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RESEARCH ARTICLE

Effect on growth performance and feed conversion efficiency of kids fed different diets with *Haemonchus contortus* infection

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Abstract

Twenty four non descript female goat kids (3-5 months) were randomly divided into six groups of four in each. Two diets: normal protein normal energy (NPNE) and high protein medium energy (HPME) were fed to kids having three levels of *H. contortus* infection (W_0, W_{500}, W_{2000}) in a 2x3 factorial design for 120 days, to study the effect of plane of nutrition with or without infection on feed consumption, average daily gain (ADG), feed conversion efficiency (FCE), nitrogen (N), calcium (Ca) and phosphorus (P) balance and egg per gram (EPG) counts. The N, Ca and P balances were higher in control (W_0) than W_{500} and W_{2000} of HPME. These balances were significantly ($p<0.05$) higher in HPME than NPNE. The interaction between nutrition and infection was non-significant. The ADG and FCE were significantly ($p<0.05$) higher in W_0 than W_{500} and W_{2000} infection; and also in HPME than NPNE. The EPG counts were higher (1637.50) in NPNE (W_{2000}) than HPME (W_{2000}). It is concluded that feeding of infected kids with HPME reduce the *H. contortus* load (EPG), improving FCE, nutrient balances and lower the cost of production.

Introduction

Small ruminant like sheep and goats are reared mainly by the people in the lower strata of society and serves either as the main or supplementary source of income for these categories of people. These animals are kept only on grazing pasture as migratory flocks which are often exposed to helminthes parasites. *Haemonchus contortus* has been considered as one of the important gastrointestinal nematodes (GIN) causing great economic loss to the farmers (Pathak and Tiwari, 2013). Depending upon gradient of infection and parasite type, immense losses of potential performance occur among these animals (Amarante et al., 2004). The larval and adult stages of parasite suck blood from the abomasal mucosa of animals and consequently lead to anemia (Ameen et al., 2006; Pathak and Tiwari, 2012). The condition becomes worse in the malnourished animals especially during months July to September when there is ample availability of grazing pasture which favors the growth of *H. contortus* infective larvae (Pal et al., 2001). The prevalence of *H. contortus* in goats is highest (29.72%) during this period (Pathak and Pal, 2008). In order to control the parasitic infections among sheep and goats, various managemental practices and anthelmintic treatment or combination of both are being practiced. However, indiscriminate use of anthemintics has led to drug resistance among nematodes. Among the alternative methods to anthelmintics currently available, the manipulation of host nutrition in order to improve the host resistance and/or resilience to parasite infestations seems to represent one of the most promising options (Haile et al., 2004; Hoste et al., 2005). There is significant relationship between nutrition and parasite infestation which needs to be exploited for the better health of the animals (Etter et al., 2000; Osoro et al., 2007; Pathak, 2011; Pathak et al., 2013). Goats that are well nourished will grow and reproduce faster and are better able to withstand the effects of worm infestation than those on a low plane of nutrition (Hoste et al., 2005; Pathak, 2011). Hence the present study was undertaken to ascertain the effect of different diets and infection levels in goats kids infested with *H. contortus* on growth performance, feed conversion efficiency, N, Ca, and P balance and faecal egg counts.

Materials and Methods

Twenty four non descript female goat kids (3-5 months, 11.05 kg average body weight) were procured from the local market to conduct the study. The kids were kept in a well-ventilated goat shed having concrete floor throughout the experiment. Hygienic and sanitary conditions were provided in the shed. All kids were dewormed by a combination of three different anthelmintics orally alternated over a three weeks. The elimination of parasitic infection was confirmed by faecal examination.

Two complete diets were prepared having normal protein normal energy (NPNE) and high protein medium energy (HPME) using conventional feedstuffs (crushed maize, ground nut cake, berseem hay and chopped rice straw). The NPNE diet contained berseem hay and chopped rice straw as source of roughage in the ratio of 60:40 and crushed maize @ 100g/d/kid as source of concentrate ingredient. However, the HPME diet contained berseem hay and chopped rice straw in the ratio of 90:10 and crushed maize and groundnut cake (50:50) as concentrate. The diets were supplemented with mineral mixture (1%), salt (0.5%) and vitamin premix (20g/q feed). The diets were formulated on the basis of DCP and TDN requirement of kids for maintenance and growth as per NRC (2007). The formulated diets contained 7% DCP and 57.3% TDN in NPNE while 13.15% DCP and 62.5% TDN in HPME. Thus, the diets were categorized as normal protein normal energy (NPNE) and high protein medium energy (HPME) on the basis of DCP and TDN requirement.

Twenty four non descript healthy female goat kids were randomly allocated to two dietary feeding regimens each having three levels of *H. contortus* infections (W_0, W_{500} and W_{2000}) with four kids in each in a 2 x 3 factorial design (Snedecor and Cochran 1994). Both the diets were fed to kids having no infection (W_0), medium infection (W_{500}) and heavy infection (W_{2000}). About 25-30 abomasums were collected from kids and the eggs of adult female *H. contortus* of caprine origin were retrieved from the gravid uterus. The infective 3rd stage larvae (L_3) were produced by petridish method of faecal culture technique as described by Urquhart et al. (1996). The infective doses of the 3rd stage larvae were prepared as W_{500} and W_{2000} larvae (Blackburn et al., 1991). All kids in W_{500}, W_{2000} of NPNE and HPME were starved for over night to setup the quick infection. The W_0 kids of NPNE and HPME were also starved over night to provide same experimental conditions as the other treatments. A controlled and monitored dose of 500 and 2000 *H. contortus* larvae (L_3) were administered orally only once before feeding and watering the kids. Thereafter the infected kids were kept off fed for 3-4 hours to avoid sloughing of larvae from the abomasum.

All kids were *ad lib* fed diet constituted chopped rice straw and berseem hay followed by weighed amount of concentrate mixture daily at 0900 hrs (NRC, 2007). The feeding trial was lasted for 120 days. A 7-day metabolism trial was conducted to study the DM intake, daily gain in body weight, feed conversion efficiency and nutrient balance in kids. Daily record of feed intake was done. All kids were weighed weekly at three consecutive days during the entire experiment. Daily gain in body weight was calculated to determine the growth pattern and feed conversion efficiency of kids. Feed conversion efficiency of kids was calculated as the ratio of gain in body weight to feed intake. The fresh faecal samples from all experimental kids were collected per rectum using hand globes at weekly intervals. The egg counting was done as per Modified McMaster Techniques of Gordon and Whitlock (1939). The samples of feed, faeces and urine were subjected to the analysis of N (AOAC, 1995), Ca (Clark and Collip, 1925) and P (Fiske and Subbarao, 1925) for their balances in each group.

Results and Discussion

The chemical composition of both diets for dry matter, organic matter, crude protein, crude fiber, ether extract, nitrogen free extract, total ash, Ca, P, NDF, ADF, hemicellulose and cellulose were 83.00, 88.37, 10.04, 24.79, 0.90, 52.64, 11.63, 1.03, 0.26, 52.23, 36.71, 15.52, 27.11 per cent in NPNE and 83.20, 89.38, 19.07, 22.72, 1.38, 46.21, 10.62, 1.37, 0.33, 48.90, 30.67, 18.23, 20.05 per cent, in HPME. Least square means of body weight, total body weight gain (kg) and body weight gain (g/d) of kids in various groups have been presented in table 1 and illustrated in fig. 1. The difference in weight gains of kid between NPNE and HPME was statistically significant at the time of zero infection. Within NPNE, the difference in body weight gains due to W_{500} and W_{2000} infection were always higher as compared to the difference in gains within HPME due to the same levels of infection. HPME kids attained more body weight as compared to NPNE. Amongst the infected groups maximum body weight gain was recorded in W_0 and minimum in W_{2000} kids. Similar observations were recorded with *H. contortus* infected kids Chartier et al. (2000), Phengvichith and Ledin (2007) and sheep (Preston and Leng, 1987) when they were fed different levels of dietary protein at different levels of infections.

The W_0 kids consistently have significantly higher feed conversion efficiency than W_{500} and W_{2000}. These values were in order of $W_{2000} < W_{500} < W_0$. It was due to more loss of body weight in W_{2000} than W_{500}. Feed conversion efficiency was higher in HPME as compared to NPNE. The reduced feed conversion efficiency in infected kids had direct bearing of parasite on the efficiency of digestion, absorption and nutrient utilization. This in turn allows a greater amount of proteinacious material to move to the caecum, thus decreasing the availability of amino acids to the host, thus affecting the over all growth of animals (Preston and Leng, 1987). A significant amount of protein is also mobilized for the repair of damaged intestinal mucosa, for the synthesis of specific serum protein (to compensate the blood protein loss) and for the production of immunoglobulin. In all, it reduces the availability of protein for muscular development leading to poor body weight gain (Preston and Leng, 1987).

Table 1: Growth and feed conversion efficiency of kids fed on diets with and without *H. contortus* post infection

Attributes	Infection				Diets		
	W_0	W_{500}	W_{2000}	SEM	NPNE	HPME	SEM
DMI (g/d)	478.25^b	455.50^a	440.75^a	7.30	440.00^A	476.33^B	5.99
Body weight (kg)							
Initial	11.04	11.05	11.06	0.38	11.05	11.04	0.31
Final	15.25^b	14.12^a	13.20^a	0.37	13.65^A	14.73^B	0.30
Body weight gain							
Total (kg)	4.13^c	3.06^b	2.14^a	0.03	2.60^A	3.68^B	0.03
(g/d)	35.16^c	25.54^b	17.82^a	0.29	21.65^A	30.69^B	0.24
FCE	0.07^c	0.05^b	0.04^a	0.001	0.05^A	0.06^B	0.00

$^{abc\ \&\ AB}$means in the same row for each parameter (infection and diets), respectively with different superscripts are significantly different at (P<0.05)
DMI: Dry matter intake; g/d: gram per day; FCE: Feed conversion efficiency
W_0: *Haemonchus contortus* worm load (L_3 larvae) zero
W_{500}: *Haemonchus contortus* worm load (L_3 larvae oral administration) Five Hundred
W_{2000}: *Haemonchus contortus* worm load (L_3 larvae oral administration) Two Thousand
NPNE: Normal protein normal energy; HPME: High protein medium energy

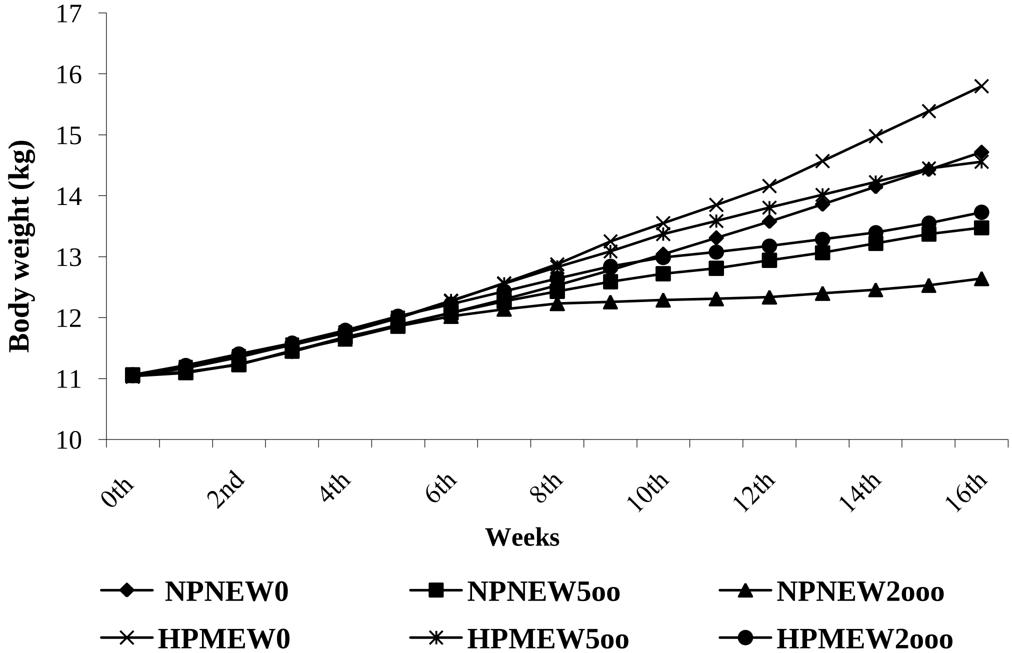
Table 2: Nitrogen, Calcium and Phosphorus balance in kids fed on diets with and without *H. Contortus* infection

Attributes	Infection				Diets		
	W_0	W_{500}	W_{2000}	SEM	NPNE	HPME	SEM
Nitrogen (g/d)							
Intake	11.23^b	10.70^a	10.47^a	0.15	7.07^A	14.53^B	0.13
Outgo							
Faecal	3.24^a	3.57^b	4.20^c	0.09	2.54^A	4.80^B	0.07
Urinary	2.58^a	3.08^b	4.33^c	0.12	2.20^A	4.58^B	0.10
Balance	5.41^c	3.87^b	1.93^a	0.12	2.32^A	5.15^B	0.14
Calcium (g/d)							
Intake	5.70	5.48	5.33	0.08	4.53^A	6.48^B	0.06
Outgo							
Faecal	3.39	3.64	3.98	0.15	2.96^A	4.38^B	0.12
Urinary	0.22	0.21	0.18	0.04	0.20	0.20	0.03
Balance	2.10^c	1.63^b	1.17^a	0.14	1.37^A	1.90^B	0.12
Phosphorus (g/d)							
Intake	1.41	1.35	1.31	0.02	1.14	1.57	0.02
Outgo							
Faecal	0.28^a	0.38^b	0.49^c	0.02	0.31	0.45	0.01
Urinary	0.05	0.05	0.06	0.003	0.05	0.05	0.003
Balance	1.08^c	0.92^b	0.75^c	0.02	0.78^A	1.06^B	0.02

$^{abc\ \&\ AB}$means in the same row for each parameter (infection and diets), respectively with different superscripts are significantly different at (P<0.05); g/d: Gram per day
W_0: *Haemonchus contortus* worm load (L_3 larvae) zero

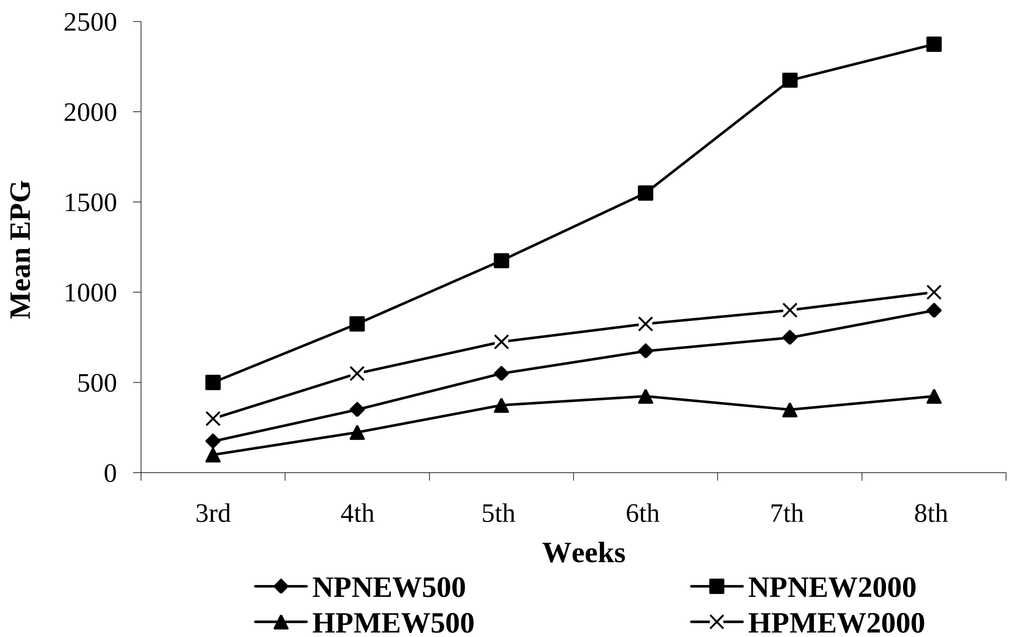
W_{500}: *Haemonchus contortus* worm load (L_3 larvae oral administration) Five Hundred
W_{2000}: *Haemonchus contortus* worm load (L_3 larvae oral administration) Two Thousand
NPNE: Normal protein normal energy; HPME: High protein medium energy

Fig. 1 Growth pattern of kids fed on diets with and without *H. contortus* infection



$NPNEW_0$: Normal protein normal energy worm load zero
NPNEW500: Normal protein normal energy worm load five hundred
$NPNEW_{2000}$: Normal protein normal energy worm load two thousand
$HPMEW_0$: High protein medium energy worm load zero
HPMEW500: High protein medium energy worm load five hundred
$HPMEW_{2000}$: High protein medium energy worm load two thousand

Fig. 2 Mean EPG of *H. contortus* (W_{500}, W_{2000}) post nfection of kids fed on NPNE and HPME diet



EPG: Egg per gram of faeces
NPNEW500: Normal protein normal energy worm load five hundred
$NPNEW_{2000}$: Normal protein normal energy worm load two thousand
HPMEW500: High protein medium energy worm load five hundred
$HPMEW_{2000}$: High protein medium energy worm load two thousand

The data of nitrogen intake, outgo and balance in kids fed HPME and NPNE diets at different levels of infection have been presented in the table 2. Data were statistically significant for diet (NPNE and HPME) and level of infection ($W_{0,}$ W_{500} and W_{2000}). With the increase in the level of dietary protein there was an increase in N outgo and N balance in kids. However, with the increase level of infection i.e. from W_0 to W_{2000} the nitrogen intake and balance were declined and the nitrogen outgo elevated. Significant ($p<0.05$) difference was observed in the faecal outgo between HPME and NPNE diets. The higher faecal N was recorded in W_{2000} as compared to W_{500} and W_0.

In the current study the infected (W_{500} and W_{2000}) and control kids (W_0) on HPME diets remained in positive nitrogen balance as reported by Hoste et al. (2005). However the kids of W_0 group retained more nitrogen than W_{500} and W_{2000} kids. In contrary, Hoste et al. (2005) observed reverse trend in lambs where more N (3.5 g/d) was retained in infected group than control group. In this study the faecal and urinary N were significantly higher in infected (W_{2000} and W_{500}) as compared to non infected kids at both levels of dietary protein. However past reports indicated more urinary nitrogen loss through urine of non infected groups while the faecal N was similar in both infected and non infected groups at normal and high protein diet (Hoste et al., 2005). It seems there exist a significant relationship between the severity of infection and the protein intake by the kids. This might be due to the competition between the host and the parasite (*H. contortus*) for nutrient availability. However, with an increased level of protein the severity of infection was less pronounced as compared to low protein diet in sheep due to rapid degradation of soluble proteins into non protein nitrogenous substance, such as ammonia which caused intoxication on the overall growth of parasites in the gut (Dutta et al., 1998). The gastrointestinal parasites (*H. contortus*) while sucking the blood from deeper mucosa of abomasum resulted into profuse loss of endogenous nitrogen in the form of desquamated epithelial cells of damaged tissues, which consequently aggravated pain. This may cause reduction in the overall nutrient intake. The current findings are in accordance to the earlier report of Ameen et al. (2006) in *H. contortus* infected sheep.

The positive correlation between protein intake and N balance could be true only when the animals meet their nutrient requirements. Thereafter protein intake declined gradually. In the current study it was reverse due to the availability of nutrients to parasite instead of host resulting into increased compensatory digestibility and utilization of proteins. In the parasitized kids the extensive protein loss redirects the protein synthesis away from skeletal muscle i.e. towards the repair of gut tissues, leading to reduced nitrogen balance (MacRae, 1993). While urea excretion in infected kids indicated the poor reutilization of absorbed N, the loss of endogenous nitrogen into the intestine is the major reason for reduced nitrogen gain (Symons, 1982).

The data of Ca and P intake, outgo and their balances in kids fed two levels of protein with and without *H. contortus* post infection have been presented in table 2. Calcium intake was significantly higher in HPME than NPNE fed kids. It was due to the high content of Ca in HPME diet. When comparison was made amongst infected groups intake was higher in W_0 than W_{500} and W_{2000}. However, faecal outgo was significantly higher in W_{2000} and W_{500} than W_0. The least Ca balance was obtained in $W_{2000,}$ which was either due to impaired Ca absorption across the intestinal wall or due to reduced feed intake. Similar findings were recorded by Sykes and Coop (1976) in lambs parasitized with *Trychostrongylus colubriformis* infection.

Phosphorus intake was significantly lower in infected kids (W_{500} and W_{2000}) than control (W_0) of both dietary protein levels. Significantly higher P intake was observed in HPME as compared to NPNE. However, faecal outgo of P followed a definite trend of $W_{2000} > W_{500} > W_0$. Accordingly, similar trend was noticed in P balance. As the level of infection increased the P balance decreased due to reduced intake and impairment of P absorption. A severe mineral disorder was recorded in sheep due to heavy infection of gut nematodes (Reveron et al., 1974).

Data of EPG have been depicted in fig. 2. At the beginning of the experiment each kid gave zero egg counts due to anthelmintic treatment. Third weeks after the administration of *H. contortus* larvae (L_3), the infected groups W_{500} and W_{2000} of NPNE and HPME diets started passing eggs in the faeces however no eggs were detected in the faeces of kids in W_0 of both dietary treatments where no infection was given. Therefore kids with no infection were kept away from EPG count. A factorial design of 2 x 2 having two level of infection viz, W_{500} and W_{2000} and two levels of dietary protein viz, NPNE and HPME were included for the statistical analysis of EPG data. EPG counts differed significantly ($p<0.05$) between dietary levels and levels of infection. EPG counts were more in W_{2000} of NPNE than W_{2000} of HPME. Similar trend was noticed for W_{500} although the overall counts were higher in NPNE fed kids. Faecal egg counts in kids of W_{2000} and W_{500} groups under NPNE diet increased throughout the period from 3rd to 8th week post infection but kids under HPME diet had lower ($p<0.05$) faecal egg counts in W_{2000} and W_{500}. This shows a significant ($p<0.05$) interaction of diet and infection. Thus the kids fed on HPME diet were able to control faecal egg output when compared with NPNE diet, indicating better immune response with HPME. Hoste et al. (2005) reported lower faecal egg counts four weeks after a single dose of *H. contortus* infection in the protein supplemented lambs. The nutritional effect related to EPG was statistically significant ($p<0.05$). NPNE kids carried more worms and achieved greater establishment rates than HPME kids. Chartier et al. (2000) found a similar difference in establishment rate of parasites due to difference in dietary protein.

Conclusion

A study was conducted in rainfed agroclimatic zone of Chhattisgarh (India) to find out the effect of the most prevalent parasitic infestation of *H. contortus* at two levels of feeding (NPNE and HPME) with three levels of *H. contortus* infection (W_0, W_{500} and W_{2000}) in kids. The infected kids at the normal level of dietary protein gained at a slower rate as compared to the kids maintained at a higher level of protein. The feed conversion efficiency, growth pattern and the cost of raising kids was worked out to be the most economical one at high plane of nutrition even with the heavy infestation. It can be concluded from the current study that feeding a high protein diet is biologically and economically beneficial for both infected and uninfected goats. Further, the feeding of infected kids with HPME reduce the *H. contortus* load (EPG), improving FCE, growth performance, nutrient balances and lower the cost of production.

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