninfected supplemented
Group C – Uninfected un-supplemented
Group D – Infected un-supplemented

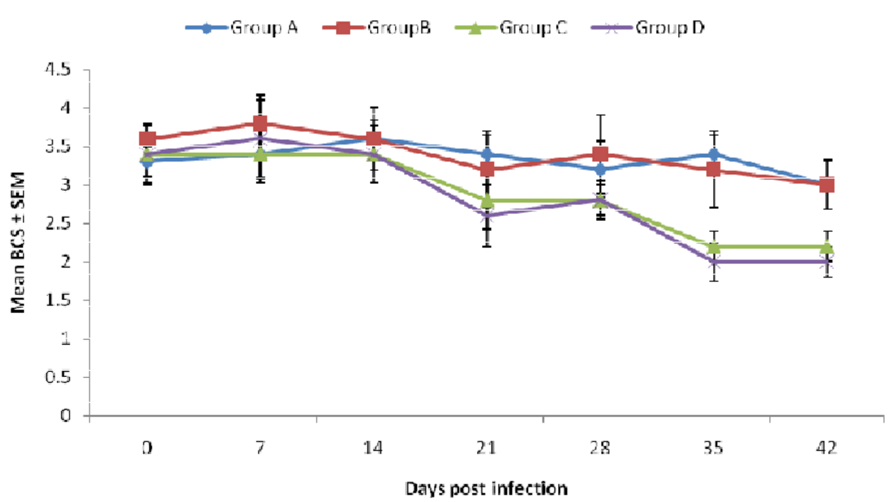

Figure 2. Body condition scores of experimental goats

Legend
Group A – Infected supplemented
Group B – Uninfected supplemented
Group C – Uninfected unsupplemented
Group D – Infected unsupplemented

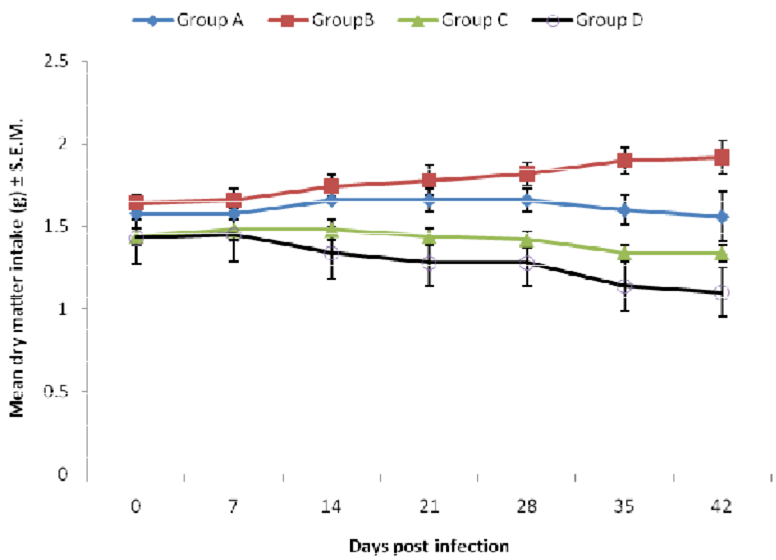

Figure 3. Variation in feed intake of experimental goats

Legend
Group A – Infected supplemented
Group B – Uninfected supplemented
Group C – Uninfected unsupplemented
Group D – Infected unsupplemented

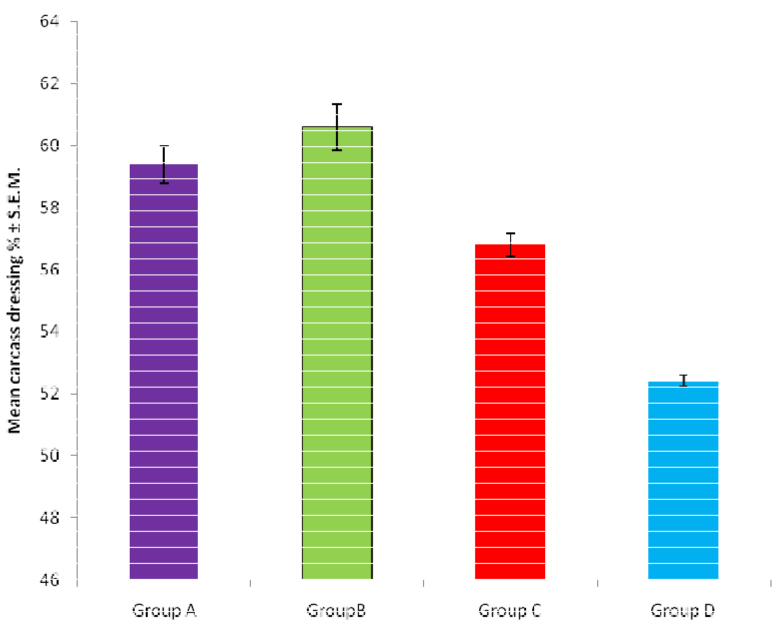

Figure 4. Dressing percentage of experimental goats

Legend
Group A – Infected supplemented
Group B – Uninfected supplemented
Group C – Uninfected unsupplemented
Group D – Infected unsupplemented

Carcass dressing percentage

Figure 4 shows the mean carcass dressing percentage of the various groups. Groups A and B had a significantly higher dressing percentage than groups C and D ($P < 0.05$). The mean, ± S.E.M, dressing percentages for groups A, B, C and D were 59.4 ± 0.6, 60.6 ± 0.7, 56.8 ± 0.4 and 52.4 ± 2.0 respectively. There was no significant difference between groups A and B. However, there was a significant difference between group D and groups A, B and C ($P < 0.05$).

Faecal egg counts

Figure 5 shows the FEC profile of the infected groups. Patency was established in both groups on D23, and on D29, all the animals became patent. Peak mean FECs in groups A and D occurred on D40 and D38 respectively. The mean FEC for group D was significantly higher than A ($F_{1,8} = 13.59$, $P < 0.001$).

Worm burden

The combined *H. contortus* (Hc) and *T. colubriformis* (Tc) worm counts are illustrated in figure 6. Group A had a mean, ± S.E.M. worm burden of 102 ± 22.4 due to *H .contortus* while group D had 326 ± 51.34 due to the same species which was significantly different ($P < 0.05$). Similarly, group A mean, ± S.E.M. for *T.colubriformis* burden was 712 ± 101.6, while group D had 1102 ± 115.68 due to the same worm specie which was also significantly different ($P < 0.05$).

DISCUSSION

Animals in group A were able to put on weight over time in spite of worm load. However, groups C and D experienced losses in body weight over time. The loss in body weights recorded by goats in groups C and D were probably due to insufficient amount of metabolizable crude protein in the forage. Although group D had a lower growth rate than group C, the difference was not significant. The difference in body weight gain between the two infected groups (A and D) was significant. This could be due to the fact that group A, which was infected and supplemented had adequate metabolizable protein for maintenance and growth of body tissues whereas group D which was not supplemented could not support gain in body weight. It is therefore apparent that adequate protein nutrition under mixed GI nematode infections enhanced the capability of goats to withstand the effects of infection. This agrees with earlier reports in cattle (Louvandini et al., 2003).

Goats in the supplemented groups had a better body condition score throughout the period of the study relative to those in the unsupplemented. This is in agreement with the earlier report by Okello and Obwolo (1984). Body condition score is an assessment which reflects the rate of lypogenesis, muscular development and rib coverage (Detweiler et al., 2008). Therefore, the good BCS observed in the supplemented groups was probably due to the conversion of excess nutrients after the normal body requirements into fat deposits. The drop in BCS of groups C and D towards the end of the experiment might be attributed to drop in feed quality due to lignification of the grasses, since the drop was hardly noticeable in the two supplemented groups. Obioha and Ndukwe (1976) had observed that forages during the dry season have low protein content and marked decrease in digestibility. This might also partly explain the significant effect of time on the body weight and BCS of all the groups. There was a significant negative correlation between worm burden and body weight and also between worm burden and BCS. This is in agreement with earlier findings (Nnadi et al., 2007).

Reduction in voluntary feed intake is a common feature of gastrointestinal nematode infections. It has been reported that following infection with GI nematodes, there is usually a 10% reduction in voluntary feed intake (Kyriazakis et al., 1994). In this study, feed intake was affected by the infections as there was a significant difference in the dry matter intake between the infected supplemented and uninfected supplemented. The infected unsupplemented and uninfected unsupplemented also varied significantly. This agrees with earlier reports by Abbot et al. (1985). They demonstrated that the degree of inappetance varies with the level and duration of parasitism and also the level of protein intake. In this study, significant differences were noticed on D28 post infection.

The dressing percentage of groups A and B were comparable as well as those of C and D. However, there was a significant difference between the dressing percentage of group A and that of group D. This is in agreement with earlier studies by Payne and Wilson (1999) where dressing percentage was found to increase with increasing levels of concentrate supplementation. Another reason why the dressing percentage of the supplemented groups where higher than those of the unsupplemented groups, might be the high fibre content in the forages, which is capable of affecting the carcass yield negatively. The high carcass yield in group A compared with group C showed the positive influence of supplementation during infection. It was also observed that the level of metabolizable protein available to group C was inadequate for optimum carcass yield even though the group was not infected.

In this study, both the supplemented and unsupplemented groups became patent on D23 post

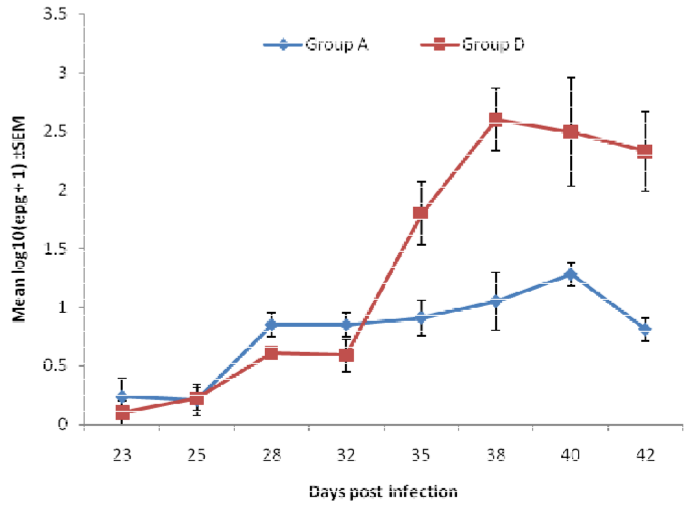

Figure 5. Faecal egg counts of infected goats

<u>Legend</u>
Group A – Infected supplemented
Group D – Infected un-supplemented

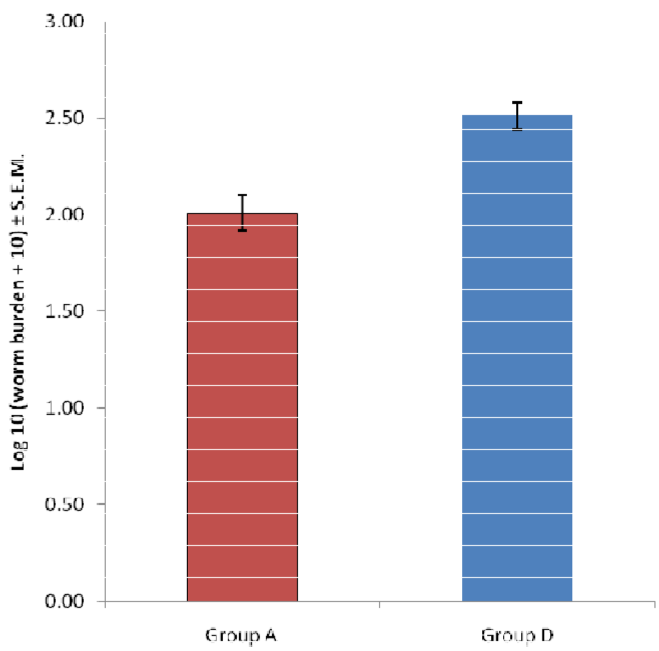

Figure 4. Worm burden of infected goats

<u>Legend</u>
Group A – Infected supplemented
Group D – Infected un-supplemented

Table. Proximate analysis of Experimental Feed.

Nutrient	Dry Matter	Ash	Ether extract	Crude fibre	Crude protein	ADF	Lignin	Cellulose
Forage (Bracharia spp & Panicum maximum) (%)	88.85	8.0	0.22	34.2	8.5	48.8	43.3	9.08
Concentrates ration (growers Mash & palm kernel cake) (%)	95.3	5.4	0.18	12.2	17.06	34	24.8	5.47

infection. This result contradicts earlier reports (Nnadi et al., 2007) in WAD goats where they observed a longer prepatent period in animals on high protein diet than those on low protein diet. The reason for this difference could be due to the fact that relatively young WAD goats that are presumed to be highly susceptible were used in this study, whereas the earlier study used relatively matured animals. This argument is supported by the nutrient partitioning framework developed by Coop and Kyriazakis (1999), in which the prepatent periods of helminths were not affected during the phase of acquisition of immunity by young animals. On the other hand, for animals at the phase of expression of immunity, plane of nutrition substantially affects the prepatent period. Consequently, the faecal egg counts per gram of faeces of the malnourished group were significantly higher than those of the supplementSed group. This agrees with earlier reports in sheep (Abbot et al., 1988; Coop et al., 1995 Van Houtert et al., 1995; Datta et al., 1998) and goats (Etter et al., 2000; Nnadi et al., 2007), where animals placed on high protein diet had lower FEC compared to low protein group.

Generally, malnutrition would be expected to promote the establishment, survival, and fecundity of GI nematodes, but the magnitude of these effects depend on factors such as breed, parasite species, particular infection protocol used, magnitude of infection, severity of the nutritional deficiency and presence of single or multiple infections and single or multiple nutritional deficiencies (Koski and Scott, 2001). In this study, supplementation of the diet lowered the worm burdens of both Hc and Tc. The mean percentage worm recovery for Tc was 25.3 ± 4.1 and 35.9 ± 3.8 for groups A and D respectively, while that of Hc was 2.3 ± 0.5 and 3.9 ± 0.8 for groups A and D respectively. However, the overall percentage recoveries were very low compared to earlier results obtained in experimental infections with Hc in this breed of goats (Fakae et al., 2004). Several factors might be responsible for these low worm burdens. The well known strong innate resistance of Nigerian WAD goats to Hc in particular and GI nematodes in general (Chiejina et al., 2010) might be responsible for the low recoveries. Other factors could be the poor infectivity of the isolates for the goats and rapid rejection/ loss of worms soon after their establishment in the host due to effective immune response by the host. Despite the generally low worm burdens recorded in this study, the role of nutrition was obvious in the two infected groups (A and D), as the worm burdens of the malnourished goats were significantly higher than those of the supplemented group. On the other hand, the difference in worm burden between groups A and D might be due to the fact that protein supplementation influences the degree of expression of immunity which can manifest as reduced establishment or arrested development of incoming larvae and as reduced survival and fecundity of the established worms. This study has shown that adequate nutrition could enhance the resilience of goats to parasitic infections, which will reduce the losses in production experienced by peasant goat keepers as a result of their inability to access veterinary services.

ACKNOWLEDGEMENT

We are grateful to Professor S.N. Chiejina for providing the facilities and materials used in this research work. We appreciate the assistance of Mr. Mike Ugwoke and Mr. Moses Asogwa in the management of the experimental animals.

REFERENCES

Abbot EM, Parkins JJ, Holmes PH (1985). Influence of dietary protein on the pathophysiology of ovine haemonchosis in Finn Dorset and Scottish Blackface lambs given a single moderate infection. Res. Vet. Sci. 38: 54- 60.

Abbott EM, Parkins JJ, Holmes PH (1988). Influence of dietary protein on the pathophysiology of haemonchosis in lambs given continuous infections. Res. Vet. Sci. 45: 11-19

Association of Official Analytical Chemists (AOAC) (2000). Official Methods of Analysis, 17th ed., Washington DC.

Athanasiadou S, Kyriazakis I, Jackson F (2003). Can plant secondary metabolites have a role in controlling gastrointestinal nematode parasitism? In: Proceedings of the VI international Syposium on the Nutrition of Herbivores, 19-24 October 2003, Meridfa Mexico

Chiejina SN, Behnke JM, Musongong GM, Nnadi, PA, Ngongeh LA (2010). Resistance and resilience of West African goats of the Nigerian savvana zone exposed to experimental escalating primary and challenge infections with *Haemonchus contortus*. Vet. Parasitol. 171: 81-90.

Chiejina SN, Musongong GA, Fakae BB, Behnke JM, Ngongeh LA, Wakelin D (2005). The modulatory influence of *Trypanosoma brucei* on challenge infection with *Haemonchus contortus* in Nigerian West African Dwarf goats segregated into weak and strong responders to the nematode. Vet. Parasitol. 128: 29-40.

Coop RL (1982). Impact of Sub-clinical Parasitism in Ruminants. In: Methric, D.F. and S.S. Desser (Eds.) Parasites, their world and the Amsterdam. Elsevier Biochemical Press Publishers, the Netherlands, pp 439-447.

Coop RL, Huntley JF, Smith WD (1995). Effect of dietary protein supplementation on the development of immunity to *Teladorsagia circumcincta* in growing lambs. Res. Vet. Sci. 30: 21 – 29.

Coop RL, Kyriazakis I (1999). Nutrition parasite interaction. Vet. Parasitol. 8: 187-204.

Crawley MT (1993). GLIM for Ecologists. Blackwell Scientific Press, Oxford. Pp 379.

Datta FU, Nolan J, Rowe J, Gray G (1998). Protein supplementation improves the performance of parasitized sheep fed a straw-based diet Int. J. Parasitol. 28:1269 – 1278.

Detweiler G, Gipson T, Merkel RC, Goetsch A, Sahlu T (2008). Body Condition Scores in Goats. In: Proceedings of 23rd Annual Goat Field Day, Langston University, Langston. Pp 127-133.

Etter E, Hoste H, Chartier C, Pors I, Koch C, Broqua C, Coutineau H (2000). The effect of two levels of dietary protein on resistance and resilience of dairy goats experimentally infected with *Trichostrongylus colubriformis:* comparison between high and low producers. Vet. Res. 31: 247 – 258.

Fakae BB, Chiejina SN Behnke JM, Ezeokonkwo RC, Nnadi PA, Onyenwe WI, Gilbert FS, Waklin D (1999). The response of Nigerian West African Dwarf Goats to experimental infections with *Haemonchus contortus*. Res. Vet. Sci. 66: 147 – 158.

Fakae BB, Musongong GA, Chiejina SN, Behnke JM, Ngongeh LA, Wakelin D (2004). Variability in the resistance of the Nigerian West African Dwarf goat to abbreviated escalating trickle and challenge infections with *Haemonchus contortus*. Vet. Parasitol. 122: 55-66.

Githigia SM, Thamsborg SM, Maingi N, Munyua WK, Nanseen P (2001). The impact of gastrointestinal helminths on production in goats. Small Ruminant Research, 4(1): 21-29.

Goering HK, Van Soest PJ (1970). Forage Fibre Analysis. Agriculture Handbook, 379. Agric. Res. Service, USDA, Washington DC, 1 – 8.

Hansen JW, Perry BD (1994). The Epidemiology, Diagnosis and Control of Helminth Parasites of Ruminants 2nd Edition. Nairobi: International Laboratory for Research on Animal Diseases, Nairobi Kenya. Second Edition. Pp 171.

Koski GK, Scott ME (2001). Gastrointestinal nematodes, nutrition and immunity: Breaking the negative spiral. Ann.l Rev. Nutr. 21: 297-321.

Kyriazakis I, Oldham JD, Coop RL, Jackson F (1994). The effect of subclinical intestinal nematode infection with *Trichostrongylus colubriformis* of sheep receiving different nutritional treatments. Vet. Parasitol. 65: 41-54.

Louvandini H, Gennari S, Abdalla AL, McManus CM (2003). Influence of protein intake on carcass composition of calves infected with *Haemonchus placei*. Arch. Zootech. 52: 305-314.

MAFF (1971). Manual of Veterinary Laboratory Diagnostic Techniques. Bulletin Number 18. Ministry of Agric. Fisheries and Food. London. HMSO. Pp 5-50.

Mandonnet N, Aumont G, Fleury J, Gruner L, Bouix J, khang JV (1996). Genetic variability in resistance of Creole goats to natural infection with trichostrongylids in Guadeloupe. Ann NY Acad. Sci. 791: 421-431.

Min BR, Pomroy WE, Hart SP, Sahlu T (2003). The effect of short-term consumption of forage containing condensed tannins on gastrointestinal nematode parasite infections in grazing wether goats. Small Rum. Res. 51: 279-283.

Musongong GA, Fakae BB, Chiejina SN, Nnadi PA (2003). A method for the Isolation of a Nigerian Field Strain of *Haemonchus contortus* and its maintenance in the West African Dwarf Goat. J. sustainable Agriculture and the Environment, 5(2): 287-292.

Nnadi PA, Kamalu TN, Onah DN (2007). The effect of dietary protein supplementation on performance of West African Dwarf (WAD) does during pregnancy and lactation. Small Rumin. Res. 71: 200-204.

Obioha FC, Ndukwe N (1976). Changes in yield and chemical composition of standing and conserved forage during the dry season in East Central Nigeria. Nig. J. Anim Prod. 3(2): 105 – 116.

Okello KL, Obwolo MJ (1984). Uganda: Review of the potentialities of goat production. World Anim. Rev. 53: 27-32.

Payne WJA, Wilson RT (1999). An introduction to Animal husbandry in the Tropics, 5th ed., Blackwell Science Ltd, London, U.K. PP. 815.

Pralomkarn W, Pandey VS, Ngampongsai W, Choldumromgkul S, Saithanoo S, Rattaanachon L, Verhulst A (1997). Genetic resistance of three genotypes of goats to experimental infection with Haemonchus contortus. Vet. Parasitol. 68: 79-90

Valencia SC , Torres LG, Yago JI (2008). Occurence of nematode-trapping fungi in goat (*Capra hircus*) and sheep (*Ovis aries*). Nueva Vizcaya State University Res. J., 15: 31-37.

Van Houtert MFJ, Barger I, Steel J, Windon RG, Emery DL (1995). Effects of dietary intake on responses of young sheep to infection with *Trichostrongylus colubriformis*. Vet Parasitol 56: 163-180.

Van Houtert MFJ, Sykes A (1996). Implications of nutrition for the ability of ruminants to withstand gastrointestinal nematode infections. Int. J.Parasitol. 26:1151 – 1167.