Resistance of Three Strains of Small East African Goats to Artificial Infection with Mixed Gastrointestinal Nematode Parasites

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Abstract

The response of three strains of Small East African (SEA) goats (Gogo, Newala and Ujiji) to artificial infection with a mixture of gastrointestinal nematodes i.e. Haemonchus spp, Trichostrongylus spp and Oesophagostomum spp was compared. Eight Ujiji, seven Newala and eight Gogo goats with initial body weight ranging from 5.4 to 11.7 kg and aged between seven and eight and half months were used in the experiment. Prior to the start of the experiment, all goats were drenched with antihelmintics. One week after anthelmintic treatment, all animals were individually dosed orally with a mixture of Haemonchus spp, Trichostrongylus spp and Oesophagostoum spp at a dose rate of 2000 larvae/ml. Following infection, faecal egg count (FEC), packed cell volume (PCV), growth rate and mortality were monitored for 10 weeks. After 10 weeks three Newala goats, three Ujiji goats and four Gogo goats were slaughtered to determine total worm count (TWC). Significant differences were observed in FEC, PCV, TWC and mortality among the SEA goat strains. Gogo goats had significantly lower FEC (606 epg). TWC (529) and mortality rate (0%) but higher PCV (20.4%) while Ujiji goats showed the highest FEC (2043 epg). TWC (795) and mortality rate (25%) and the lowest PCV (16.6%). All strains lost weight following infection. On average, Ujiji goats showed the highest weight loss (86 g/d), followed by Newala (58 g/d and Gogo had the lowest weight loss (10 g/d). The study demonstrated that the Gogo goats were more resistant while the Ujiji goats were more susceptible to gastrointestinal nematode infection.

Keywords: Small East African goats, gastrointestinal nematodes, resistance

Introduction

In Tanzania, goats play an important role in providing animal protein and income generation, especially to resource poor farmers in rural areas. Tanzania has 12.5 million goats of which 98% are indigenous goats belonging to the Small East African breed (SEA) (MAFS, 2002). The productivity of SEA goats under village production system is reduced by inadequate nutrition, diseases and parasites and improper management (Njombe, 1993). Diseases and in particular gastrointestinal nematode parasitism is the most serious constraint affecting goat production world-

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wide (Stear *et al.*, 1990). In Tanzania, gastrointestinal nematode infections (GI) cause considerable economic losses in rural areas (Connor *et al.*, 1990, Mboera and Kitalyi, 1994). These occur through mortalities, reduced weight gain and milk yield, increased susceptibility to viral, protozoan and bacterial diseases, and direct cost associated with preventive and curative measures. High kid mortality rate (up to 38.4%) caused by gastrointestinal nematode infections have been reported at Magadu farm, Sokoine University of Agriculture (SUA), Morogoro, Tanzania (Mruttu, 2001).

Potential control strategies for helminth infections include treatment with anthelmintics, supplementary feeding, grazing management and breeding for disease resistance. The use of anthelmintics is threatened by the development of resistance in parasites to most commonly used drugs (Craig, 1993; Waller, 1994). Also, there has been concern that residues of ant-helmintic chemicals may accumulate in the tissues of host animals and ultimately result in adverse consequences for human health. The high prices of the most commonly used anthelmintics is another factor limiting their use by small-scale farmers. Grazing management in rural areas is not feasible due to communal ownership of land. Feed supplementation, particularly with high plane of protein is often necessary to maintain adequate productivity of livestock (Coop and Holmes, 1996). However, the costs involved and the limited supplies of concentrate make this option quite unrealistic for the majority of goat owners in Tanzania. Recently, attention has been turned to the search for control strategies that involve immune response. Two options are currently being explored: development of vaccines (Emery and Wagland, 1991; Tavernor *et al.*, 1992) and use of genetically resistant breeds (Baker, 1995). Development of effective vaccines against gastrointestinal nematodes is still faced by many practical problems. The use of resistant animals seems to be appealing since once identified they can be used for selective breeding. It has been shown that resistance to GI nematodes is genetically determined and is heritable (Baker *et al.*, 1998;) and that there is breed and individual variations in resistance to GI nematode infection in small ruminants (Mugambi *et al*, 1997; Wanyangu *et al.*, 1997). Therefore, crossbreeding and within-breed selection can take advantage of this. Identification and utilization of strains of goats

that are genetically resistant to helminth infections is an attractive, sustainable, low cost option for the control of worm burden as it leads to reduction in costs of purchasing drugs and chemicals and also is an effective conservation strategy for the indigenous breeds. In assessing within breed genetic variation, artificial indoor infection is preferred since it helps to control some of the environmental effects (Stear *et al.*, 1996).

Information on genetic variation among the indigenous goats in Tanzania with respect to resistance to nematode infection is lacking. The present study was therefore undertaken to compare the response of three strains (Gogo, Newala and Ujiji) of SEA goats to artificial mixed infection with *Haemonchus spp, Trichostrongylus spp* and *Oesophagostomu spp*.

Materials and Methods

Animals and their management.

The study was conducted at the Department of Animal Science and Production (DASP), Sokoine University of Agriculture (SUA), Morogoro, Tanzania. Three strains (Newala, Gogo and Ujiji) of SEA goats were used. In total, 23 male growing goats (eight Ujiji, seven Newala and eight Gogo goats) were used in the experiment. The age of the goats ranged from seven to eight and half months and the initial body weight ranged from 5.4 to 11.7 kg. The animals were kept indoors in three pens in a building with iron sheet roof and concrete floor. Wood shavings were used as bedding materials and were changed every week. The pens were equipped with hay and concentrate feeders and drinkers. Prior to the start of the experiment, all goats were drenched with drug combination of levamisole and ivermectin at the dose recommended by the manufacturers. The goats were stall-fed with *Brachiaria* hay, supplemented with concentrate feed to meet the nutrient requirements and provided with water in *ad lib* amount. The concentrate feed was composed of a mixture of maize bran (69%), cotton seed cake (29%), salt (1%) and mineral premix (1%). The hay was sprayed with molasses to improve its palatability and hence dry matter intake.

Experimental design

Seven to eight animals were randomly allocated into each pen. Infective larvae were prepared by collecting faeces directly from the rectum of all goats, the faeces were then pooled and cultured by incubating for six days. After six days, the larvae were harvested and identified. The most predominant species of worm were *Haemonchus spp, Trichostrongylus spp* and *Oesophagostoum spp*. The larvae of these species were made into a concentration of 2000 larvae/ml. One week after anthelmintic treatment, all animals were individually dosed orally with a mixture of *Haemonchus spp, Trichostrongylus spp* and *Oesophagostoum spp* at a dose rate of 2000 larvae/ml two times fortnightly. The animals were then monitored for 10 weeks.

Sampling and sample processing

Collection of faecal and blood samples from the artificially infected goats started on the 14th day after infection and was done on every two weeks thereafter. Faecal and blood sampling were done in the morning between 0700 and 0800 h. Faecal samples were collected into plastic containers from the rectum and each sample was labelled and kept at 4°C until analysed. Faecal egg counts (FEC) were determined as number of eggs per gram (epg) using a Modified McMaster technique (MAFF, 1986). Blood samples were obtained by jugular vein puncture using vacutainer tubes with ethylene diamine tetraacetic acid (EDTA). The blood samples were used for determination of packed cell volume (PCV) to evaluate the degree of anaemia. PCV was analysed using haematocrit centrifuge technique as described by MacLeod *et al.* (1981).

All animals were weighed at the start of the experiment and then once every week up to the end of the experiment. Weights of individual goats were recorded using Salter weighing scale model 235 6S. Initial and final weights were obtained by taking the average weights of two consecutive days at the start and end of the experiment, respectively. Mortality was recorded on each strain as it occurred.

A random sample of 10 goats (three Newala, three Ujiji and four Gogo) was deliberately slaughtered at the end of the experiment (10 weeks post infection) to assess total worm count (TWC). The abdominal cavity was opened and the abomasal and intestinal contents were separately removed and washed thoroughly in plastic buckets. The contents were passed through a sieve and the adult worms were isolated, identified and counted accordingly.

Statistical analysis

Data on growth rate, FEC, PCV and TWC were analysed using the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS, 1998). The fixed effect was the goat strain. The initial weights of goats were used as covariate in analysing growth rate data. The FEC and TWC data were analysed after a logarithmic transformation of log (FEC + 25) and (TWC + 10), respectively. The results were back transformed by taking antilogarithms of the least squares means and results were presented as geometric means i.e. Geometric means Faecal Egg Count (GFEC) and Geometric means total worm count (GTWC). In order to evaluate the association between TWC, FEC, PCV and growth rate, data were analysed using Multivariate Analysis of Variance (MANOVA) option of GLM (SAS, 1998). In addition, statistical analysis was carried out to investigate the effect of goat strain on mortality rate using Chi-square test. This involved construction of a 2x2 contingency table and the use of the following formula: $\chi^2 = (O-E)^2/E$ Where: χ^2 = calculated Chi-square value, O = observed values, E = expected values.

Results

Mortality

Following infection, seven goats died within the 10 weeks of monitoring and two goats died in the week following termination of the experiment. Among the three strains, Ujiji goats had the highest mortality rate (25%), followed by Newala goats (4%). There were no deaths in the Gogo strain. Post-mortem findings revealed haemonchosis to be the main cause of deaths. Out of the nine goats that died, six (67%) died due to haemonchosis and the rest due to a combination of haemonchosis and pneumonia.

Indicators of worm burden (PCV, FEC and TWC)

The least square means for PCV of the three strains during the 10 weeks of the trial are shown in Figure 1. Two weeks after artificial infection the PCV values were relatively high and averaged 25, 27 and 29% for Ujiji, Gogo and Newala goats, respectively. Thereafter, in all the strains the PCV fell progressively up to the sixth week and then slightly increased. In the 10th week PCV values ranged from 15 to 17 %. Statistical analysis showed significant (P<0.05) differences in PCV among the goat strains. On average Ujiji goats had significantly lower PCV (16.6%) than the other

was very significant (P<0.01) on GFEC. Gogo strain had significantly (P < 0.05) lower GFEC than the other two strains and their GFEC ranged from 398 epg in the fourth week to 928 epg in the 8th week of the study. Ujiji strain had the highest GFEC from the second week (1483 epg) up to the six week (2951 epg) while Newala goats had the highest GFEC in week eight (3344 epg) and ten (4423 epg) of the experiment. The GFEC of the two strains (Ujiji and Newala) differed significantly (P < 0.05) from that of Gogo strain. On average, Ujiji goats had the
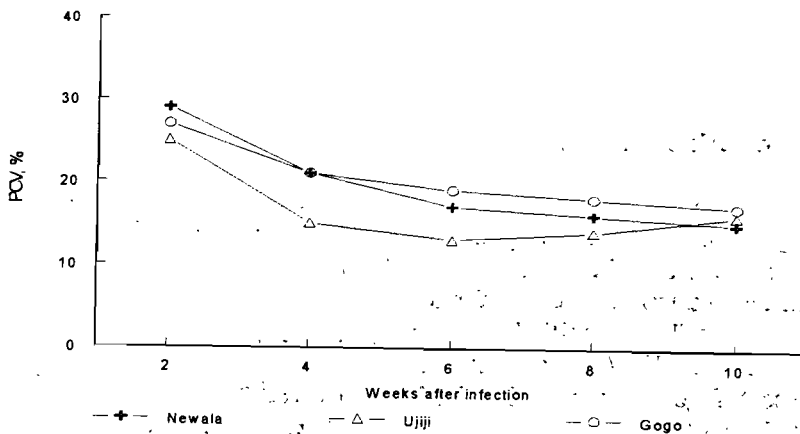

Figure 1: PCV pattern of three strains of SEA goats artificially infected with a mixture

two goat strains, while Gogo (20.4%) and Newala (19.6%) goats had values, which did not differ (P>0.05) significantly. The least square means for GFEC during the experimental period are shown in Figure 2. Generally the GFEC decreased from the second week to the fourth week post infection and then progressively increased. All strains showed minimum GFEC in week four. Statistical analysis indicated that the influence of goat strain

highest GFEC (2043 epg) while Gogo had the lowest GFEC (606 epg). The average GFEC for the Newala goats (2032 epg) was in between the two strains, though more close to that of Ujiji goats.
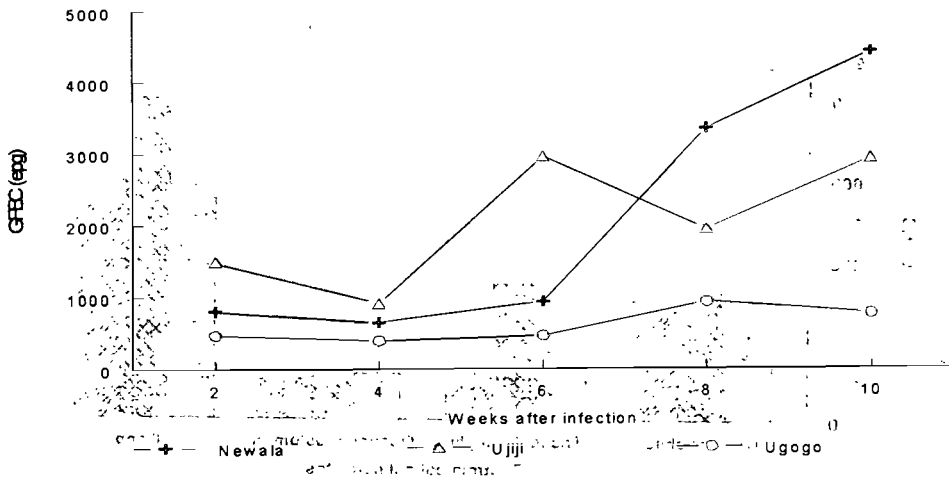
Figure 2: Geometric means for faecal egg counts of three strains of SEA goats following deliberate infection with a mixture *Haemanchus spp*, *Trichostronglyus spp* and *Oesophagostomum spp*

Upon slaughter at the end of the experiment, post mortem results indicated that *Haemonchus spp* accounted for 48% while *Trichostrongylus spp* and *Oesophagostomum spp* accounted for 35% and 17% of the total worm burden, respectively. In all the goat strains the amounts of Oesophagostomum spp were the least while that of *Haemonchus spp* were the highest (Figure 3), except in Ujiji goats where *Trichostrongylus spp* was found to be the highest. The differences in GTWC were not significant among the strains. However, Ujiji goats had numerically the highest average GTWC (795) while Gogo had the lowest (529).
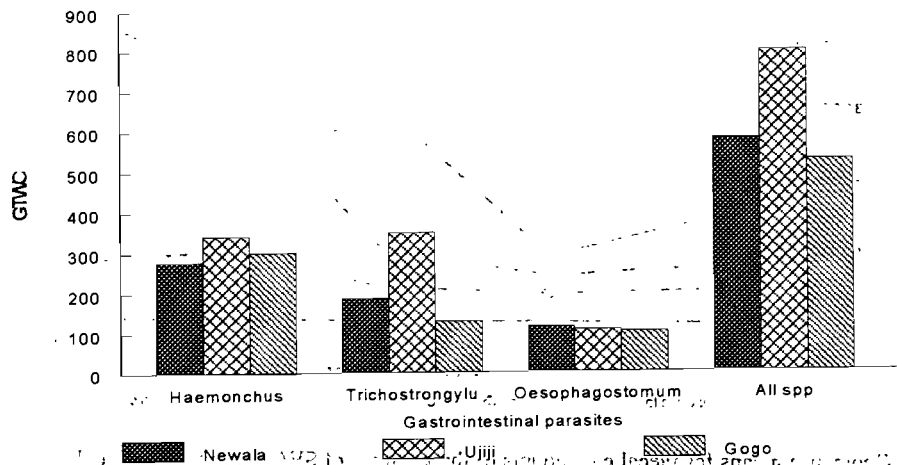
Figure 3. Geometric means for total worm counts of three strains of SEA goasts slaughtered after ten weeks following deliberate infection with a mixture *Haemonchus spp. Trichostronglylus spp* and *Oesophagostomum spp.*

Growth performance

The growth performance of the goats after infection with nematodes is shown in Figure 4. Generally all the three goat strains lost weight. Gogo and Newala goats gained weight from the seventh week and ninth week, respectively to the end of experimental period while Ujiji goats lost weight throughout the experimental period. The effect of goat strain on post infection growth rate was significant (P<0.05). Gogo goats lost significantly lower average weight (10 ± 17 g/d) than the other strains while Ujiji goats showed the highest average loss of weight (86 ± 21 g/d), followed by Newala goats (58 ± 21 g/d). Growth rate was negatively correlated with GFEC (r = - 0.50) and GTWC (r = - 0.56) but positively correlated with PCV (r = 0.44). The GFEC was positively correlated with GTWC (r = 0.30) obtained after slaughtering the animals at the end of the experiment. PCV was negatively correlated with GFEC (r = -0.55) and GTWC (r = - 0.47). All correlations were significant (P<0.05) except that between GFEC and GTWC.
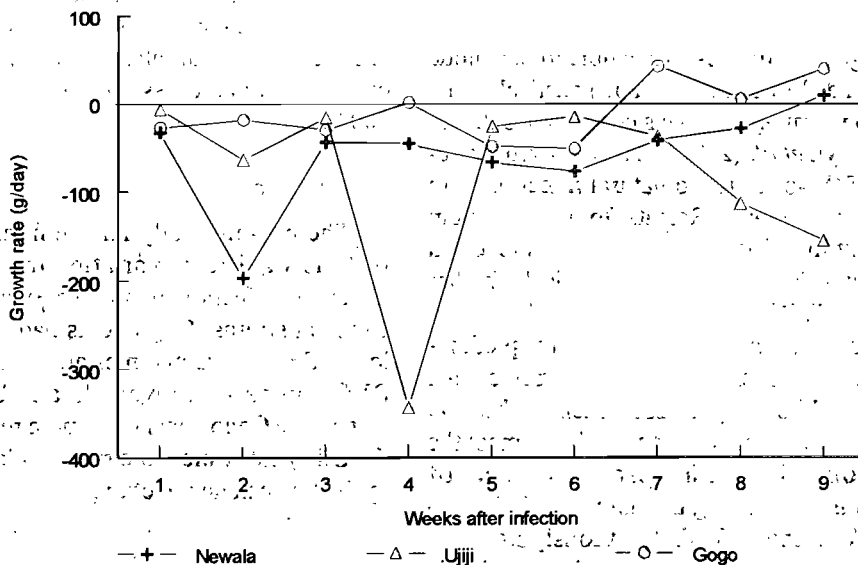
Figure 4: Growth performance of three strains of SEA goats following deliberate infection with a mixture Haemonchus spp, Trichostronglus spp and Oesophagostomum spp.

Discussion

Diarrhoea was observed in most goats a few weeks post infection and was probably caused by increased worm burden since symptoms corresponded well with the level of FEC. In addition to diarrhoea, there were signs of dullness, pale mucus membranes, loss of body condition and anorexia. Wamae and Ihiga (1990) have reported similar observations in goats infected with nematodes. According to Herlick (1978) gastrointestinal nematodes destroy the gastric glands and small intestinal mucosa and result into a change of pH of gastric contents and reduction in the level of various enzymes. These pathological disturbances cause diarrhoea in case of heavy worm burden and may result into death of the animals. In this study high mortality rate was observed in Ujiji goats (25%) but in Newala goats mortality rate was low

(4%) and none in Gogo goats. This indicates that the Newala and Gogo goats were capable of withstanding the deliberate infection with the nematodes.

The initial mean values of PCV of the goat strains were within the normal reference values (22 – 38%) reported by Schalm et al. (1985). The decline in PCV following infection (Figure 1) implies that the goats were developing anaemia due to blood sucking parasites. Similar decline in PCV values following infection with nematodes has been reported by Wanyangu et al. (1997). According to Newsholmes and Start (1976) heavy worm burden leads to low PCV values that range from 8 to 22%. In the present study Gogo goats maintained relatively high PCV values (17 – 27%) throughout the experimental period compared to other strains. This shows that the three goat strains differed in resis-

tance/susceptibility to gastrointestinal nematode infections because they showed variable immune responses as supported by their differences in FEC, which was significantly lower for Gogo strain compared to Newala and Ujiji strains throughout the experimental period. Gogo strain might be genetically less susceptible to nematode infection and Ujiji strain might be genetically susceptible to worm burden. This corroborates the results of Keyyu *et al.* (2001) who compared the resistance of these strains to natural infection with *Haemonchus contortus*. Results from post mortem worm count in artificially infected goats revealed that Ujiji and Gogo strains had numerically higher and lower TWC, respectively. In Gogo and Newala strains, *Haemonchus spp* was the predominant species recovered from the gastrointestinal tract (GIT) while in Ujiji goats *Haemonchus spp* and *Trichostrongylus spp* occurred in almost the same proportion. The predominance of *Haemonchus spp* among the helminths being recovered from the GIT had previously been reported in Tanzania (Connor *et al.*, 1990), Nigeria (Anene *et al.*, 1994), and Kenya (Gatongi *et al.*, 1998).

The observed negative growth rates in artificially challenged goats (Figure 4) might be due to increased worm burden. Worm burden tend to reduce weight gain of the affected goats due to nutritional and physiological disturbances (Herlick, 1978). The magnitude of weight loss varied depending on the immune response of the goat strain. Gogo strain performed better as they lost weight only during the first six weeks post infection and from the seventh to the tenth week they were gaining weight. This indicates that the Gogo goats were able to tolerate the pathogenic effect of worm burden, implying that Gogo goats are relatively resistant to worm infection.

The differences observed in the parameters studied ie. PCV, FEC, TWC, mortality rate and growth rate are more likely a reflection of the true genetic differences between the strains in response to nematode infection. The superiority of the Gogo goats in all aspects provided evidence that this strain is resistant to haemonchosis. Furthermore, the low TWC and reduced egg output in the Gogo goats indicated that these goats are not only more resistant, but also they contaminate pastures less than the other strains. The observed superiority of the Gogo goats to the other strains is in con-

junction with the results of production parameters reported from on-station evaluation studies of the three strains. Gogo goats have been reported to perform clearly better than Newala and Ujiji goats, not only in having low mortality rate (Mruttu, 2001), but also in terms of higher kid and weaner growth rates, slaughter weight, carcass weight and dressing percentage (Malole, 2002).

Conclusion

The present study has demonstrated that there is significant variation in resistance to nematode infection among the Small East African goat strains. Gogo goats had significantly lower FEC, TWC and mortality rate but higher PVC compared to Newala and Ujiji goats. Hence, the Gogo goats were more resistant while the Ujiji goats were more susceptible to gastrointestinal nematode infection.

Acknowledgements

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