GENETIC RESISTANCE OF SMALL EAST AFRICAN GOATS TO MIXED GASTROINTESTINAL NEMATODE PARASITES

J.D. Keyyu[1a] , A. A. Kassuku[1], N.C. Kyvsgaard[2] , A.L.Willingham[2] and G. C. Kifaro[3]

[1]Department of Veterinary Microbiology and Parasitology, Sokoine University of Agriculture, P.O. Box 3019, Morogoro, Tanzania
[2]Danish Centre for Experimental Parasitology, Royal Veterinary and Agricultural University, Ridebanevej 3, DK-1870 Frederiksberg C, Denmark
[3]Department of Animal Science and Production, Sokoine University of Agriculture
P.O. Box 3004, Morogoro, Tanzania

SUMMARY

Within-breed variation in resistance to gastrointestinal nematode parasites in mature Small East African (SEA) goats was studied in Morogoro, Tanzania. Three strains of the breed namely Dodoma, Kigoma and Mtwara were used in the study. The goats were purchased from the Central, Western and Southern zones of the country and transported to the station in Morogoro (Eastern zone). Animals were grazed on contaminated communal pastures at Sokoine University of Agriculture for seven months. Faecal samples and whole blood were collected monthly from each animal for determination of faecal egg counts (FEC), packed cell volume (PCV) and blood eosinophils (EOS). All animals were weighed at each of the sampling dates. Results showed that there was a significant difference in FEC ($P<0.01$), PCV ($P<0.05$) and EOS ($P<0.01$) among strains and that means of Dodoma and Kigoma were not significantly different ($P<0.05$). The Dodoma strain had the lowest FEC but the highest PCV and EOS while Mtwara strain had the highest FEC and mortality and the lowest PCV, EOS and live weight. Kigoma strain had the highest live weight while FEC, PCV and EOS

a Corresponding author. Tel: +255 56 4980, Fax: +255 56 3177, E-mail: Vetmipar@twiga.com

were between those of Dodoma and Mtwara strains. Anthelmintic treatment and high worm burdens resulted in decreased EOS in all strains. There was a negative phenotypic correlation (r =-0.17) between FEC and EOS within-strains and it decreased with an increase in worm burdens. Phenotypic correlation between FEC and live weight was low and close to zero (r =-0.02). It is concluded that there is a significant variation among strains in resistance to gastrointestinal nematodes in strains of SEA goats, and in order of increasing susceptibility the three strains were ranked as Dodoma, Kigoma and Mtwara respectively. It is also concluded that FEC, PCV and EOS are equally efficient as selection criteria for resistance where *Haemonchus contortus* is dominant except at high levels of worm infection where EOS is of little value.

Keywords: Goats; Genetics; Resistance; Nematode

INTRODUCTION

Small ruminants are an important component of agricultural systems in the developing world, and are especially important to small holders and the landless, resource-poor, rural population. The main constraints hindering the productivity of the livestock sector in Tanzania are diseases, poor nutrition, poor breeding policies and poor management (Mpelumbe, 1984). About 40-60% of small ruminant losses in Tanzania are due to diseases (Mtenga et al., 1986) and of all the diseases, helminthoses are considered to be the most important cause of reduced productivity in goats (Connor et al., 1990). Gastrointestinal nematode parasitism in small ruminants is a world-wide problem causing economic losses in the form of mortality, reduced milk and meat, reduced feed intake and utilisation, reduced growth rate as well as control costs.

Control of gastrointestinal parasites for many decades has been almost entirely based on the use of anthelmintics. Routine and indiscriminate use of anthelmintics has resulted in the development of nematode strains resistant to anthelmintics that have been in use over a long period (Waller, 1994). Anthelmintic resistance is a world-wide problem and once acquired by a parasite strain, resistance appears to be more or less an irreversible property. Genetic control through breeding for resistant hosts is one of the alternative measures for control of gastrointestinal parasites. This method is based on selection of worm resistant animals between and within-breeds and strains or genetic manipulation of host resistance through selective breeding. There is ample evidence that, resistance to helminths is genetically controlled and is heritable in cattle, sheep and goats; thus breeding for resistant hosts is feasible.

Animals with genetically improved resistance carry fewer worms than susceptible animals and the worms they do carry are less fecund (Dineen and Windon, 1980; Bisset et al., 1996) and so the phenomenon of host resistance results in reduced contamination of pasture with worm eggs. Studies have shown that worms in resistant animals require less treatments for adequate worm control (Barger, 1989) and the risk of worms developing resistance is therefore reduced if the timing and frequency of treatment are properly managed.

Genetic resistance of goats to parasites has received much less attention compared to sheep (Shavulimo, 1988; Baker, 1994). Moreover most investigations have been on between-breed variation in resistance with very few reports on within-breed variation. Therefore the major objective of this study was to investigate resistance of the Small East African goats from different geographical regions in Tanzania under natural grazing conditions.

MATERIALS AND METHODS

Study area

The study was conducted at Sokoine University of Agriculture (SUA) in Morogoro. Animals used in the study were three strains of Small East African (SEA) breed of goats. Animals were obtained from three regions in different zones of Tanzania, i.e. Dodoma (Central zone), Kigoma (Western zone) and

Mtwara (Southern zone). One hundred mature animals (15-18 months old) of both sexes were purchased from each region and transported to the station at SUA (Eastern zone).

Prior to commencement of the observation period (in September), all animals were treated with a combination of levamisole and oxyclozanide (Levafas®, Norbrook Laboratories Ltd, London) orally at a dose rate of 22.5 mg/kg. During day time, animals were grazed daily on pastures contaminated with worm eggs at SUA for seven months. The aim of grazing them was to expose them to natural nematode infection.

Samples and Sample processing

Faecal and whole blood samples were taken once every month. Faecal samples were taken per rectum using gloved fingers. Blood samples were taken from the jugular vein in evacuated blood collecting tubes (Vacutainers®). Faecal egg counts (FEC) in terms of eggs per gram of faeces (epg) for each goat was determined by the modified MacMaster method (MAFF, 1986), packed cell volume (PCV) was determined by the micro-haematocrit centrifuge technique. Blood eosinophils (EOS) were determined by mixing 100μl of blood with 900 μl of Carpentier's eosinophil staining solution (Dawkins et al., 1989) and their counting on a Fuch's Rosenthal counting chamber. Bulked faecal samples by strain were cultured for larvae identification. In addition, all animals were weighed at each of the sampling dates. At any of the sampling dates, any animal that was found to have reached FEC ≥ 3000 epg and /or PCV ≤ 18% was individually drenched with a combination of levamisole and oxyclozanide (Levafas®) orally at the dose rate of 22.5 mg/kg.

Data analysis

Data was analysed by Least Squares Analysis of Variance using the PC-2 Version of the Mixed Model Least Squares and Maximum Likelihood Computer Program (Harvey, 1990). The statistical model fitted included effects of strain (3 levels) and sex (2 levels). All analyses were carried out at each sampling date. To normalise data, FEC and EOS were logarithm transformed [$\log_{10}$ (FEC+25) for FEC and $\log_{10}$ (EOS+10) for EOS] and results back-transformed by taking the antilogarithms of the least squares means (i.e. the geometric means). Where there was significant difference among strains, means were compared by linear contrast functions.

RESULTS

Faecal egg counts

Results of faecal egg counts (FEC) during the study period are shown in Fig. 1. The FEC pattern generally paralleled that of total monthly rainfall being highest in March and April. In most of the study period, Dodoma strain had the lowest FEC, Mtwara strain had the highest FEC while Kigoma strain had FEC between the other two strains. Except in October, Mtwara strain had significantly higher FEC than the other strains (P<0.05), and that means of Dodoma and Kigoma were not significantly different (P>0.05). Male animals tended to have higher FEC than females but this was not significant (P>0.05). There was a negative within-strain phenotypic correlation (r =-0.21) between FEC and PCV (range -0.11 to -0.29). There was also a negative phenotypic correlation (r =-0.17) between FEC and EOS (range -0.07 to -0.27) and the association decreased with an increase in worm burdens.

Packed cell volume

Results of Packed Cell Volume (PCV) are shown in Fig.2. A decrease in PCV was associated with an increase in FEC. In most of the study period, Dodoma strain had the highest PCV, Mtwara strain had the lowest PCV while Kigoma strain had PCV between the other two strains. Except in March, Mtwara strain had significantly lower PCV than the other strains (P<0.05), and that means of Dodoma and Kigoma were not significantly different (P>0.05). In March, PCV increased in all strains despite an increase in worm burdens. There was a positive within-strain phenotypic correlation (r =0.22) between PCV and EOS (range 0.09 to

0.34).

Blood eosinophils

Results of blood eosinophils (EOS) in goats during the study period are shown in Fig. 3. In most of the study period, Dodoma strain had the highest EOS, Mtwara strain had the lowest EOS while Kigoma strain had EOS between those of Dodoma and Mtwara strains. Except in April, Mtwara strain had significantly lower EOS than the other strains ($P<0.01$), and that means of Dodoma and Kigoma were not significantly different ($P>0.05$).

Anthelmintic treatment and mortality

The number of animals treated with anthelmintic when FEC was ≥ 3000 epg and /or PCV ≥ 18% during the study period were 7% (Dodoma), 20% (Kigoma) and 38% (Mtwara). Mtwara strain required more/frequent anthelmintic treatment than the other strains. Mortality rates were higher in Mtwara strain than in the other strains. The number of animals that died during the study period were 1 (Dodoma), 1 (Kigoma) and 25 (Mtwara). The main causes of mortality were helminthosis, pneumonia, collibacillosis, trypanosomosis and coccidiosis.

Faecal culture

The pooled mean faecal culture during the grazing period showed that the infection was predominantly *Haemonchus contortus* (67.9%), *Oesophagostomum* spp (14.9%), *Trichostrongylus* spp (13.3%) and *Cooperia* spp (2%). There was no significant difference in larval composition among strains ($P>0.05$).

Live weights

Results of live weight (LWT) are shown in Fig. 4. Throughout the study period, the Kigoma strain had the highest live weight, Mtwara strain had the lowest live weight while Dodoma strain had live weight between the other two strains. There was a significant difference in live weight among strains throughout the study period ($P<0.05$). The correlation between FEC and LWT was negative and close to zero ($r=-0.02$).

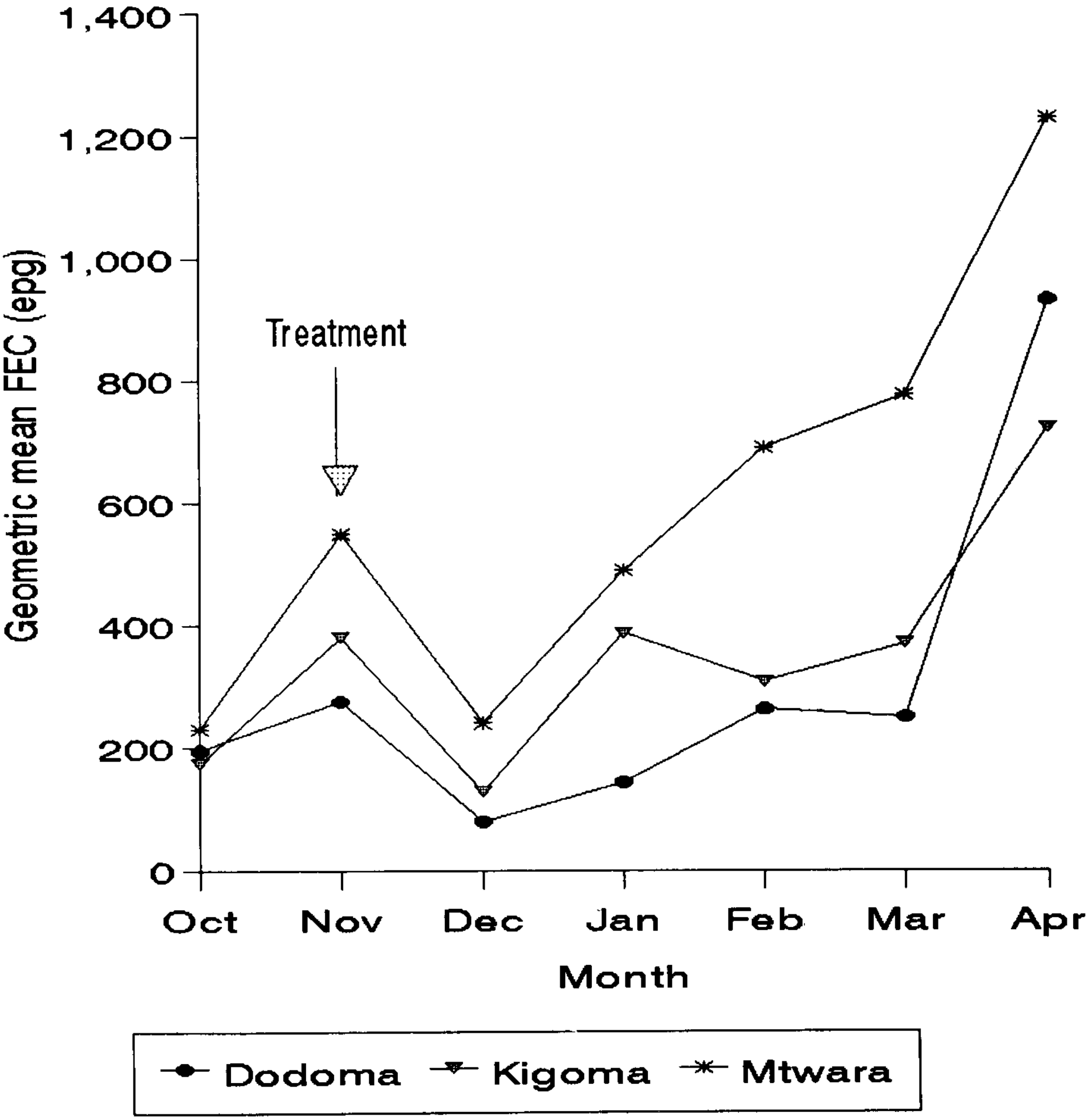

Fig 1. Faecal egg counts in adult goats

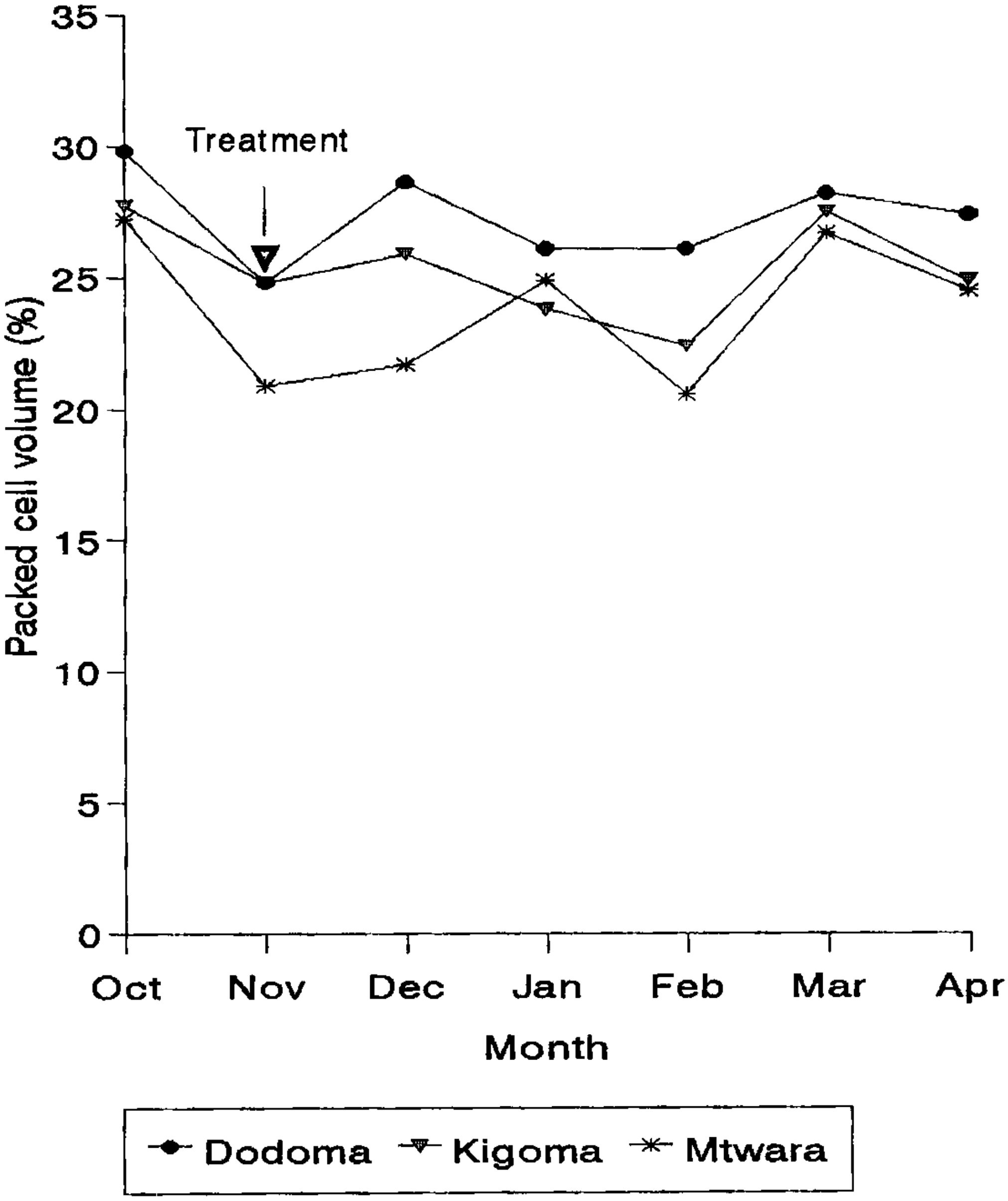

Fig 2. Packed cell volume in adult goats

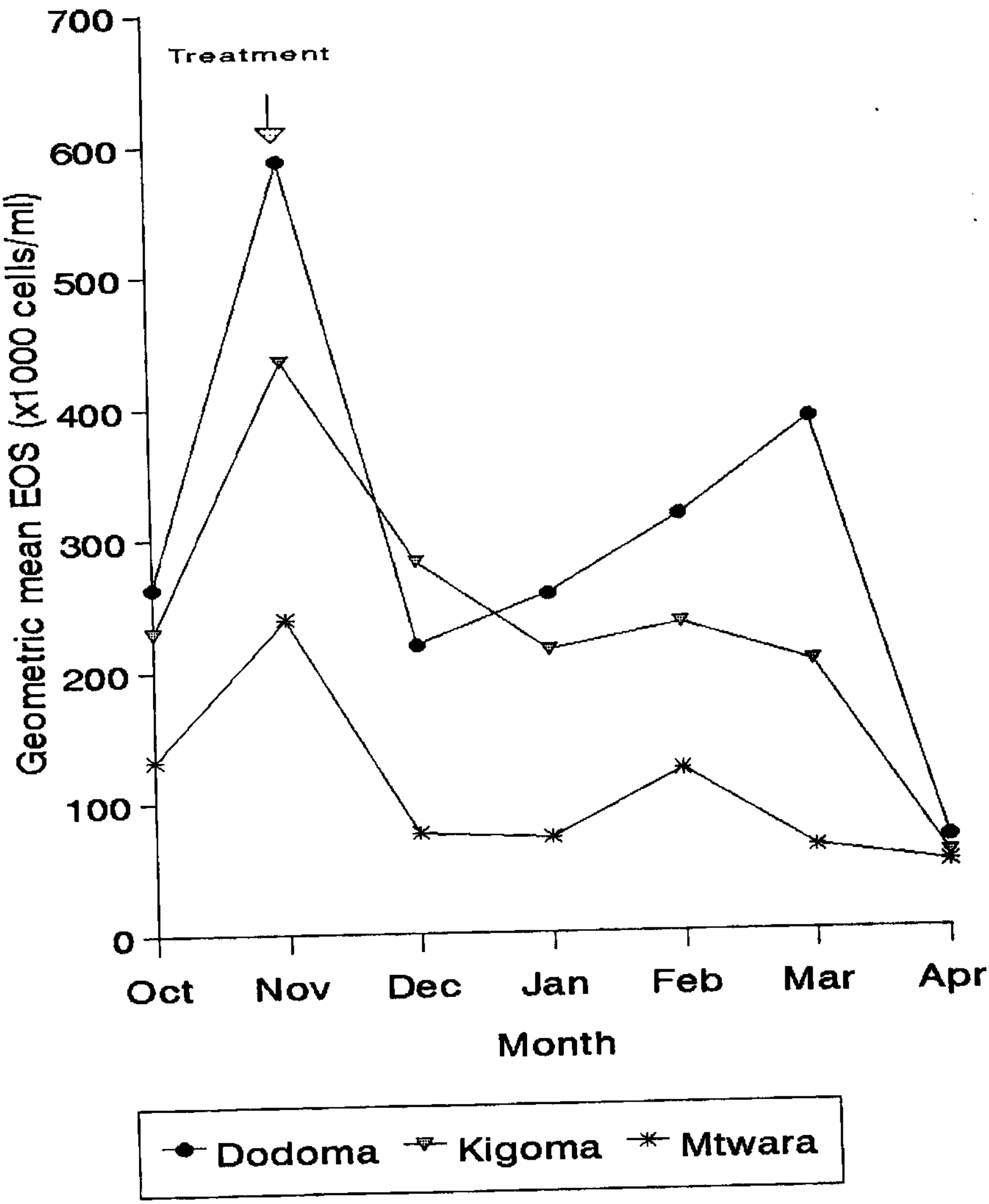

Fig 3. Blood eosinophils in adult goats

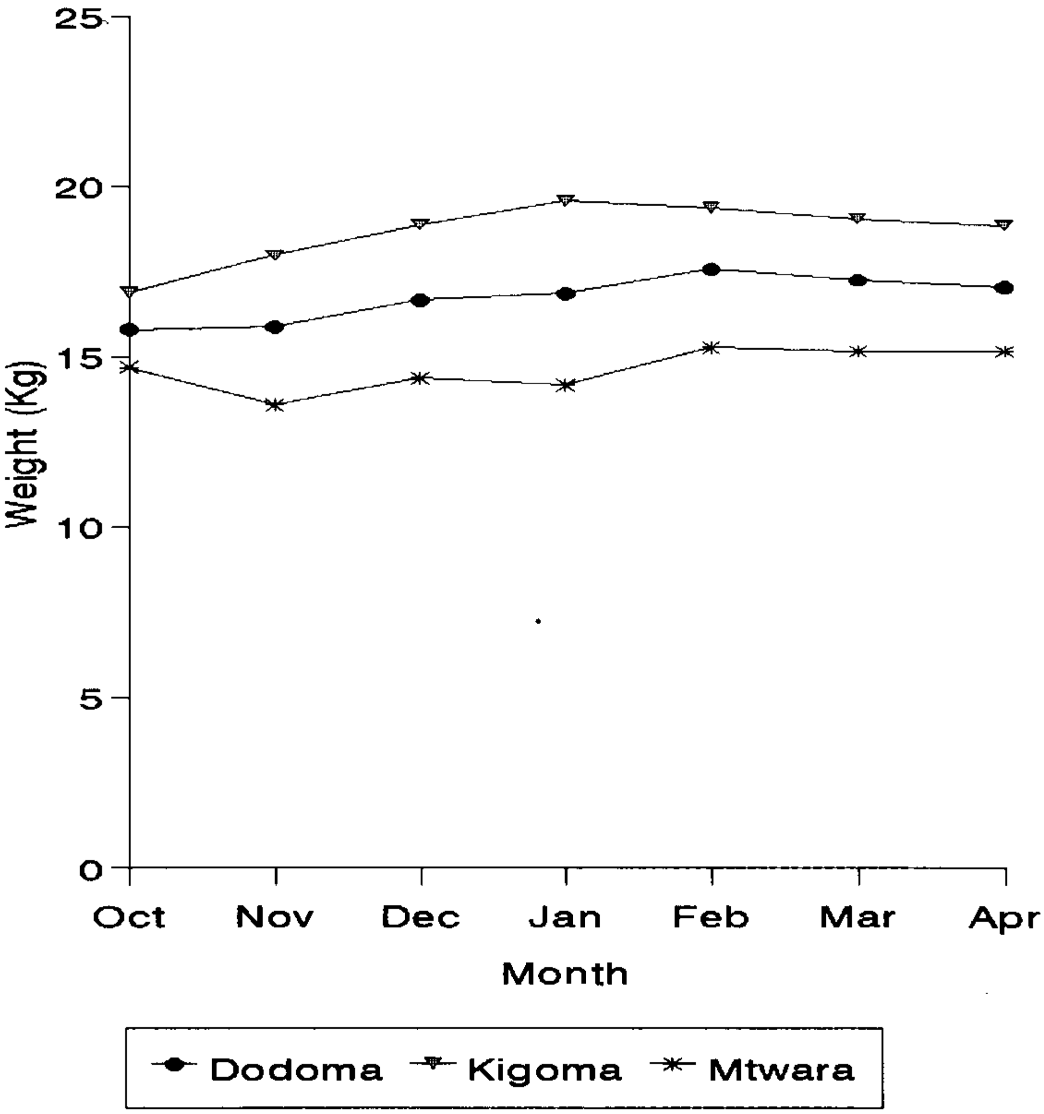

Fig 4. Live weights in adult goats

DISCUSSION

The results indicate that there was a significant difference in FEC among strains starting the second month of the study period. The lack of a significant difference in FEC among strains one month from commencement of the study may be due to the fact that all strains were drenched prior to commencement of the study period in order to terminate pre-existing infections. Baker et al. (1994) reported the lack of a significant difference between Red Maasai and Dorper sheep two months after drenching them. The findings suggest that selection experiments for resistance whereby all animals are drenched every after sampling (e.g. at monthly intervals) may result in lack of differences between individuals due to inadequate worm burdens. The sharp increase in FEC in March indicated that pasture contamination in the period of heavy rainfall was very high and so the intake of infective larvae by grazing animals apparently increased. The observations concur with that of Ngomuo et al. (1995) who reported high FEC in goats from March to May in the same grazing area.

The higher FEC in males than in females indicates that male goats may be more susceptible than females. The findings concur with those in sheep by Windon and Dineen (1981). The mechanism remains unknown, but Grossman (1989) and Schuurs and Verheul (1990) in their reviews indicated that circulating levels of major immunoglobulin classes and antibodies to a variety of antigens are higher and more sustained in females than in males. Physiological levels of oestrogen in females have been shown to stimulate humoral and cell-mediated immune responses, while androgens have the opposite effect (Barger, 1993).

Results from PCV indicated that when animals are drenched as expected PCV increases and when worm burden is high PCV decreases. In March PCV increased in all strains despite an increase in worm burdens in all the animals. This may have been attributed by plenty of pastures in grazing areas as it was the period of high rainfall. Therefore improved plane of nutrition enabled animals to maintain relatively high PCV in the face of high worm burdens. The results are in agreement with those of Blackburn et al. (1992) who found that as nutrition improves, PCV is increased. However results in the present study indicated that the effect of improved nutrition on PCV was short lived as a further increase in FEC led to a marked reduction in the PCV despite the availability of grazing pastures. These findings from the present study suggest that a good plane of nutrition is of value in minimising the effect of parasitism at low levels of infection beyond which nutrition is of little value especially during overwhelming worm burdens. The negative phenotypic correlation between FEC and PCV indicated that where blood sucking parasites are dominant, high FEC is associated with low PCV and vice versa.

This study has shown that an increase in EOS is associated with consistent parasite establishment. It appeared that a certain threshold of worm burden is required for effective stimulation of immune response below which EOS remain at normal or sub-normal levels. In December, EOS decreased dramatically in all strains. The sudden decrease may have been attributed by anthelmintic treatment given to all animals following an outbreak of multiple infections. However it is not clear as to whether the decline in EOS was due to elimination of parasites *per se* or was due to a combination of several factors. In April EOS were very low in all strains probably due to overwhelming worm burdens. The results indicated that very high worm burdens reduce the response of animals to parasites, the results are similar to those of Silverman et al. (1970) who found that the immune mechanism is partially paralysed or inactivated in animals surviving an overwhelming infection.

The lack of significant difference in FEC, PCV and EOS between Dodoma and Kigoma goats probably indicated that the two strains are more or less genetically similar in terms of resistance/susceptibility. Polymerase Chain Reaction (PCR) based DNA fingerprints (profiles) of the three strains conducted by Chalya et al. (1997) indicated that there was no significant genetic distance between Dodoma and Kigoma strains while both of them had a significant genetic distance with Mtwara strain. The present resistance studies further substantiate their findings.

The negative correlation between EOS and FEC indicated that high EOS is associated with low FEC and vice versa. Dawkins et al. (1989) found that high eosinophil counts is associated with suppression of FEC. The association between high EOS and suppression of FEC has also been reported in Suffolk and Fin Dorset crossbred lambs (Kimambo et al., 1988) and in Romney lambs (Buddle et al., 1992). The positive correlation between EOS and PCV indicates that where *Haemonchus contortus* is dominant, animals with high EOS are able to maintain high PCV.

In the present study, EOS ranked the strains as Dodoma, Kigoma and Mtwara in order of decreasing resistance to nematodes as other selection criteria (e.g. FEC and PCV). However, EOS may be of value at low and moderate levels of parasite infection, while at very high levels of parasite infection EOS are very much lowered to an extent that it may not be possible to discriminate resistance/susceptibility between hosts. Moreover, EOS is influenced by anthelmintic treatment and therefore this criterion may be of value when used in addition to other selection criteria and not as the sole criterion. In a study conducted in Merino sheep by Woolaston et al. (1996), it was concluded that EOS offers no advantage over FEC as a selection criterion for resistance.

It is concluded that there is a significant variation in resistance to gastrointestinal nematodes in strains of SEA goats, and in terms of increasing susceptibility to gastrointestinal nematodes the three strains were ranked as Dodoma, Kigoma and Mtwara respectively. Dodoma and Kigoma strains are not significantly different from one another in resistance/susceptibility and that both of them appear to be more resistant than Mtwara strain. The present study is in agreement with the speculation that goats in the central zone are relatively more resistant to diseases than goats from other zones. Moreover FEC, PCV and EOS are equally efficient as selection criteria for resistance at moderate natural mixed infections where *Haemonchus contortus* is dominant. However, the present findings should be interpreted with caution as the present expressed resistance may have been influenced by previous exposure (experience) and frequency of anthelmintic treatment of the three strains in the regions of origin. Further studies on the offspring are required before reaching firm conclusions.

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