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Objektyp: **Article**

Zeitschrift: **Acta Tropica**

Band (Jahr): **43 (1986)**

Heft 2

PDF erstellt am: **12.07.2024**

Persistenter Link: <https://doi.org/10.5169/seals-313622>

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Epidemiological studies on *Schistosoma bovis* in Iringa Region, Tanzania

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Summary

Various aspects of the epidemiology of *Schistosoma bovis* were studied over a one-year period in Iringa Region, Tanzania. An abattoir survey revealed an overall prevalence rate of 30.8% in cattle and 3.8% in goats in the area, and field studies on two dairy farms both providing good opportunities for schistosome transmission provided information concerning the transmission ecology of *S. bovis* in relation to different types of grazing and water supply. The traditional management system on one farm with a large number of cattle utilizing a limited water resource highly suitable for sustaining populations of the snail host *Bulinus africanus* resulted in intensive transmission as evidenced by uptake of massive infections in calves and development of resistance to *S. bovis* challenge in dairy cows. On another farm, appropriate management comprising watering of cattle at a *B. africanus*-free pond provided the background for less intensive transmission in that transmission risk was confined to occasional contact with water contact sites of secondary importance. Besides, the transmission pattern as regards intensity and seasonality was affected markedly by the geographical and seasonal distribution of the host snail *B. africanus*. Thus, transmission in canals and temporary ponds was limited mainly to the dry season and the end of the rainy season, respectively, while transmission in permanent ponds occurred intermittently throughout at least most of the year. It is concluded that prevention of severe loss of productivity in domestic ruminants due to schistosome infections should be possible using strategic management procedures provided that essential information is available concerning the pattern of transmission in the particular area.

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Key words: *Schistosoma bovis*; *Bulinus africanus*; cattle; transmission ecology; Tanzania.

Introduction

Domestic ruminant schistosomiasis caused mainly by *Schistosoma bovis* or *S. matthei* is widely distributed in most parts of Africa (Dinnik and Dinnik, 1965; Pitchford, 1977; Christensen et al., 1983). Traditional grazing and watering procedures tend to be conducive of enzootic schistosomiasis, which is characterized by high prevalence of moderate worm burdens in the cattle population. As a result schistosomiasis of domestic ruminants appears mainly in the chronic subclinical form which may, however, cause significant loss of productivity according to extensive experimental studies and field observations (see Dargie, 1980; McCauley et al., 1983). The importance of schistosomiasis is expected to increase in future as a result of intensified animal husbandry and water conservation, creating ideal conditions for the propagation of schistosome transmission (see Christensen et al., 1983). Although some drugs have proved effective (Bushara et al., 1982, 1983a) mass chemotherapy appears economically unrealistic in veterinary medicine. The same appears to be the case with extensive use of molluscicides, and immunoprophylactic procedures are so far not commercially applicable.

The above observations call for low-cost practical control measures based on the prevention of schistosome infection through strategic management procedures involving grazing patterns, water supply, and drainage. Such measures will obviously imply detailed epidemiological knowledge, which has so far mainly been obtained in the Sudan, however (Majid et al., 1980, 1983). Hence epidemiological investigations are needed in other climatic regions of Africa. The present study forms a contribution of this kind describing important aspects of *S. bovis* transmission in a relatively cool part of East Africa. The results originate from a one-year field study conducted from July 1983 to July 1984 in Iringa Region, Tanzania.

Materials and Methods

Local conditions of the study areas

The major part of the study was conducted at herd level on two dairy farms – farm A and farm B – both situated at an altitude of approx. 1,800 m above sea level along the Little Ruaha River approx. 10 km away from Iringa Township in Central Tanzania. Both of the farms kept their animals on natural pastures, partly on the lowland (flood plain) along the river and partly on drier highland away from the river.

On farm A the grazing animals were in close contact with one temporary and two permanent ponds on the flood plain. On farm B the permanent water bodies comprised an artificial drinking pond receiving water from a well, and several drainage canals on the flood plain. During the rainy season the water level of the permanent pond rose considerably, and there was fast-flowing water in the canals. At the same time numerous temporary ponds were formed in other parts of the pasture.

Monitoring of local climatic parameters was based on meteorological data recorded at Nduli Meteorological Station situated about 10 km away from the farms, at a comparable altitude. Preceded by a 4-month dry period, rains occurred from October 1983 to May 1984, during which period 39 rainy days resulted in a total precipitation of 571 mm. Heavy rains, however, were confined to the period December 1983 to April 1984 (see Fig. 1). From October 1983 to July 1984 the overall mean of monthly maximum temperatures was 25.3°C (range 23.5°C to 27.1°C, highest in January), and the overall mean of monthly minimum temperatures was 14.8°C (range 13.0°C to 16.5°C, lowest in June).

Animals and management

The herd of Farm A comprised approximately 50 Ayrshire cows of more than 3 years of age. Except for a few days of flooding, the animals were grazed on the flood plain. Various ponds, including the permanent ones, were used for drinking.

Farm B had approximately 600 head of Ayrshire cattle and a flock of about 50 sheep and goats. The cattle herd was grazed in six separate groups:

- Group B1: unweaned calves, aged 0 to 4½ months,
- Group B2: weaned calves, aged 4½ to 11 months,
- Group B3: young heifers, aged 12 to 18 months,
- Group B4: older heifers, aged 19 to 24 months,
- Group B5: dry cows, more than 24 months old,
- Group B6: lactating cows, more than 24 months old,

B1 was kept in calf pens supplied with drinking water from a snail-free well. B4 and the sheep/goat flock remained on the highland pastures throughout the year, whereas all other cattle groups were grazed in the highland during the heavy rains and otherwise along the drainage canals on the flood plain. Three times a day all grazing animals were led to the central artificial drinking pond which constituted their primary water contact site. While grazing, however, they had as well contact with other water bodies, i.e. the drainage canals and the temporary ponds created during the rainy season.

Due to steep banks the river was not an essential water contact site on any of the farms.

Livestock investigations

Faecal excretion of *S. bovis* eggs was detected and quantified (eggs per g of faeces = EPGF) according to a modified Bell filtration technique (Kassuku, 1985). This applied in all cases except for B1 and B2 calves on farm B, in which case an even more sensitive miracidial hatching technique was used (Kassuku, 1985).

On farm A the *S. bovis* egg excretion of 5 to 20 identifiable dairy cows was followed at one to two months intervals from September 1983 to July 1984. Mid-January 1984 5 nine-months-old Ayrshire calves were added to the original cattle herd. These calves were obtained from an area known to be schistosome-free, and had been confirmed negative for *S. bovis* infection at 3 consecutive monthly examinations prior to the introduction into the herd. These calves served as tracer animals, picking up the natural schistosome infection while grazing together with the dairy cows. Faecal samples of the tracer calves were collected and examined for schistosome eggs at one-month intervals throughout the tracing period.

On farm B faecal samples from randomly selected animals within all groups of grazing cattle were examined in April and July 1984. B3, B5 and B6 were examined in April, B3, B4 and B5 in early July and finally B3, B4, B5 and B6 in late July. In addition 5 sheep and 10 goats were sampled in early July.

For weaner calves entering B2 a special sampling procedure was applied in order to elucidate the approximate time of initial acquisition of *S. bovis* infection. For a start all unweaned calves (B1) were examined and found free from schistosome infection, obviously because they were never exposed to *S. bovis* cercariae prior to weaning. A total of 29 identifiable weaner calves entering B2 during the

period August 1983 to May 1984 were subsequently followed individually at monthly intervals and sampled systematically until schistosome miracidia were detected for the first time on faecal examination. Estimation of time of initial acquisition of infection is based on a prepatent period of *S. bovis* in cattle in the range of 8 weeks.

Snail investigations

The snail populations of all water bodies on farm A and of permanent water bodies on farm B were monitored throughout the study period. Monthly samplings were conducted at essential water contact sites of the cattle using a standard scoop and a scooping time of 15 min. Snail identification to species level was verified by Dr. T. Kristensen, Danish Bilharziasis Laboratory. Trematode infection of snails was detected based on cercarial shedding, and furcocercous cercariae were identified to the *Schistosoma* genus level according to Frandsen and Christensen (1984).

Though theoretically possible, transmission of *S. haematobium* was unlikely in the study area, since fencing and extensive use of the water bodies by cattle made them unsuitable for human use. Besides, the nearest human settlements, situated more than 500 m away from the water bodies, had proper sanitary facilities, and the adjacent river provided ideal conditions for water-related recreational activities. Considering these observations, it may be concluded that schistosome cercariae shed from *Bulinus* snails were those of *S. bovis* rather than of *S. haematobium*. This was verified on 3 occasions by experimental infection of goats using cercariae shed by *B. africanus* collected in the permanent pond on farm A and by the uptake of *S. bovis* infection by the tracer calves at farm A and by group B2 calves at farm B (see below).

Laboratory compatibility studies were conducted in accordance with Frandsen (1979). First generation offspring of locally collected snails were exposed to miracidia (4 miracidia/snail) hatched from cattle faeces originating on farm A.

Abattoir survey

Apart from the local field studies a general survey was conducted at Iringa Abattoir. Livestock killed at this abattoir originates from small-holders grazing various types of communal rangeland in Iringa Region. During the period September 1983 to July 1984 a total of 165 bovine and 52 caprine carcasses were examined. One jejunal sample of 5–10 g was digested in KOH and examined according to Børneboe and Frandsen (1979), and individual egg counts per g of tissue (EPGT) were recorded.

Results

Snails

On both farms all the primary water contact sites of the cattle harboured *Bulinus* snail of which two species, namely *B. africanus* and *B. tropicus*, were represented. Naturally acquired *S. bovis* infection was detected in *B. africanus* only. This field observation was supported by laboratory compatibility studies in which *S. bovis* infection was established in 83.3% of surviving *B. africanus* snails exposed to miracidia, whereas *B. tropicus* proved completely refractory to the infection. No other potential intermediate snail host species were detected on any of the farms.

On farm A *B. africanus* snails naturally infected with *S. bovis* were found in the temporary pond and in one of the permanent ponds on the flood plain. The *B. africanus* population in the permanent pond fluctuated irregularly at a moderate to low level throughout the observation period, and *S. bovis* infected snails were found on five occasions randomly distributed in time (see Fig. 1). The

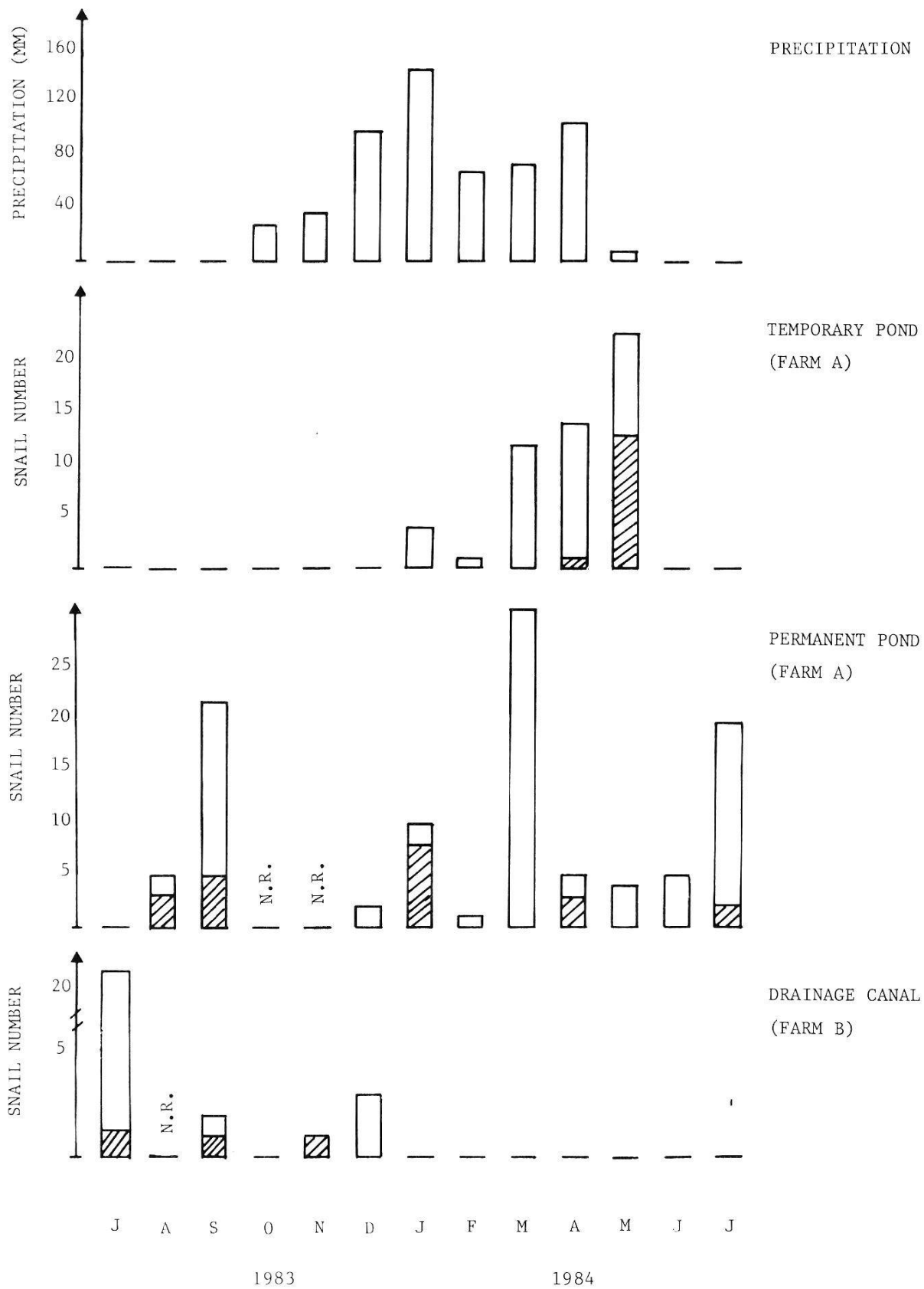


Fig. 1. Seasonal variation in the population density of *Bulinus africanus* and in the infection rate of *Schistosoma bovis* in *B. africanus* in three types of transmission habitats in the Iringa Region, Tanzania. □ = number of snails recovered (standard scoop, 15 min scooping); ▨ = number of *S. bovis* infected snails recovered.

water level of the temporary pond rose to its maximum in January 1984 followed by a gradual decline and eventually complete dryness in June 1984. Few *B. africanus* snails were recovered in January and February 1984. Subsequently, the population density increased markedly to a maximum in May, followed by abrupt disappearance of snails in June when the habitat became dry (see Fig. 1). The snails recovered in January and February were large individuals (11–14 mm shell height), which had obviously aestivated during the preceding dry period. These snails died out in April 1984 and at the same time a new generation appeared (shell height less than 10 mm). In April and May 1984 *S. bovis* infection rates in *B. africanus* were 7.1% and 54.2%, respectively (see Fig. 1).

On farm B the most striking observation was the absence of *B. africanus* from the very important artificial drinking pond. Few *B. africanus* were found in the drainage canals on the flood plain during the dry season and at the beginning of the wet season before flooding (see Fig. 1). *S. bovis* infected snails were found in July, September, and November 1983, infection rates being 5%, 50% and 100%, respectively. Irregular samplings of temporary ponds in the highland and on the flood plain revealed a relatively high density of *B. africanus* in March, April and May 1984 (data not presented). In June 1984 *S. bovis* infected snails were recovered from a temporary pond on the flood plain.

Livestock

On farm A all dairy cows sampled excreted *S. bovis* eggs during the entire study period, with average faecal egg output persistently at a low level ranging from 4.0 to 19.4 EPGF (see Fig. 2). The tracer calves started excreting *S. bovis* eggs in March or in April 1984, and the average egg outputs increased rapidly from 69.4 EPGF in May to 159 EPGF in July 1984 (see Fig. 2). Thus, the faecal egg counts of the tracer calves exceeded those of dairy cows to a statistically significant level ($p < 0.05$, Student's t-test) from April 1984 and onwards.

On farm B the prevalence rates of egg excretors during April and July 1984 were high in all groups of grazing cattle, ranging between 80% and 100% (see Table 1). From the Table it also appears that the average egg outputs of the groups were generally low in July, ranging from 7.2 to 14.4 EPGF, with no significant differences between the groups. Faecal samples of sheep and goats revealed prevalence rates of 40% and 20%, respectively. In both sheep and goats the average faecal egg outputs were very low with group means of 1.5 EPGF and 2.0 EPGF, respectively (see Table 1).

The observations on B2 calves at farm B indicated the presence of two transmission peaks during the study period. The first peak was seen from August to December, when all calves entering the group started schistosome egg excretion less than 3 months following entry. From January to March 1984 the transmission appeared less intensive since only 2 out of 10 animals entering B2 during this period turned positive within a 3-month period. The second peak of

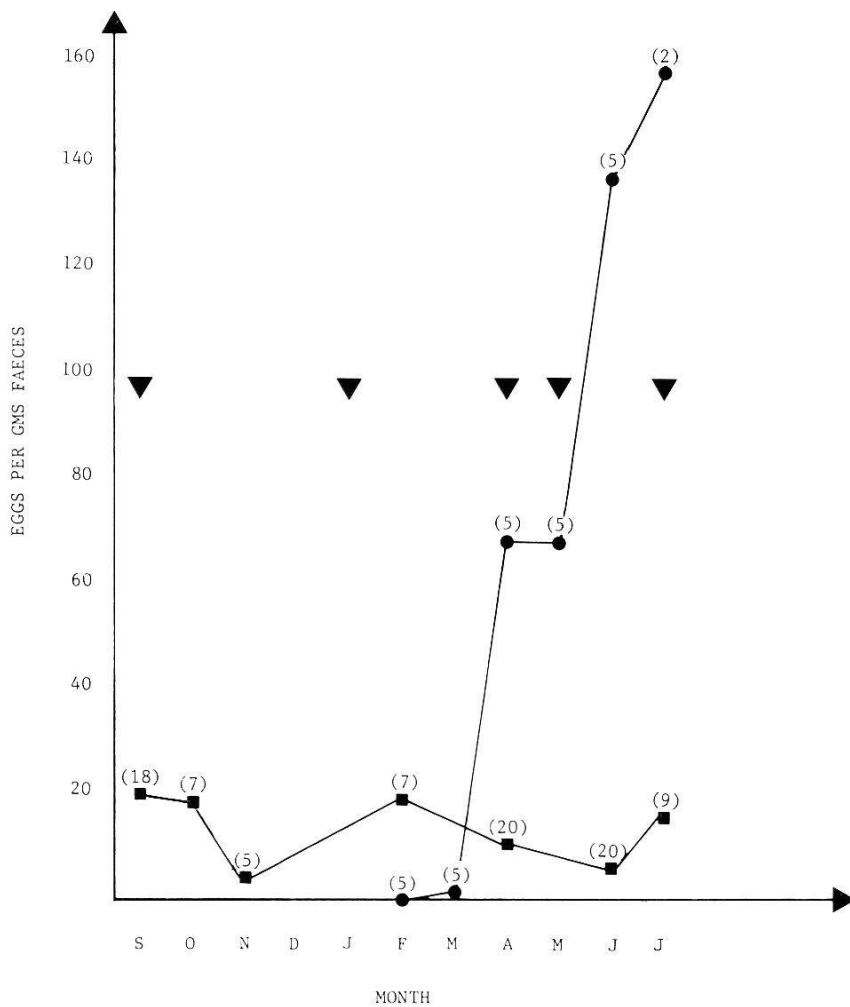


Fig. 2. Size of faecal egg output (eggs per gms of faeces, group means) of *Schistosoma bovis* infected dairy cows and tracer calves under conditions of a prolonged natural exposure to heavy cercarial exposures (farm A). ■—■ = dairy cows; ●—● = tracer calves. Figures in parenthesis indicate number of animals examined. ▼ indicates finding of *S. bovis* infected snails at the water contact sites at the farm.

Table 1. Faecal excretion of *Schistosoma bovis* eggs in four groups of grazing cattle and in the flock of sheep and goats on farm B, Iringa, April and July 1984

Animal group	Age of animals (years)	I. Egg excreters, prevalence rate			II. Faecal egg output, EPGF	
		April % (N)*	Early July % (N)	Late July % (N)	Early July $\bar{x} \pm S.D$	Late July $\bar{x} \pm S.D$
B3	1-1½	80 (5)	81 (16)	80 (15)	11.8±14.0	7.2±5.5
B4	1½-2	-	81 (16)	94 (16)	7.5±4.3	8.3±7.2
B5	>2	86 (7)	96 (16)	79 (14)	13.7±12.0	11.3±10.5
B6	>2	71 (7)	-	100 (14)	14.4±2.4	11.8±4.7
Sheep	?	-	40 (5)	-	1.5±0.7	-
Goats	?	-	20 (10)	-	2.0±1.4	-

* Number of animals examined

transmission occurred in April and May 1984, since all animals remaining negative during March, April and May and all animals entering B2 during this period turned positive either in June or July 1984. Common for all 29 animals examined was the acquisition of only light infections with miracidial numbers per g of faeces only occasionally exceeding 10.

Abattoir

Schistosome eggs were detected in 30.8% of the bovine samples collected at the abattoir, while 3.8% of the caprine samples were positive. The intensity of infection was generally low in both animal species as indicated by the low tissue egg counts only occasionally exceeding 100 EPGT.

Discussion

The epidemiology of domestic ruminant schistosomiasis is governed by a complex of interacting ecological factors, basically depending on local geographical, climatic, and management-related conditions. The transmission pattern may therefore be fairly variable, even within a well-defined geographical area, and the present study provides at least two examples of such epidemiological variability. Firstly, the overall moderate prevalence rate of *S. bovis* infection in cattle at the regional level, as judged upon the abattoir survey, contrasted strongly the high prevalence rates recorded locally on two farms in the region, and secondly, marked differences in the epidemiological pattern existed at the two almost neighbouring farms in spite of the very high prevalence rate of *S. bovis* on both farms.

Combined observations on the snail host and tracer calves revealed that transmission of *S. bovis* may occur throughout at least most parts of the year on both farms, but the actual importance of each transmission site is determined primarily by seasonal changes in the density of the snail host population. Thus, on farm A the permanent pond on the flood plain was responsible for intermittent transmission throughout the year, whereas the importance of the temporary pond was confined to the end of the rainy season. On farm B, the drainage canals on the flood plain contributed to *S. bovis* transmission mainly during the dry season when the water current was sufficiently slow to allow for establishment of *B. africanus* snail populations. In addition, however, transmission continued on this farm, although on fluctuating levels, throughout most parts of the rainy season, mainly in temporary ponds on higher pastures as shown by the pattern of uptake of infection in B2 animals. Previously, Pitchford and Visser (1965) observed a slightly fluctuating all-year-around transmission of *S. mattheei* in Eastern Transvaal, whereas marked seasonality in transmission intensity has been reported for *S. bovis* in the White Nile Province of the Sudan (Majid et al., 1980). In that area, the transmission is almost negligible at the end of the dry season due to extensive drying-up of major transmission sites.

When comparing the overall transmission patterns prevailing on the two

farms of the present study, it is evident that cattle grazing on farm A was generally much more massively exposed than the herd on farm B. Thus, the tracer calves readily picked up heavy burdens of *S. bovis* within a few months of grazing together with the dairy cows on farm A, whereas young animals on farm B (B2 and B3 calves) during the same time period acquired only light infections at a slow rate as evidenced by the fact, that the faecal egg/miracidial counts were much lower than the faecal egg counts detected in the group of tracer calves on farm A. Potential transmission sites were abundant on both farms, and the relatively low transmission intensity on farm B must be attributed to the management system practised on the farm, particularly the systematic use of the artificial drinking pond, which happened to be free from *B. africanus* and other potential intermediate host snails. Hence the infection risk was confined to occasional contact with secondary water contact sites on pasture. However, in spite of the low transmission intensity on farm B schistosome infection was established in almost all calves within 6 months of grazing. In contrast, the traditional type of management practised on farm A created ideal conditions for massive *S. bovis* transmission, since a relatively large cattle population had unlimited access to only few natural water bodies sustaining *B. africanus* snail populations.

The fact that all dairy cows on farm A exhibited consistently much lower faecal egg counts than the tracer calves using the same pastures provides the background for the conclusion that these cows had acquired natural resistance to *S. bovis* challenge under conditions of frequent and heavy cercarial exposure. Previously, acquisition of resistance to experimental *S. bovis* and *S. mattheei* challenge has been demonstrated on several occasions (Massoud and Nelson, 1972; Lawrence, 1973; Bushara et al., 1980, 1983a, b). In this connection it should be noted that the existence of pure age-dependent *S. bovis* resistance in cattle was ruled out by Bushara et al. (1980) who clearly demonstrated that schistosome-naïve adult Zebu cows were fully susceptible to *S. bovis* infection. As far as farm B is concerned there is little indication of acquired resistance. Elaboration of this aspect would imply more extensive field investigations, however.

Little emphasis was put on sheep and goats in this study. Observations on farm B, however, revealed low prevalence rates and extremely low faecal egg outputs in both species, and these findings are in line with those of Majid et al. (1983) as regard the sheep population at Umm Hani in the White Nile Province of Sudan. Since all domestic ruminant species are known to be equally susceptible to experimental *S. bovis* infection, the moderate infection rates among sheep and goats sharing water contact sites with infected cattle presumably reflect their reluctance to enter water while drinking (Christensen et al., 1983). It has been suggested that sheep and goats are predominantly infected per os (Kassuku et al., 1985) and it is generally assumed that their epidemiological importance is usually secondary to that of cattle (see Christensen et al., 1983).

In spite of the wide distribution and commonly high prevalence rates, schistosome infections of domestic ruminants create normally no major disease problems. Outbreaks of clinical schistosomiasis in domestic ruminants may, however, occasionally occur under conditions of especially intensive disease transmission (see Christensen et al., 1983 and references herein), and loss of productivity as a result of severe, chronic schistosome infections is also well documented (see Dargie, 1980). As shown in the present study, however, factors providing the background for intensive schistosome transmission, and thereby for ruminant schistosomiasis being a veterinary problem, are relatively easily recognized, normally comprising the use, by a large number of non-resistant animals, of a limited water resource ideal for sustaining populations of the snail host species and the intramolluscan larval schistosome development. Provided that essential information is available concerning the transmission pattern in a particular area, prevention of severe loss of productivity in domestic ruminants due to schistosome infections should thus be possible using strategic management procedures.

Acknowledgments

This study was supported by grants from the Danish International Development Agency, the Research and Publication Committee of the University of Dar es Salaam, Tanzania, and Knud Højgaard Foundation. Grateful thanks are due to the Veterinary Investigation Centre, Iringa, to Kibebe Farm, and to the Ruaha Centre for Training for Rural Development for hospitality and collaboration rendered by their leaders and technical staff. Thanks are also extended to the Sokoine University of Agriculture, Morogoro, Tanzania, particularly for technical assistance by the staff of the Department of Veterinary Microbiology and Parasitology.

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