The importance of animals in human schistosomiasis in South Africa

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Summary

The importance of animals in human schistosomiasis in South Africa is reviewed. The prevalence of animal schistosome species in humans, the role of animals as reservoir hosts of *Schistosoma haematobium* and *S. mansoni*, and the possibility of false-positive serological reactions in humans following exposure to animal or bird bilharzia are considered.

It is concluded that, as regards animal schistosomes, at present only *S. mattheei* and a hybrid of *S. mattheei* and *S. haematobium* pose a potential threat to human health in South Africa.

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In southern Africa schistosomiasis is practically as widely disseminated in animals as in humans. The prevalence in animals is very high in certain areas, for instance up to 90% in parts of the lowveld of the Transvaal.

Schistosoma mattheei is the only schistosome of importance in animals in South Africa; with the exception of *S. mansoni*, which has been recovered from primates and rodents and a single waterbuck,[1] and *S. haematobium*, recovered from one buffalo,[1] it is probably the only schistosome of mammals occurring naturally in domestic and wild animals in the country.

S. mattheei was discovered in 1926 by Veglia and Le Roux[2] in sheep near Humansdorp in the eastern Cape Province, and Le Roux[3] recovered *S. mattheei* ova from cattle faeces on the same farm. Although regarded by some[1,5] as equivalent to or a variant of *S. bovis*, differences in the ova[6-8] and biological and biochemical differences[9-11] have confirmed it as a separate species. Occurrence of *S. bovis* has not been confirmed in South Africa.[1]

In this paper the following aspects were discussed: (*i*) the prevalence and importance of *S. mattheei* in humans; (*ii*) the role of animals as reservoir hosts of *S. mansoni* and *S. haematobium*; (*iii*) animal schistosome species beyond our borders; (*iv*) serological reactions in humans; and (*v*) avian bilharzia.

The prevalence and importance of *S. mattheei* in humans[12]

S. mattheei, which shares the intermediate snail host, *Bulinus (Physopsis)* spp., with the human schistosome, *S. haematobium*, is primarily of veterinary importance. Apart from South Africa, it occurs in most neighbouring territories and as far north as parts of Tanzania, Chad and Nigeria.[1]

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The wide definitive host range includes man, cattle, sheep, goats and horses among the domestic animals and a large number of wild animals, including primates (baboons and monkeys), antelopes (kudu, waterbuck, impala, nyala, puku, lechwe, etc.), zebra, buffalo, giraffe, bushpig, warthog and various rodents.[1]

As can be expected from the fact that they share a common intermediate host, *S. mattheei* and *S. haematobium* have a very similar distribution in South Africa — mainly in the lowveld of the Transvaal, in large parts of Natal and coastal areas as far south as Humansdorp in the Cape. They also occur to a lesser extent in the Transvaal highveld. C. J. Visagie (personal communication) estimates that 3-4 million people in South Africa are infected with *S. haematobium* and/or *S. mansoni* and Pitchford[13] has reported that in the areas of highest prevalence (more than 90% *S. haematobium* in humans and up to 90% *S. mattheei* in cattle, for example in the Transvaal lowveld) man and domestic and wild animals often share the same water sources infested with the intermediate snail host.

Man is often exposed to *S. mattheei* infection. The parasite has the ability to develop in humans, as cattle schistosome ova have been demonstrated in both urinary and intestinal infections in humans in southern Africa by numerous workers.[6,13-17] With one exception,[16] cattle schistosome ova were always accompanied by *S. haematobium* and/or *S. mansoni*.[13]

Nevertheless, it is difficult to gauge just how susceptible man is to *S. mattheei*. In some well-documented cases man appears to be practically refractory to infection. While Le Roux[3] had good evidence that people were exposed to *S. mattheei*, by swimming in and drinking infested water, he could not demonstrate infection in them: 'Judging from the fact that the pool responsible for the infection of the sheep is used by man and beast alike, it is only natural to assume that if man could be infected, the human beings on the farm should have been. Both urine and faeces were examined with negative results.' He also examined 2 workers who had swum in the water but obtained consistently negative faecal and urine examinations 1 day and 2 and 3 months after exposure.

On the other hand, *S. mattheei* infections in humans are sometimes very prevalent, high infection rates having been reported from parts of the Transvaal, for instance. Pitchford[13] surveyed 275 people from different parts of the Transvaal and found cattle schistosome ova in the rectum and bladder in humans from the whole of the eastern Transvaal, east of the Drakensberg, from the western Transvaal, and Swaziland. He concluded: 'The distribution of the parasite in man in South Africa therefore probably follows very closely that of *S. haematobium*, and though not many cases have been found in the north-western and central Transvaal, this may be due to insufficient search being made.' He found a prevalence of up to 40% of cattle schistosomiasis in humans on one farm in the Komatipoort area in the eastern Transvaal (R. J. Pitchford — personal communication).

The apparent anomaly therefore exists that up to 40% of humans have been found to be infected with cattle schistosomes in certain areas, while in other areas they do not appear to be susceptible.

A comparable situation exists in the case of *S. japonicum* in the Far East. While a zoophilic strain of this parasite in Taiwan is

apparently not infective to man, the same species from other localities is known to be highly infective to man.[18]

Van Wyk[12] suggests that an answer to these apparent strain differences in South Africa may lie in the fact that some of the schistosome ova recovered from man were not pure *S. mattheei*, but a hybrid between *S. mattheei* and *S. haematobium*, as demonstrated by Pitchford,[19] who recovered ova indistinguishable from *S. mattheei* from man, which, when passaged in rodents and a calf gave rise to ova intermediate in size between *S. mattheei* and *S. haematobium*. In another case typical-looking *S. haematobium* ova recovered from a naturally infected rodent from Komatipoort gave rise to typical but short *S. mattheei* ova when passaged in white mice.[19]

Subsequently Taylor[10] demonstrated that *S. mattheei* and *S. haematobium* can cross, giving rise to a viable hybrid. Wright and Ross[20] confirmed (by iso-electric focusing of enzymes of worms obtained by passage from 2 patients) that this hybrid does occur naturally in man in South Africa and concluded that the shape of the eggs produced is: '. . . not necessarily a guide to the genetic constitution of the enclosed larvae'.

The possibility therefore exists that the apparent *S. mattheei* ova demonstrated in man in areas of high prevalence may be from hybrid parents producing ova morphologically indistinguishable from those of *S. mattheei*. Furthermore, by inference, some of the typical-looking *S. haematobium* ova in these people may also be hybrids. While not confirmed in the limited study by Wright and Ross[20] this inference is perhaps not too farfetched if one considers the abovementioned typical-looking *S. haematobium* ova from a rodent giving rise, on passage in mice, to almost typical *S. mattheei* ova.[19]

Van Wyk[12] suggested that patent infections of *S. mattheei* may develop in man only if exposure occurred for a certain minimum time, and that this may tie up with Pitchford's[13,19] surmise that *S. mattheei* females can give rise to patent infections in man only if carried by foreign or hybrid males. Continued exposure of man to large numbers of *S. mattheei* cercariae may improve the chances of female *S. mattheei* pairing with male *S. haematobium*.

The exact character of what has thus far been regarded as *S. mattheei* in man remains to be determined, which may be quite difficult despite the availability of sophisticated techniques such as iso-electric focusing. If an *S. mattheei*-like ovum is an F_1 hybrid, identification would be relatively easy. Where, however, the hybrid has been bred back repeatedly to one of the parent species, the shape of the ovum may be typical of one parent species, but will passage and enzyme comparisons reveal the fact that it is not of pure origin? More work is necessary, including cross-breeding studies proceeding further than the F_1 hybrid or even the first 2 or 3 crosses to determine up to what point the hybrids can be identified by any presently available means.

We have ample evidence that man is susceptible to cattle schistosomes and hybrids, but no positive suggestions have been forthcoming concerning the possible clinical effect of *S. mattheei* or the *S. mattheei*/*S. haematobium* hybrid, either on their own or together with the human schistosomes.

At present *S. mattheei* or hybrid infections are probably not a serious health problem in South Africa. It is, however, difficult to estimate the clinical effect because *S. mattheei* is invariably associated with *S. haematobium* or *S. mansoni* in human cases. Nevertheless, Pitchford[19] was able to conclude: '. . . it appears that the cattle schistosome *S. mattheei* will infect man, but that man is not a particularly good host; if he were, there seems no reason why the incidence of *S. mattheei* in man should not be as high as that of *S. haematobium* in those areas where there is close association between the two definitive hosts'.

Furthermore, in cases where *S. mattheei* succeeds in infecting man, the infection does not seem to be sustained. Although it must be borne in mind that they examined only urine, Pitchford and Visser[21] found only relatively low *S. mattheei* egg counts with no sustained rise in 10 children examined regularly over 14 months.

A prevalence as high as 40% in some areas, however, indicates that the parasite (pure strain or hybrid) may be adapting to the human host. As stated by Pitchford,[19] '. . . there is every likelihood that the incidence of *S. mattheei* in man might increase. The resulting hybrids will in time possibly supplant *S. mattheei* and *S. haematobium* with a schistosome infecting man and cattle with equal ease.' Already Pitchford and Lewis[22] have suggested that the poor response of *S. mattheei* in humans to oxamniquine treatment may be due to hybridization with *S. haematobium*, which is not susceptible to the drug.

The role of animals as reservoir hosts of *S. mansoni* and *S. haematobium*

For a reservoir host (defined by Nelson *et al.*[23] as: 'an animal which maintains under natural conditions an infection transmissible to man') to be an important source of *Schistosoma* infection in man it must be readily susceptible, must occur in sufficiently large numbers, so that a high level of transmission is maintained, and must frequent water sufficiently so that substantial amounts of excreta containing large numbers of schistosome ova are deposited in or near water. As the two human schistosomes in South Africa differ markedly in their infectivity for various definitive hosts, they need to be considered separately.

S. mansoni

Pitchford[1] lists the following animals as susceptible to *S. mansoni:* chimpanzee, various species of baboon, grivet monkey, sheep, dog, waterbuck, various species of rodent and two species of shrew, of which the chimpanzees, baboons and perhaps the monkeys are of potential practical significance as hosts.

Elsewhere in Africa it appears that baboons are able to maintain *S. mansoni* in nature for at least 18 months and that the *S. mansoni* is infective to man.[25] In South Africa Pitchford *et al.*[26] found only 1 out of 280 samples of baboon faeces containing eggs of *S. mansoni* (compared with 22 with *S. mattheei* ova); they found no infected humans, but this is probably inconclusive as the survey was conducted in the Kruger National Park with only a very low human population. No infected monkeys have as yet been found, but perhaps insufficient search has been made.

Although *S. mansoni* has been recovered from a few rodents, this is probably of little importance in this country.[13,27] Infection in sheep and dogs is very rare in nature, and all the ova recovered by Pitchford *et al.*[28] from a single waterbuck were dead.

S. haematobium

The following records of natural infection are listed for *S. haematobium:*[1] two species of baboon, chimpanzee, vervet monkey, pig, sheep and the Cape buffalo. Nelson *et al.*[23] consider man to be the only true host of *S. haematobium* and that the few records of this parasite from animals represent incidental or dead-end infections. No evidence exists to dispute this contention.

Animal schistosome species beyond our borders

The two species concerned are *S. margrebowiei* and *S. leiperi*, referred to as 'lechwe schistosomes' by Pitchford.[29] He considers the reports on *S. spindale* and *S. japonicum* in southern Africa to represent probable records of lechwe schistosomes. He lists man

as being susceptible to *S. margrebowiei* but not to *S. leiperi.*[1] Man, however, appears to be a poor host, and cases of infection are rare. According to Pitchford and Wolstenholme[30] '. . . the low *S. margrebowiei* egg counts . . . suggest that man is a poor host with low grade short lived infections . . . Alternatively man acts as a host in the same manner as cattle, i.e. unisexual male infections occur with an occasional female reaching maturity, which may or may not be short lived.' It is therefore very unlikely that these animal schistosomes will be important in humans. On the contrary, there is circumstantial evidence that the animal schistosomes (and specifically the two lechwe schistosomes) may limit or prevent the spread of the human schistosomes (*S. mansoni* and *S. haematobium*) presumably by stimulating resistance to infection.

Le Roux, cited by Pitchford,[29] suggested that animal schistosome cercariae may immunize man against human species and *vice versa*. Nelson *et al.*[23] coined the term 'zooprophylaxis' for instances where zoonoses '. . . stimulate man's immunological mechanisms so that he is able to resist the more pathogenic organisms in his environment'. An example given is the previously mentioned zoonotic strain of *S. japonicum* in Taiwan that fails to reach maturity in man, possibly the reason why the pathogenic strain of *S. japonicum* has not become established in that country.[31]

Indications of an inverse relationship between human schistosomiasis and the presence of lechwe schistosomes have been seen in the Okavango and Caprivi,[29,30] and very little human bilharzia was found in all areas where lechwe (shown to be commonly infested with the lechwe schistosomes) were common, a moderate amount where lechwe were scarce, and high rates where lechwe and puku were absent. Furthermore, over a number of years the rate of infection at Maun in Botswana has increased very greatly, in parallel with a simultaneous decrease in the lechwe population in the area. There are also indications that the lechwe schistosomes may have blocked the advance of *S. mattheei* in animals and man in these areas.

Serological reactions in humans

There are indications that false-positive serological reactions result in man from infection with animal schistosomes. Pitchford and Wolstenholme[30] surveyed 77 children from areas of the eastern Caprivi not endemic for human schistosomiasis and obtained 62% positive serological reactions. They found no schistosome ova and concluded that the children had been exposed to lechwe schistosomes. In two other areas where human schistosomiasis is endemic, positive serological reactions corresponded closely with the occurrence of ova in the excreta of the patients.

Apart from this limited evidence in southern Africa, similar results were obtained by Sadun and Biocca[32] with *S. bovis* in Sardinia. Using *S. mansoni* antigen in fluorescent antibody tests, they reported a 40% positivity rate in humans with a history of cercarial dermatitis. They posed the question whether this phenomenon perhaps signifies the presence of cross-immunity between *S. bovis* and human schistosomes. Wright[33] doubts this possibility because of a high prevalence of *S. bovis* in cattle and *S. haematobium* in humans in Gambia where the two parasites share the same intermediate host. The circumstantial evidence supplied by Pitchford and co-workers, however, seems to point to a different situation in the Caprivi and the Okavango.[29,30]

Avian bilharzia

Exposure to avian schistosomes also needs to be considered as a possible cause of cercarial dermatitis and false-positive serological reactions in humans.

Conclusion

The only animal schistosome that at present constitutes a threat to human health in South Africa is *S. mattheei*, a parasite with such a wide host range (including cattle and game) that control will be extremely difficult, especially in areas where man and cattle share the same water sources. Control in cattle is much more feasible than in game, and reduction of the prevalence and the level of infestation of cattle should greatly reduce the threat to which man is exposed.

The *S. mattheei/S. haematobium* hybrid poses a potential but as yet unidentified threat to human health. If this hybrid can successfully maintain itself in man in the absence of animals, it could prove to be of considerable importance. It is suspected to be in the process of adaptation to man, and therefore this situation should be closely monitored.

This article is dedicated to Dr R. J. Pitchford, world-renowned for his work on the epidemiology of both human and animal schistosomiasis in southern Africa. Without the work of R. J. Pitchford our knowledge of the epidemiology of bilharziasis in this country as well as in some neighbouring territories would have been scanty to the point of being well-nigh non-existent.

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