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A SURVEY OF THE INTESTINAL NEMATODES OF BUSHMEN IN NAMIBIA

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Abstract. Studies in Namibia revealed prevalence rates of 63% for hookworm and 35% for *Trichuris* in 31 Bushmen, 4–65 years of age, who were encamped in the Kaudom Game Reserve. The study also revealed prevalence rates of 85% for hookworm, 25% for *Strongyloides*, and 1% for *Trichuris* in 103 children, 6–17 years of age, attending 5 schools in Bushmanland. The 25% *Strongyloides* infection rate is one of the highest prevalences recorded in southern Africa. The *Trichuris* infections in the Kaudom group appeared to be autochthonous, and this population did not harbor *Strongyloides*. Regular contact with pans in summer and boreholes at any time probably facilitated the acquisition of infections in wet and fecally polluted sites. Thirteen spurious *Physaloptera* infections were recorded.

Two recent publications on schistosomiasis and other parasitic infections in schoolchildren from 6 schools in the East Caprivi region[1,2] contain the only records of the presence of intestinal nematodes in this part of the African continent. As far as we could ascertain, no prevalence data were available on intestinal nematode infections among the !Kung Bushmen living in the Kaudom Game Reserve and schoolchildren living in Bushmanland (Fig. 1). In this publication, we detail the intestinal nematode infections of these populations and speculate on certain epidemiological factors that could play a role in their dissemination within the environment.

MATERIALS AND METHODS

Study areas and subjects

Topographically, the Kaudom area is largely flat with low fossil sand dune ridges, ancient watercourses, and river beds[3] which form depressions; many of these formations are covered with aeolian Kalahari sand layers of various depths.[4] The eastern part of Bushmanland is also largely flat with patches of sand, dune ridges, and stony outcrops.

Pans varying in size from a few square meters to several hundred meters are scattered throughout the study areas, especially Bushmanland. Water holes occasionally occur along ancient river courses. There is little binding material except in the pans and depressions, where there are sometimes extensive deposits of silt and composted soil. The extremely fine texture of the sand does not allow rainwater to drain deeply into the ground; instead, it slows the process down considerably, absorbing and holding water at or near the surface.[3]

The climate is tropical and arid. Accurate weather data were not available for the target areas at the time of the surveys. The mean annual rainfall is ~500 mm in Bushmanland, increasing to 600 mm to the northeast at Rundu on the Okavango River[4] and to 700 mm in East Caprivi. However, the total annual rainfall is estimated to be far less during periods of drought, when the rains are more scattered. Thundershowers occur during the summer, mainly between January and April.[5] Shade temperatures in summer probably exceed 35°C[4] and, by deduction, exposed ground temperatures exceed 40°C for several hours a day during the sunny periods which are prevalent most of the year. Winter temperatures drop to as low as −4.2°C in July,[5] but frost is rare. The low mean annual relative humidity of 30–40%[6] is probably much higher during rainy periods. The mean annual duration of sunshine is 70–80%.[6]

The vegetation is mainly savanna scrub and mixed woodland with sparse grass cover interspersed with open grassland, especially in the depressions and around pans. Reeds (*Phragmites* sp.) cover extensive areas of the Kaudom depression, formed by an ancient watercourse ("amaramba") adjacent to the Bushmens' encampment.

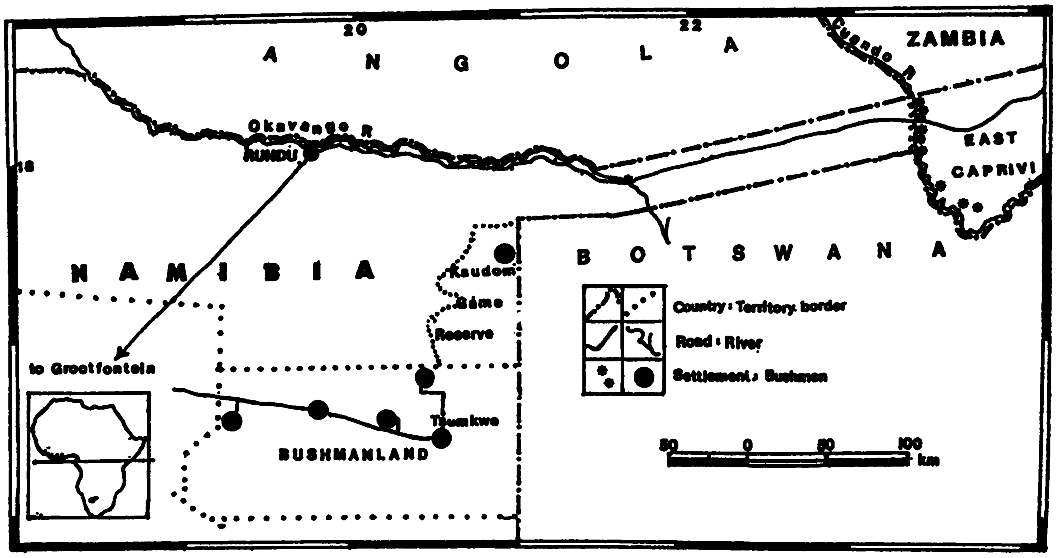

FIGURE 1. Map showing position of main Bushmen settlements in Bushmanland, the encampment in the Kaudom Game Reserve (●) and other ethnic group settlements (*) studied in East Caprivi.

Patches of reeds, several hundred square meters in area, are periodically razed by fire caused by spontaneous combustion due to the degradation of organic material, which generates excessive heat below the surface. Razed areas take several seasons to recover.

Besides the pans that are used during the rainy season, there is 1 borehole which is a reliable, potable source of water for the Kaudom Bushmen used also by game some distance from the encampment. Boreholes are the main and pans the secondary source of water for the children in Bushmanland.

Bushmanland (18,000 km^2) is sparsely populated (1 person/2.5 km^2) with an irregular distribution of encampments, some with schools. The Kaudom Bushmen live in an encampment, roam freely, have semi-permanent shelters, and keep dogs, but their natural hunting activities are severely restricted in the Game Reserve. The children in Bushmanland also come mainly from semi-permanent shelters, some of them corrugated iron structures, but they attend schools and are rapidly being drawn into a more western style of existence, away from their ethos and the pristine hunter-gatherer way of life. However, most families still venture afield periodically as a group for weeks at a time to gather "Bushman food," including nuts, berries, roots, caterpillars, and beetle grubs, and to collect material for making bows, arrows, and ceremonial items. We assumed that in all situations people had regular contact with water or moist soil, and that such contact was unavoidable during the rainy season. Footwear is rarely worn and the soles of the adult Bushmens' feet are generally heavily callused.

Specimens

In December 1987 and January and April 1988, stool samples were obtained from an isolated group of 31 Bushmen, consisting of adults and children 4–65 years of age, living in the Kaudom Game Reserve. In February 1986, stool samples were collected from 103 schoolchildren, 6–17 years of age (mean age 9.3 years), attending 5 schools in Bushmanland. Feces were collected and formalinized in the field in 30 ml screw-cap plastic jars. Helminth ova and larvae were detected microscopically, having been concentrated by the formol-ether concentration technic.

RESULTS

The intestinal nematode infections of the 31 Bushmen and the 103 schoolchildren are shown in Tables 1 and 2, respectively. The number of hookworm infections was high. Larvae of *Strongyloides*, probably almost all *S. stercoralis*, were only present in the Bushmanland schoolchildren, while the prevalence of *Trichuris* infections was

TABLE 1

Nematode infections by host sex of 31 Bushmen (adults and children) living in the Kaudom Game Reserve, Namibia

	Infections*					Totals (%)	
	Sex	No.	Hw	Hw/Tri	Tri	Hw	Tri
Children	M	4	2	1	0	3	1
	F	4	2	1	0	3	1
Adults	M	13	3	5	1	8	6
	F	10	4	2	1	6	3
Subtotals (%)	M	17	5	6	1	11 (65)	7 (41)
	F	14	6	3	1	9 (64)	4 (29)
Totals (%)		31	11 (35)	9 (29)	2 (6)	20 (65)	11 (35)

* Hw = hookworm; Tri = *Trichuris*.

second to that of hookworm in the Kaudom group.

Table 1 presents data on infections by sex of children and adults in the Kaudom Game Reserve. There were no marked differences between the sexes as regards numbers of infections. Seventy-one percent of the group were infected with either or both hookworm and *Trichuris*; only 2 of 8 children and 7 of 23 adults (5 males and 4 females) were free of nematode infestation.

Table 2 displays the results by host sex for each of the 5 schools in Bushmanland. The prevalence of infection by nematodes was similar in both sexes. One third of the total number of children examined were female, and 31 (86%) harbored either hookworm or *Strongyloides* or both. Of the males, 58 (87%) were infected; 1 had a triple infection which included *Trichuris*. Of particular importance was the 100% prevalence of hookworm infestation at the Nhoma (11 children) and Aasvoëlnes (13 children) schools. Sixteen children had single infections and 8 were host to *Strongyloides* as well. Nine males (7–12 years of age) and 5 females (6–14 years of age) were free of infection with nematodes. Thirteen children from the Omatako (8 children) and Luhebu (5 children) schools also had a few (1–4) thick-shelled, ovoid, embryonated eggs assumed to be those of *Physaloptera* sp. in their feces.

DISCUSSION

Rhabditiform larvae present in feces were assumed to be those of *Strongyloides stercoralis*. However, thin-walled embryonated ova were seen in 2 cases, together with free larvae. An attempt to confirm the species was not successful, but *S. fulleborni* was suspected. The 13 cases with thick-

TABLE 2

Distribution by host sex of nematode infections in schoolchildren attending 5 schools in Bushmanland, Namibia

	Infections*							Totals (%)	
School	Sex	No.	Hw	Hw/Str	Str	Pos.	Neg.	Hw	Str
Nhoma	M	8	4	4	0	8	0	8	4
	F	3	2	1	0	3	0	3	1
Omatako	M	19	10	8†	0	18	1	18	8
	F	3	2	0	0	2	1	2	0
Tsumkwe	M	21	10	1	3	14	7	11	4
	F	14	10	0	0	10	4	10	0
Luhebu	M	12	11	0	0	11	1	11	0
	F	10	4	6	0	10	0	10	6
Aasvoëlnes	M	7	7	0	0	7	0	7	0
	F	6	3	3	0	6	0	6	3
Subtotals (%)	M	67	42 (63)	13 (19)	3 (4)	58 (87)	9 (13)	55 (82)	16 (24)
	F	36	21 (58)	10 (28)	0 (0)	31 (86)	5 (14)	31 (86)	10 (28)
Totals (%)		103	63 (61)	23 (22)	3 (3)	89 (86)	14 (14)	86 (83)	26 (25)

* Hw = hookworm; Str = *Strongyloides*.
† One case with *Trichuris* present as well.

shelled embryonated eggs were regarded as spurious infections with *Physaloptera* sp. This may be the result of the consumption of beetle grubs.

The prevalence of *Strongyloides* in the Bushmanland schoolchildren (25%) is among the highest recorded in southern Africa (Table 2). However, there are some non-Bushmen communities with higher (~30%) prevalence rates living 250–500 km to the East along the Cuando River floodplain in East Caprivi (C. H. J. Schutte, Research Institute for Diseases in a Tropical Environment, personal communication). The parasite has also been recorded in less arid environments of the eastern Transvaal[7] and Natal,[8–10] but prevalences were very low; the highest (3–9%) was found in farming communities in the eastern Transvaal.

The fact that some of the children from Bushmanland were infected with both hookworm and *Strongyloides* suggests that both infections were contracted in the same areas. This can be explained in terms of the environmental requirements of the parasites themselves. Hookworm disease is caused primarily by soil-transmitted helminths, whereas strongyloidiasis is predominantly fecally transmitted.[11] The rhabditiform larvae of the latter worm become infective ~24 hr after being voided in feces,[12] which remain a source of infection for as long as the filariform larvae live. The larvae can survive for several days under favorable conditions of warmth and dampness, even in excess water.[13] *Strongyloides* also has a free-living adult phase[12,14] which develops under the same environmental conditions. However, further work is required to clarify whether the free-living cycle can be continued for >1 generation. On the other hand, hookworm larvae that hatch from ova voided in feces move down into the upper layers of substrate soils and take ≥5 days, including 2 molts (ecdyses), to reach the infective stage. They also require warm, moist conditions, but die in excess water. They also require aerated sandy or friable soils containing organic matter and microorganisms.[13] They can, therefore, move vertically and obtain food. The sand particles assist their ecdysis. Hence, governed by the need for moisture, common transmission sites for hookworm and *Strongyloides* would be mainly in the vicinity of the pans on a seasonal basis and boreholes on a perennial basis. Inevitably, situations which offer privacy adjacent to these water points become polluted by habitual promiscuous defecation. Increased shade and the growth of grass in the summer protect the fecal deposits from direct sunlight and desiccation, and dew does not evaporate so quickly. Thus the life span of larvae would be prolonged. Feces deposited on open ground in summer would be rapidly dried out by the high ground temperatures, probably destroying most ova and larvae alike.[15] Some are thought to survive and develop for a time underneath the fecal deposits, as the moisture-retaining properties of the finely-textured sand slows down the drying process.

The *Trichuris* infections of the Kaudom Bushmen (Table 1) can only be regarded as autochthonous, since the cases co-exist within an extended family unit. The original source of infection is unknown, as is the reason for the complete absence of strongyloidiases in the group. It is noteworthy that neither *Ascaris* nor *Trichuris* have to date been recorded in the northeastern and northern parts of Namibia[4] or Caprivi,[1] as is the fact that, apart from our single case in Bushmanland, *Trichuris* seems to be limited to the Kaudom group. Both ascariasis and trichuriasis are generally coexistent, but a combination of climatic, physical, and human behavioral factors, together with a sparse host population distribution, appear to preclude dissemination of the extremely resistant *Ascaris* and limit the distribution of the more delicate *Trichuris* ova, except within narrow limits pertaining to a familial situation such as that found in the Kaudom Bushmen. Future and more extensive surveys among the schoolchildren may, on the other hand, reveal a higher prevalence of trichuriasis in Bushmanland. However, it does seem as though *Ascaris* is not yet present in the region.

Dung beetles are possible disseminators of hookworm, *Strongyloides*, and other helminthic infections.[14] Furthermore, by disturbing fecal deposits in order to make pellets, they help to aerate and mix feces with moist soil.[12] This may aid the development and survival of larvae in the area. Through indiscriminate defecation after consuming human feces, dogs may also play a small but undetermined role in disseminating ova and *Strongyloides* larvae around living areas.[16]

In conclusion, the high prevalence of nematode infestations in Namibian Bushmen is no doubt related to their behavioral activities. The reasons for the ease of transmission of hookworm and *Strongyloides* infections in Bushmanland and of hookworm in the Kaudom group, and the absence of *Strongyloides* and the presence of *Trichuris* in the Kaudom group, remain largely unclear. Bushmen are heavily callused underfoot, especially adults, so that infection would presumably normally have to occur via the soft-skinned areas of the foot. Skin penetration by larvae may not, of course, be the only means of transmission of hookworm and *Strongyloides*.[13] Epidemiological aspects which need to be investigated include the possibilities of transmammary transfer of hookworm and *Strongyloides* and the carriage of *Strongyloides* by dogs in the region.

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