Soil-transmitted helminthiases: nationwide survey in China

Xu Long-Qi,[1] Yu Sen-Hai,[1] Jiang Ze-Xiao,[1] Yang Jia-Lun,[2] Lai Chang-Qiu,[3] Zhang Xiang-Jun,[4] & Zheng Chang-Qian[5]

A total of 2848 study sites, with about 500 people in each, were randomly sampled for this investigation which covered a total population of 1 477 742. By stool examinations using the Kato–Katz thick-smear and larval-culture techniques, overall prevalences of 47.0%, 18.8%, and 17.2% were obtained for Ascaris lumbricoides, Trichuris trichiura, *and hookworm infections, respectively. The number of infections due to* Ascaris, Trichuris, *and hookworm was estimated as 531 million, 212 million, and 194 million, respectively. Egg counts showed that 75–95% of the subjects had light infections. Higher prevalences of ascariasis and trichuriasis were found in the age group of 5–9, 10–14 and 15–19 years, and among adults for hookworm. Students, farmers (including vegetable growers) and fishermen were the occupational groups with high infection rates. The prevalence of helminthiases was found to be closely associated with climatic and geographical factors. In view of the morbidity and mortality due to these helminthiases, their control, particularly in shoolchildren, is very important.*

Despite the global distribution of soil-transmitted helminth infections, especially those due to *Ascaris lumbricoides*, hookworm, and *Trichuris trichiura*, with high prevalences in many developing countries, they remain one of the most neglected of human diseases. Although the morbidity and mortality due to these infections are relatively low, the numbers of fatal or diseased cases are high (*13, 15*). As they present a considerable public health problem in the rural areas of China (*18, 24*), a national control programme could not be developed without knowing their overall distribution, prevalence and impact on the health of the people, particularly children. Consequently, a nationwide survey of human parasites was conducted during 1988–92 (*23*). This paper describes the results of the investigation on soil-transmitted helminthiases.

Materials and methods

At the request of the Ministry of Public Health, the Institute of Parasitic Diseases of the Chinese Academy of Preventive Medicine in Shanghai was responsible for designing, organizing and supervising the survey. The coordinating group was composed of 30 technical officers, one from each of the 30 Provinces, Autonomous Regions, and Municipalities (P/A/M).

Sampling of the study population. The rural areas and towns in all 30 P/A/Ms were included in the random sampling. According to their geographical location, each P/A/M was divided into several sectors, the counties in each sector being grouped into higher, intermediate and lower levels based on socioeconomic parameters (income, sanitary situation, and level of literacy); the townships were also ranked into three strata; the villages, towns, and the areas surrounding the towns were then sampled in the investigation of each site with a population of about 500. All samplings were randomized.

Stool examination. The entire population in each sampled site was asked to submit a faecal specimen for examination; the compliance rate was not less than 90%. Using the Kato-Katz thick-smear technique (*9*), the eggs were counted on all the positive slides of hookworm and *Trichuris trichiura*, but in only one slide from every 10 positive slides for *Ascaris lumbricoides*. The intensity of infection for *Ascaris* and *Trichuris* was indicated, following the criteria given by the WHO Expert Committee (*20*). The intensity of hookworm infection was classified in four degrees (*6*); for field use, these corresponded to light, moderate, heavy, and very heavy infections (*10*). The test-tube filter-paper culture method (*23*) was used to detect nematode larvae and to differen-

[1] Institute of Parasitic Diseases, Chinese Academy of Preventive Medicine, Shanghai, China. Requests for reprints should be sent to Dr Xu Long-Qi at this address.

[2] Yunnan Provincial Station of Sanitation and Epidemic Prevention, Kunming, China.

[3] Zhejiang Provincial Station of Sanitation and Epidemic Prevention, Hangzhou, China.

[4] Hunan Provincial Station of Sanitation and Epidemic Prevention, Changsha, China.

[5] Jiangsu Provincial Institute of Parasitic Diseases, Wuxi, China.

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tiate larvae of *Ancylostoma duodenale* and *Necator americanus*.

The stool specimens were collected at the village office or township health centre by the assigned persons in the sites and examined, usually in the laboratory of the township health centre but sometimes in the public health laboratory of the county's sanitation and epidemic prevention station.

Since the stool examinations were critical for the results of the survey, various species of intestinal parasites being involved, close attention was given to quality control and accuracy during the project. All the microscopists followed a provincial or prefectural training course and had to pass a test before they were qualified to join the investigation team. A senior microscopist from the provincial institution, trained in the national course, was designated to supervise the team's work. Double-checks of randomly selected slides were made between microscopists, particularly during the initial surveys. Specimens of different stages of any "new" parasite were sent to a parasitologist in the provincial institution or university, or in the Institute of Parasitic Diseases in Shanghai for identification. Requirements for data recording and collecting were also established.

Analysis of data. A data bank was established using FOXBASE language on microcomputer AST premium II 486/33 (AST, USA), which was ultimately transferred to computer VAX-II/750 (DEC, USA) for processing and analysis by using SAS software package. For every 4–5 P/A/Ms, an inspection group consisting of computer experts and parasitologists was established to review the data bank at the provincial level.

Results

The study population totalled 1 477 742, distributed in 2848 sites from 726 counties sampled in the survey.

Prevalence of soil-transmitted helminth infections. The overall prevalences of ascariasis, trichuriasis and hookworm disease in the country were 47.0%, 18.8% and 17.2%, respectively. Table 1 shows the prevalences of these helminthiases in each of the P/A/M.

The prevalences of ascariasis and trichuriasis were highest in the age groups of 5–9, 10-14 and 15–19 years; the prevalence of hookworm disease was higher in adults above 20 years of age (Fig. 1).

By random sampling, egg counts were made on 170 252 individuals harbouring *A. lumbricoides*; light (<5000 eggs/g), moderate (5000 to <50 000 eggs/g) and heavy (>50 000 eggs/g) infections were identified in 77.0%, 21.1% and 1.8% of cases, respectively. In 247 020 *T. trichiura*-infected subjects, 94.6%, 5.2% and 0.2% were found with light (<1000 eggs/g), moderate (1000 to <10 000 eggs/g) and heavy (>10 000 eggs/g) infections respectively. *Ancylostoma duodenale* and *Necator americanus* infections were light (<400 eggs/g), moderate (400 to <3000 eggs/g), heavy (3000 to <10 000 eggs/g) and very heavy (>10 000 eggs/g) in 75.4%, 21.9%, 2.1% and 0.6% of cases, respectively.

Analysed by age groups, the proportion of moderate and heavy infections of *Ascaris* and *Trichuris* was significantly higher in groups aged 0–14 years than in those aged ≥15 years (P <0.01). In contrast, the average intensity of hookworm infection was heavier in adults than in 0–14-year-olds (P <0.01).

The larva cultivation showed that both *Ancylostoma duodenale* and *Necator americanus* are endemic simultaneously in 20 P/A/Ms; in Gansu, Liaoning, Nei-Mongol, Ningxia, Shanxi and Tianjing only *A. duodenale* was found. There is a trend for a higher prevalence of *N. americanus* in the southern P/A/Ms, while *A. duodenale* is predominant in the north.

Based on the prevalences from the survey and the nation's population data (1990 census), an estimate of the numbers of infected people was made. Infections with *A. lumbricoides* accounted for 531 million (range, 523–539 million); *T. trichiura*, 212 million (range, 202–220 million); and hookworm, 194 million (range, 187–201 million). The total number of infected people including double and triple infections was 646 million.

Relationship of helminth infection with occupations and natural factors. Table 2 shows the relationship of helminth infections to people's occupations in the countryside. High rates of ascariasis were found among students (48.5%), fishermen (47.9%) and farmers (45.2%), and of trichuriasis among fishermen (50.3%) and vegetable growers (47.9%), followed by students (20.8%). Hookworm infections showed higher prevalences among vegetable growers (31.0%) and farmers (19.8%) than other groups.

A close correlation between the prevalence of soil-transmitted helminthiases and climatic and geographical factors is shown in Tables 3 and 4.

Discussion

Nearly 50 years ago, Stoll (*18*) estimated the prevalences of *A. lumbricoides*, hookworm and *T. trichiura* infections at respectively 29.7%, 21.1% and 16.4% of the total world population of 2166.8 million. Although much has been achieved in reducing both the prevalence and the intensity of infection of soil-transmitted helminthiases in some areas by

Table 1: **Prevalences of soil-transmitted helminth infections in the Provinces/Autonomous Regions/Municipalities (P/A/M) of China**

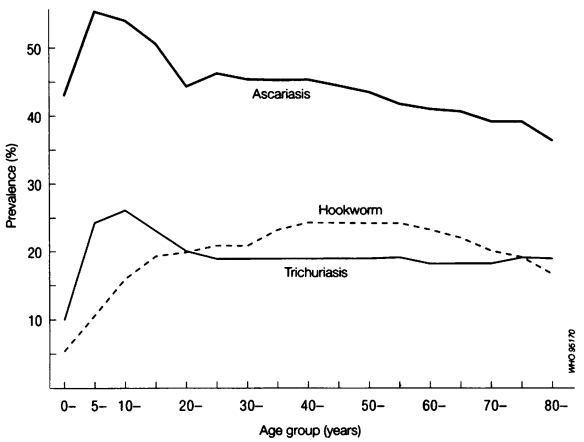
P/A/M	No. examined	*Ascaris lumbricoides* (%)	*Trichuris trichiura* (%)	Hookworm (%)
Beijing	41 633	29.5 (1.5)[a]	0.8 (0.1)	0.0 (0)
Tianjing	22 142	28.3 (2.1)	6.9 (1.0)	0.4 (0.03)
Hebei	65 803	31.8 (1.9)	0.6 (0.1)	0.3 (0.1)
Shanxi	52 453	25.7 (1.8)	1.1 (0.3)	0.02 (0.007)
Nei-Mongol	30 714	16.6 (2.9)	0.2 (0.1)	0.087 (0.03)
Liaoning	51 405	55.5 (1.8)	6.6 (1.5)	0.03 (0.01)
Jilin	50 023	28.4 (2.2)	0.4 (0.1)	0.0 (0)
Heilongjiang	52 131	10.3 (1.1)	0.6 (0.1)	0.0 (0)
Shanghai	62 134	29.8 (1.6)	23.2 (1.9)	3.8 (0.6)
Jiangsu	63 699	39.5 (1.7)	27.3 (1.8)	21.8 (1.5)
Zhejiang	55 284	60.0 (1.7)	40.3 (2.3)	28.2 (1.8)
Anhui	54 392	46.4 (1.9)	17.4 (1.7)	33.4 (1.9)
Fujian	53 416	57.1 (1.9)	41.0 (2.6)	21.6 (1.8)
Jiangxi	52 069	71.1 (1.4)	17.1 (1.7)	17.6 (1.3)
Shandong	87 825	38.3 (1.5)	13.6 (1.5)	6.1 (0.8)
Henan	85 554	41.4 (1.2)	8.2 (0.8)	20.7 (1.5)
Hubei	53 382	39.5 (2.2)	18.3 (1.4)	8.8 (1.1)
Hunan	63 794	67.7 (1.3)	20.2 (1.3)	22.9 (1.4)
Guangdong	61 517	46.4 (1.8)	33.2 (2.1)	22.3 (1.4)
Guangxi	51 883	66.0 (1.7)	47.7 (2.0)	37.9 (1.7)
Hainan	7 958	61.8 (4.7)	66.7 (6.6)	60.9 (7.0)
Sichuan	97 222	68.4 (1.2)	30.4 (1.3)	40.9 (1.9)
Guizhou	52 938	71.1 (1.3)	29.1 (1.8)	22.9 (1.6)
Yunnan	53 061	59.6 (1.7)	27.3 (2.2)	19.3 (2.2)
Xizang	10 303	6.0 (2.2)	2.3 (1.9)	0.4 (0.3)
Shaanxi	53 590	41.4 (1.7)	5.3 (0.7)	0.01 (0.005)
Gansu	28 700	37.5 (3.6)	2.1 (0.8)	0.01 (0.008)
Qinghai	16 083	33.9 (3.5)	0.6 (0.2)	0.0 (0)
Ningxia	20 333	24.5 (2.8)	0.4 (0.1)	0.4 (0.1)
Xinjiang	26 301	9.1 (1.6)	1.2 (0.3)	0.3 (0.1)
Total	1 477 742	47.0 (0.4)	18.8 (0.3)	17.2 (0.3)

[a] Standard error is given in parentheses.

means of local control activities and by improvements in farming and living conditions, the total human burden of geohelminths in China is more than it was in Stoll's time because of the increase in human population and sluggish socioeconomic development in most rural areas. Recently Crompton (*7*) estimated the number of ascariasis cases in 83 countries with a population of more than 2 million each, excluding those in Europe, at 1008 million, or a global prevalence of 22% in a world population of 4653 million. The present survey in China showed a 47% prevalence of ascariasis, more than double Crompton's global estimate.

Our survey's age distribution pattern for soil-transmitted helminthiases is similar to that in most other areas of the world. Higher prevalences of ascariasis and trichuriasis in the age groups of 5–9, 10–14 and 15–19 years indicate that control programmes should be focused on children of school age. The prevalence of hookworm infection, however, increased with age up to the age group of 40–44 years old because it was linked with farming activities. Human nightsoil being the major source of fertilizer in agricultural production, the more frequently it is used shows higher prevalences of hookworm infection among vegetable growers. The higher prevalence of *Ascaris* and *Trichuris* infections among fishermen was related to the lack of sanitary facilities and unhygienic habits since most of them moved along the rivers or lakes and were unable to

Fig. 1. **Percentage prevalences of soil-transmitted helminthiases, by age group.**



settle down permanently; the prevalences were low among herdsmen, the majority of whom lived in the low-endemic northwestern provinces.

Light infections, as defined by egg counts of *Ascaris, Trichuris*, and hookworm were identified in 77.0%, 94.6%, and 75.4% (97.3% if the moderate ones were added), respectively, of persons sampled. Earlier reports had found about 70% of the parasites to be harboured in 15–30% of the community (*1, 3*). The reason for the uneven distribution of intestinal helminths, i.e., most individuals have few worms while a few people harbour disproportionately large worm burdens, is not known although the predisposition to hookworm and *Ascaris* infections has been discussed (*4, 16*).

Table 2: **Prevalences of soil-transmitted helminthiases in relation to occupations**

Occupation	Prevalence (%)		
	Ascaris	*Trichuris*	Hookworm
Farmers	45.2	17.5	19.8
Vegetable growers	36.7	47.9	31.0
Fishermen	47.9	50.3	7.8
Students[a]	48.5	20.8	9.8
Teachers	32.3	10.8	7.6
Herdsmen	4.8	0.6	0.6

[a] In primary and high schools.

The close correlation between the geohelminth infections and natural factors is not surprising, higher prevalences being found in tropical and subtropical areas. There were positive correlations with temperature and humidity, and negative correlations with latitude, altitude, and the duration of daily sunshine, which are confirmed by the much higher prevalence in the south-eastern provinces than in the north-western ones (Table 1).

Pawlowski & Davis (*14*) reviewed the influence of ascariasis on nutrition and immune status and its effects on child growth, development and morbidity, and they indicated the need for more specific studies in order to acquire reliable measurements. Based on field studies, Stephenson (*17*) clearly showed that deworming of *Ascaris*-infected malnourished children could lead to increase of growth rates, which were 20–35% greater during the 3 to 12 months following treatment as compared with untreated infected or treated uninfected children. The functional consequences of ascariasis on the utilization of certain nutrients, particularly fat, lactose, and possibly vitamin A, have been established (*12*). The reported

Table 3: **Prevalences of soil-transmitted helminthiases in different climatic zones**

Climate zone	Prevalence (%)				
	Ascaris	*Trichuris*	*Hookworm*[a]	*N. americanus*	*A. duodenale*
Tropical	59.7	50.3	53.1	42.7	11.6
Subtropical	56.2	28.3	23.2	10.6	9.6
South temperate	35.4	7.0	7.0	0.9	4.0
Meso-temperate	26.0	1.0	0.06	0.0	0.05
North temperate	5.4	0.5	0.0	0.0	0.0
Qinghai-Xizang plateau	26.4	2.3	0.1	0.07	0.003
Moist	54.3	27.4	22.0	10.4	8.9
Semi-moist	35.9	6.3	6.8	1.1	3.8
Semi-arid	28.3	0.7	0.03	0.002	0.02
Arid	10.5	0.6	0.3	0.002	0.3

[a] Infection of both *Necator americanus* and *Ancylostoma duodenale*.

Table 4: **Correlation coefficients of prevalences of soil-transmitted helminthiases to meteorological and geographical factors (P <0.05 to 0.001)**

	Annual average temperature	Extreme highest temperature	Extreme lowest temperature	Precipitation	Annual relative humidity	Annual difference in temperature	Average daily sunshine	Latitude	Altitude
Ascaris	0.4751	0.1960	0.5553	0.5620	0.4475	–0.2528	–0.4963	–0.2898	–0.2091
Trichuris	0.5010	0.1563	0.6086	0.5833	0.4172	–0.2219	–0.3902	–0.3247	–0.2094
Hookworm	0.5091	0.2657	0.6304	0.5596	0.4043	–0.1514	–0.4630	–0.3183	–0.2362

cases of ectopic ascariasis and their complications in China in the period 1953–90 have recently been reviewed (*22*); for example, biliary ascariasis and intestinal obstruction (caused by twisting worms) were identified in 55.5% and 26.4%, respectively, of 11 133 cases. The case fatality was high in some of the complications: 11.3% of 467 cases of complicated biliary ascariasis; 19% of 329 intestinal obstruction cases with volvulus, intussusception or perforation; 15% of 145 cases of *Ascaris* appendicitis with perforation and peritonitis; 37.5% of 48 cases with liver involvements; 11.6% of 43 cases of pancreatic ascariasis; and 44% and 100% of 18 cases of tracheal involvement and 14 cases of pulmonary artery and cardiac involvement, respectively. A high proportion of the cases occurred in children and most of them were under 10 years old: 70% of the intestinal obstruction cases, 74.5% of the appendicitis cases, 29% of the cases with hepatic involvement, 94% of the cases with tracheal involvement, and 97% of the cases with toxic encephalopathy probably due to the ascaron (toxin of ascarid) effect or an allergic reaction. The number of reported cases may be a fraction of the true figure which cannot be obtained at community level since medical services are lacking. The most serious consequence of hookworm infection is chronic blood loss from the small intestine which leads to iron deficiency anaemia, particularly in children and in women of childbearing age, whose physiological needs for iron are greater. In areas where hookworm anaemia is present, 50% or more of the population may have haemoglobin values below the normal range and some of these may have severe degrees of anaemia (*15*). However, in terms of total morbidity, it is likely that other complications relating to pulmonary, intestinal and nutritional disturbances are more important, in that many more people are affected (*11*). Serious hookworm disease in infants within 20 days of birth has been reported in China (*21*). Data on the pathology of trichuriasis are relatively scanty but dysentery, chronic colitis, anaemia, and growth retardation associated with the infection have been described (*2*).

In general, morbidity and mortality rates due to geohelminth infections are low, but because hundreds of millions of people are affected, the overall numbers of symptomatic patients and deaths are relatively high. According to the global estimate presented by Walsh & Warren (*19*), which was considered to be low (*14*), the annual deaths caused by *Ascaris* were about 20 000, with around one million cases. With hookworm prevalence at 900 million in the world, the total deaths and the number of patients attending health services have been estimated at 50 000 to 60 000 and 1 500 000 a year, respectively (*15*). Consequently, one can imagine the great importance of intestinal helminthiases in China where 531 million and 194 million persons are estimated to contract *A. lumbricoides* and hookworm, respectively. Based on the observed prevalence of human intestinal nematode infections, Chan and coworkers (*5*) developed a method of estimating the potential global morbidity due to the infections. These authors, using the results from the early stage of this survey, found considerable morbidity due to *Ascaris, Trichuris* and hookworm infections in China and suggest that the global disease burden of soil-transmitted helminthiases may be significantly greater than was supposed.

As pointed out by Davis (*8*), the prevalence of soil-transmitted helminthiases reflects the socioeconomic status of the population. The success of specific control efforts is therefore linked with socioeconomic development of the endemic areas. One object of this survey was to provide baseline data for establishing a national programme to control common parasites. As a result of the investigation, geohelminth control has been proposed and accepted by the Ministry of Public Health as part of the national parasite control programme. The major strategies for such control are mass chemotherapy by either mebendazole or albendazole (both are available in the country), sanitary improvement, and community health education. Appropriate disposal of human nightsoil has also been suggested to reduce environmental contamination, but this is not easy to carry out since human excreta are used as fertilizer for crops and vegetables in most rural areas. In view of the high prevalence in school-age children and limited resources in many endemic provinces, the target

of control activities at present is mainly schoolchildren. Deworming efforts are being made jointly by the ministries of health and education.

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Résumé

Helminthiases transmises par le sol: enquête nationale en Chine

Une enquête nationale sur les parasitoses humaines a été réalisée en 1988–1992 en Chine. Après stratification des divisions administratives selon leur niveau socio-économique — élevé, moyen et faible — des prélèvements ont été réalisés après tirage au sort au niveau des districts, des communes et des villages. La population d'étude, comptant 1 477 742 personnes, était répartie en 2848 sites sur 726 districts couvrant l'ensemble des 30 provinces, régions autonomes et municipalités. Le présent article expose les résultats concernant les helminthiases transmises par le sol.

Pour l'examen des selles, on a utilisé la méthode de Kato-Katz et la culture des larves d'ankylostomes. La prévalence générale des ascaridiases, des trichocéphaloses et des ankylostomiases était, respectivement, de 47,0%, 18,8% et 17,2%. Au niveau national, le nombre de personnes infestées par *Ascaris lumbricoides* était de 531 millions, par *Trichuris trichiura* de 212 millions et par des ankylostomes (*Ancylostoma duodenale* et *Necator americanus*) de 194 millions. Les plus fortes prévalences de l'ascaridiase et de la trichocéphalose ont été observées dans les groupes d'âge 5–9 ans, 10–14 ans et 15–19 ans: 54,5%, 54,2% et 49,8% respectivement pour l'ascaridiase et 23,9%, 26,4% et 22,8% pour la trichocéphalose. En ce qui concerne les ankylostomiases, la prévalence augmentait avec l'âge pour se stabiliser après 20 ans. Les résultats des dénombrements d'œufs (œufs/g) ont montré que 75 à 95% des sujets atteints avaient des infestations légères. Les infestations à *Ascaris* et à *Trichuris* étaient les plus fortes chez les enfants de 0 à 14 ans, les adultes étant plus fortement infestés par les ankylostomes.

L'enquête a révélé l'existence d'une relation étroite entre les helminthiases et la profession des habitants. L'ascaridiase avait une prévalence plus élevée chez les étudiants (48,5%), les pêcheurs (47,9%) et les agriculteurs (45,2%), la trichocéphalose chez les pêcheurs (50,3%) et les maraîchers (47,9%), et les ankylostomiases chez les maraîchers (31,0%) et les agriculteurs en général (19,8%). On a également observé une corrélation positive avec la température, l'hygrométrie et les précipitations et une corrélation négative avec la durée de l'ensoleillement, la latitude et l'altitude, ce qui correspondait avec la prévalence plus élevée des helminthiases dans les provinces du sud-est.

Des cas d'ascaridiase ectopique avec complications notifiés au cours des 40 dernières années ont été étudiés ainsi que des données publiées sur la morbidité et la mortalité des helminthiases transmises par le sol. Il en ressort qu'il est important de promouvoir la lutte contre les helminthiases intestinales, en particulier chez les enfants d'âge scolaire.

References

1. **Anderson RM, Medley GF.** Community control of helminth infections of man by mass and selective chemotherapy. *Parasitology*, 1985, **90**: 629–660.
2. **Bundy DAP, Cooper ES.** Trichuriasis. In: Warren KS, Mahmoud AAF, eds. *Tropical and geographical medicine*, 2nd edition. New York, McGraw-Hill, 1990: 400–402.
3. **Bundy DAP et al.** Evaluating measures to control intestinal parasitic infections. *World health statistics quarterly*, 1992, **45**: 168–179.
4. **Chan L, Kan SP, Bundy DAP.** The effect of repeated chemotherapy on age-related predisposition to *Ascaris lumbricoides* and *Trichuris trichiura*. *Parasitology*, 1992, **104**: 371–377.
5. **Chan MS et al.** The evaluation of potential global morbidity attributable to intestinal nematode infections. *Parasitology*, 1994, **109**: 373–387.
6. **Cort WW et al.** Researches on hookworm in China. *American journal of hygiene* (Monog. Series, No. 7) Baltimore, 1926.
7. **Crompton DWT.** The prevalence of ascariasis. *Parasitology today*, 1988, **4**: 162–169.
8. **Davis A.** Introduction. In: Crompton DWT, Nesheim MC, Pawlowski ZS, eds. *Ascariasis and its prevention and control*. London, Taylor & Francis, 1989: 1–2.
9. **Katz N et al.** A simple device for quantitative stool thick-smear technique in schistosomiasis mansoni. *Revista do Instituto de Medicina Tropical de São Paulo*, 1972, **14**: 397–400.
10. **Lin JX et al.** [Distribution and epidemiological features of human parasitic infections in Fujian province.] *Chinese journal of zoonosis*, 1993, **9** (Suppl.): 27–35 (in Chinese).

11. **Nelson GS.** Hookworms in perspective. In: Schad GA, Warren KS, eds. *Hookworm disease: current status and new directions.* London, Taylor & Francis, 1990: 417–430.
12. **Nesheim MC.** Ascariasis and human nutrition. In: Crompton DWT, Nesheim MC, Pawlowski ZS, eds. *Ascariasis and its prevention and control.* London, Taylor & Francis, 1989: 87–100.
13. **Pawlowski ZS.** Ascariasis. In: Warren KS, Mahmoud AAF, eds. *Tropical and geographical medicine*, 2nd edition. New York, McGraw-Hill, 1990: 369–378.
14. **Pawlowski ZS, Davis A.** Morbidity and mortality in ascariasis. In: Crompton DWT, Nesheim MC, Pawlowski ZS, eds. *Ascariasis and its prevention and control.* London, Taylor & Francis, 1989: 71–86.
15. **Pawlowski ZS, Schad GA, Stott GJ.** *Hookworm infection and anaemia.* Geneva, World Health Organization, 1991.
16. **Schad GA, Anderson RM.** Predisposition to hookworm infection in humans. *Science*, 1985, **228**: 1537–1540.
17. **Stephenson LS.** *Impact of helminth infections on human nutrition.* London, Taylor & Francis, 1987.
18. **Stoll NR.** This wormy world. *Journal of parasitology*, 1947, **33**: 1–18.
19. **Walsh JA, Warren KS.** Selective primary health care. An interim strategy for disease control in developing countries. *New England journal of medicine*, 1979, **301**: 967–974.
20. *Prevention and control of intestinal parasitic infections. Report of a WHO Expert Committee.* Geneva, World Health Organization, 1987 (WHO Technical Report Series, No. 749).
21. **Yu SH, Shen WX.** Hookworm infection and disease in China. In: Schad GA, Warren KS, eds. *Hookworm disease: current status and new directions.* London, Taylor & Francis, 1990: 44–54.
22. **Yu SH, Xu LQ.** Ectopia and complications in ascariasis. In: Yokogawa M et al., eds. *Collected papers on the control of soil-transmitted helminthiases, Vol. 5.* Tokyo, APCO, 1993: 343–345.
23. **Yu SH et al.** Special report: nationwide survey of human parasites in China. *Southeast Asian journal of tropical medicine and public health*, 1994, **25**: 4–10.
24. **Zhao WX.** [*Human parasitology*, 1st edition.] Beijing, People's Publishing House, 1983 (in Chinese).