HOOKWORM INFECTIONS OF SCHOOLCHILDREN IN SOUTHERN THAILAND

Malinee T Anantaphruti, Wanna Maipanich, Chatree Muennoo, Somchit Pubampen and Surapol Sanguankiat

Department of Helminthology, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand

Abstract. A study of hookworm infections of schoolchildren was conducted in Nakhon Si Thammarat Province, southern Thailand. Of the 2,940 hookworms that were recovered from the children, almost all (99.9%), were *Necator americanus*, only three (0.1%) were identified as *Ancylostoma duodenale*, and all were female worms. An estimation of the worm burden of and the worm expulsion from the schoolchildren indicated there were 17 cases of light intensity hookworm infection. Fifteen cases (88.2%) expelled worms in numbers that corresponded with the worm burden that was estimated from the number of eggs per gram of feces. Two cases (11.8%) expelled more worms than predicted. In 16 moderate intensity cases, five (31.3%) expelled worms in a quantity that corresponding with the estimated worm burden. Eleven cases (68.7%) expelled fewer worms than predicted. All cases of heavy intensity infection expelled fewer worms than predicted.

INTRODUCTION

Soil-transmitted helminthiases are a world-wide public health problem and are especially troublesome in tropical and subtropical regions. Thailand, a subtropical country, faces the same problem: it was found that 41.7% of the total population of Thailand were infected with one or more helminths, the most common of which was hookworm, with a prevalence of 27.7% (Jongsuksantikul *et al*, 1992). *Ancylostoma duodenale*, an old-world hookworm and *Necator americanus*, a new-world hookworm, are the major human hookworms. *A. ceylanicum*, a zoonotic hookworm of dogs and cats, is a cause of minor hookworm infection in humans. According to Beaver *et al* (1984), *N. americanus* is distributed in tropical and subtropical climates: the southern United States, Caribbean islands, Central America, and northern South America; the worm predominates in central and southern Africa, southern Asia, Melanesia and Polynesia. *A. duodenale* is found in subtropical and warm temperate climates: southern Europe, the north coast of Africa, northern India, northern China, Japan, Malaysia, and Taiwan. *A. ceylanicum* is found in tropical and semitropical regions.

The southern part of Thailand is known to be endemic for soil-transmitted helminthiases. Hookworm infection has been a public health problem for several decades. Its prevalence has been reported as 34.4% (Vajrasthira and Harinasuta, 1957); 75.9% (Preuksaraj *et al*, 1983); 78.9% (Yokogawa *et al*, 1983); 49.1% (Jongsuksantikul *et al*, 1992); 66.8% (Muennoo *et al*, 1998).

Radomyos and Saovakontha (1968), and Harinasuta and Areekul (1980), identified adult hookworms in patients admitted to the Hospital for Tropical Diseases, Bangkok: *N. americanus* 98.75% and 98.6%; *A. duodenale* 0.81% and 1.1%; and *A. ceylanicum* 0.45% and 0.3%; respectively. The prevalence of *A. ceylanicum* in the patients was 11.1% (Harinasuta and Areekul, 1980).

In Nakhon Ratchasima Province, northeast Thailand, Harinasuta and Areekul (1980) re-

Correspondence: Dr Malinee Thairungroj, Department of Helminthology, Faculty of Tropical Medicine, Mahidol University, 420/6 Rajvithi Road, Bangkok 10400, Thailand.
Fax: 66-0-26435600
E-mail: tmmtr@mahidol.ac.th

ported that after drug administration, 99.1% of hookworms recovered were *Necator americanus* and 0.9% were *A. duodenale*; there were no examples of *A. ceylanicum*.

A. ceylanicum is a common hookworm of dogs and cats throughout the world. It was first recorded in Thailand by Kerr (1916) among the prisoners of Chiang Mai jail. Harinasuta and Areekul (1980) reported that 93-96% of dogs in Bangkok were infected with *A. ceylanicum*. In Prachinburi Province, 92% of cats harbored *A. ceylanicum*, with the maximum number of worms per cat being 83 (Setasuban *et al*, 1976). *A. ceylanicum* was found in dogs in Bangkok during the period 1997-1998: the infection rate was 72.5% (Anantaphruti *et al*, 2000). There is no doubt that *A. ceylanicum* from dogs and cats can be transmitted to, and develop into adults in, man.

Although a high prevalence of hookworm infection has been recorded in the south of Thailand for several decades, no study of the hookworm species from humans in the south of Thailand has yet been conducted. This study aimed to determine the species of hookworm among schoolchildren in an endemic area in Thailand; furthermore, the study examined the relationship between the estimated worm burden calculated from egg counts and the number of worms recovered in each class of intensity of infection.

MATERIALS AND METHODS

The study subjects were schoolchildren from 6 primary schools in 4 districts of Nakhon Si Thammarat Province: Paisarn Sathit (Muang district); Sa Bua (Tha Sala district); Put Hong, Thara Wong (Ron Phibun district); and Sa Krai and Don Thore (Chalerm Prakiat district). The feces of these schoolchildren were collected and examined for hookworm eggs by the Kato-Katz's method (Katz *et al*, 1972). The intensities of hookworm infection were classified according to the number of eggs counted in the entire fecal smear and the calculation of the number of eggs per gram of feces. The worm burden in each child was estimated from the number of eggs per gram.

All those infected with soil-transmitted helminths were given mebendazole 100 mg twice daily for 3 days. After medication for 24 hours, all of the feces passed by the hookworm-infected children was collected for seven consecutive days. Each daily sample was washed with tap water by simple sedimentation until a clear supernatant was left. The worms were collected and fixed in 5% glycerine in 70% alcohol. Only hookworms were separated for study. Daily fixed worms from each individual child were sexed, counted and identified by species using a compound microscope. The total number of worms expelled from each child was compared with the estimated worm burden calculated from the number of eggs per gram by Kato-Katz's method. Only complete 7-day fecal samples were used for the analysis of worm burden. All the hookworms obtained from these children were included in the study.

Three weeks after medication, all treated children were asked to provide fecal samples for the detection of any uncured cases using the method mentioned above.

RESULTS

The prevalence of hookworm infection in schoolchildren from the six primary schools is shown in Table 1. The intensity of hookworm infection was classified as light, moderate, or heavy. Based on a WHO Technical Report (1987), these intensities are determined according to the number of eggs counted per gram of feces (NEPG). The worm burdens in each intensity class are then estimated as shown in Table 2.

Thirty-eight subjects delivered complete 7-day stools. Stool samples of 17 light intensity hookworm cases were collected for 7 complete days. The total number of hookworms recovered ranged from 1 to 79, with the number of males ranging from 0 to 41 and females from 1 to 45 (Table 3). Fifteen cases (88.2%) expelled a number of worms that corresponded to light

Table 1
Prevalence of hookworm infection in six primary schools in Nakhon Si Thammarat Province.

Schools	No. examined	No. positive with hookworm (%)
Paisarn Sathit	319	85 (26.6)
Sa Bua	274	157 (57.3)
Put Hong	172	31 (18.0)
Thara Wong	154	44 (28.6)
Sa Krai	283	56 (19.8)
Don Thore	271	108 (39.9)
Total	1,473	481 (32.7)

Table 2
Hookworm burden estimated from the number of eggs per gram (NEPG) of feces in each intensity class.

Intensity	NEPG	Hookworm burden
Light infection	< 2,000	≤ 50
Moderate infection	2,000-7,000	51-200
Heavy infection	> 7,000	> 200

intensity infection, *ie* from 1 to 50 (Table 4). The worm count exceeded this intensity interval (50) in 2 cases (11.8%). For the moderate intensity infections, 16 samples of 7-day stool were collected. The number of worms recovered ranged from 2 to 80, with males and females ranging in number from 1 to 38 and 1 to 53 respectively. There were five cases (31.3%) in which between 51-200 worms were recovered: moderate intensity. However, 11 cases (68.7%) expelled worms below the level of moderate intensity infection (51-200) (Table 3). For the heavy intensity group, five samples of 7-day stools were collected. The number of worms recovered ranged from 20 to 126, with males and females ranging in number from 9 to 54 and 11 to 72. There were no cases of worms expelled at a rate consistent with heavy intensity infection (over 200) (Table 3).

Table 3
Number of hookworms recovered from the 7-day bowel movements of each school-children with light, moderate and heavy intensity infection; after treatment with mebendazole 100 mg twice daily for 3 days.

Case No.	NEPG	Number of worms recovered		
		Male	Female	Total
Light intensity				
1	1,504	-	1	1
2	1,806	1	1	2
3	940	1	3	4
4	1,302	-	4	4
5	1,452	1	4	5
6	799	2	4	6
7	1,680	4	4	8
8	1,692	3	6	9
9	1,269	2	10	12
10	966	6	7	13
11	1,128	4	9	13
12	1,470	4	9	13
13	1,218	6	9	15
14	1,927	19	15	34
15	1,551	27	18	45
16	1,092	29	45	74[a]
17	1,302	41	38	79[a]
Moderate intensity				
1	6,016	-	2	2[b]
2	3,008	1	1	2[b]
3	2,184	-	3	3[b]
4	2,982	2	4	6[b]
5	2,303	2	5	7[b]
6	6,300	7	12	19[b]
7	2,058	12	11	23[b]
8	2,820	9	15	24[b]
9	3,192	14	21	35[b]
10	2,209	9	27	36[b]
11	2,679	12	37	49[b]
12	4,935	27	42	69
13	6,652	28	45	73
14	2,490	32	41	73
15	2,394	38	41	79
16	6,300	27	53	80
Heavy intensity				
1	14,112	9	11	20
2	7,854	16	25	41
3	14,617	16	48	64
4	20,586	30	54	84
5	52,875	54	72	126

NEPG = Number of eggs per gram of feces.
[a]Worms recovered above the light intensity interval (50).
[b]Worms recovered below the moderate intensity interval (51-200).

Table 4
Relationship between worm expulsion and worm burden calculated from the number of eggs per gram of feces for each intensity of hookworm infection.

Intensity	Number of cases		Number corresponding (%)	Number not corresponding (%)
	Calculated intensity	Worm expulsion intensity		
Light	17	15	15(88.2)	2(11.8)
Moderate	16	5	5(31.3)	11(68.7)
Heavy	5	0	0	5(100)
Total	38	20	20	18

Table 5
Hookworm cure rates: 21 days after treatment with mebendazole 100 mg daily for 3 days.

Intensity of infection	Number treated	Number cured (%)
Light	84	71 (85.5)
Moderate	76	58 (76.3)
Heavy	33	20 (60.6)
Total	193	149 (77.2)

Stool samples of 193 hookworm cases from these six schools were examined 21 days after treatment: the overall cure rate was 77.2 % (Table 5).

The total number of hookworms recovered from 193 schoolchildren from these 6 primary schools was 2,940; there were 1,103 male and 1,837 female worms. All male hookworms were identified as *Necator americanus*. Of the female hookworms, 99.84% were *N. americanus* and only 0.16% (3 worms) were *A. duodenale*. Of the 2,940 hookworms, 99.9% were *N. americanus* and 0.1% were *A. duodenale*. In total, 1,103 male and 1,834 female *N. americanus* were recovered, and the M : F sex ratio was 1:1.66. All the *A. duodenale* were recovered from schoolchildren from the Don Thore Primary School. The prevalence of *A. duodenale* infection in this study was 7.9% (3 of 38 cases). However all of these featured co-infection with *N. americanus*. No *A. ceylanicum* infection was detected in this study.

DISCUSSION

This study has shown that *Necator americanus* is the predominant hookworm in Nakhon Si Thammarat Province, southern Thailand; *Ancylostoma* sp is a far less significant cause of infection. The result is consistent with those of previous studies (Radomyos and Saovakontha, 1968; Areekul *et al*, 1970b; Harinasuta and Areekul, 1980). In the study of hookworm-related anemia by Areekul *et al* (1970b), 7 of the 45 cases were caused by *A. ceylanicum*. On the other hand, the prevalence of *A. ceylanicum* in this study was 16%. One case was of single infection: the patient was a 2-year-old boy who expelled 6 (2 male and 4 female) *A. ceylanicum*; the other cases featured co-infection with *N. americanus*; there was one case of triple infection (*N. americanus*, *A. duodenale*, and *A. ceylanicum*). Of 8,037 hookworms examined, 95.8% were *N. americanus*, 0.5% *A. duodenale* and 0.3% *A. ceylanicum*. Almost all of the cases reported were mixed infections: the predominant species was *N. americanus* and the associated minor species were *A. duodenale*, and *A. ceylanicum*.

Ancylostoma species was recovered from patients from the central, eastern and northeastern provinces; patients from the southern province expelled only *N. americanus* (Radomyos and Saovakontha, 1968; Harinasuta and Areekul, 1980). Neither *A. duodenale* nor *A. ceylanicum* has been reported from the southern provinces by previous researchers (Table 6).

Table 6
Previous reports on hookworm species in human infection in Thailand.

Authors	Number of		Prevalence (%)		Species recovered (%)		
	Cases	Hookworms	*A.d.*	*A.c.*	*N.a.*	*A.d.*	*A.c.*
Radomyos and Saovakontha1968[a]	38	5,308	18.4	15.8	98.7	0.8	0.45
Areekul *et al*,1970b[a]	45	8,037	-	16.0	95.8	0.5	0.3
Harinasuta and Areekul, 1980[a]	18	1,943	22.2	11.1	98.6	1.1	0.3
Harinasuta and Areekul, 1980[b]	21	4,197	38.1	0	99.1	0.9	0
Anantaphruti *et al*, 2002[c]	38	2,940	7.9	0	99.9	0.1	0

[a]In Hospital for Tropical Diseases; [b]In Nakhon Ratchasima Province; [c]In Nakhon Si Thammarat Province; *N.a. = Necator americanus; A.d. = Ancylostoma duodenale; A.c. = Ancylostoma ceylanicum.*

In our study, we found 3 cases infected with *A. duodenale*, only one worm in each case. No *A. ceylanicum* was found in the present study. This may be due to the comparatively small sample size in this study; the absence of *A. ceylanicum* might be explained by the fact that half of the schoolchildren examined were from Thai-Muslim families, which seldom keep domestic pets.

The route of transmission of *Ancylostoma* sp to their normal hosts is mainly oral; infection via the percutaneous route is far less common. *A. ceylanicum* is also transmitted by the oral route (Yoshida, 1968; Yoshida *et al*, 1968) and by the cutaneous route (Areekul *et al*, 1970a). In areas where dogs and cats are usually kept as pets or where many stray animals are present, there is a high risk of human infection due to the likelihood of contact with pets, their feces, or soil or sand contaminated with infective larvae.

Worm expulsion from the schoolchildren did not entirely correlate with the worm burden estimated from the number of eggs per gram of feces. In many moderate, and all heavy intensity groups, actual numbers were lower than those that had been estimated. Many factors may have been involved, such as the lower cure rates of chemotherapy in moderate and heavy infections and the consequently incomplete worm expulsion. In our study, the cure rate of light intensity of infection was higher than those of moderate and heavy infections.

Many factors are related to the variability in the number of eggs found in the feces, which influenced the egg count. These factors include fluctuations in the egg output of female worms (Anderson and Schad, 1985), the fecundity of worms in the gut (Hill, 1926), and the uneven distribution of eggs in the stool. In patients with diarrhea, the consistency of the stool sample influences the amount and weight of feces that is examined, leading to errors in the calculation of the number of eggs per gram and in the estimation of the worm burden.

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