35

Trichuris and Trichuriasis

THERE ARE THREE intestinal worm infections of man having cosmopolitan distributions and producing severe clinical consequences in heavily infected individuals. These are hookworm infection (chapter 22), ascariasis (chapter 23), and trichuriasis (this chapter). Trichuriasis is often considered jointly with ascariasis because they are usually endemic in the same communities and their life cycles, modes of transmission, and epidemiologies are similar.

Description of Pathogen and Disease

Trichuriasis is an infection of man by the human whipworm *Trichuris trichiura*. It is commonly referred to as whipworm infection and, rarely, as trichocephaliasis. Recent reviews include Chanco and Vidad (1978), Mahmoud (1979), and Wolfe (1978).

Identification

Trichuriasis is a helminthic infection of the large intestine and cecum. Most infections in adults are symptomless, but there may be slight abdominal pain and some diarrhea. In malnourished children heavy infection can cause anemia, bloody diarrhea, and occasionally, prolapse of the rectum (Jung and Beaver 1951; Jung and Jelliffe 1952; Kamath 1973). Diagnosis is by identification of *Trichuris* eggs in the feces. Safe and effective drugs—for instance, mebendazole—are now available for treating trichuriasis, and some of these are effective in mixed infections with hookworm and *Ascaris*.

Occurrence

Trichuriasis occurs throughout the world and is very common in some areas with warm and humid climates. Local prevalences of 50–99 percent are reported, although 25–40 percent is more usual. Prevalence and intensity of infection are highest among children 5–15 years old.

Infectious agent

Trichuris trichiura (formerly called *Trichocephalus dispar*, *Tricho. trichiura*, and *Tricho. hominis*), a nematode, is the human whipworm. Adult female worms are 25–50 millimeters in length; males measure 30–45 millimeters, with a tightly coiled posterior end (figure 35-1). The eggs are lemon-shaped with plug-like, translucent prominences at each end. The eggs are 50–55 micrometers long and 22 micrometers wide. The pig whipworm, *T. suis*, is very similar and can also infect man; routine stool examination does not distinguish between eggs of *T. trichiura* and those of *T. suis*. Closely related species infect other animals; for instance, *T. ovis* in sheep, *T. vulpes* in dogs and foxes, and *T. muris* in mice.

Reservoir

The reservoir of *T. trichiura* is man, who may also act as a minor reservoir of *T. suis*. It is possible that pigs, lemurs, and monkeys may also act as a reservoir of *T. trichiura*.

Transmission

Female worms lay 2,000–10,000 eggs per day. The unsegmented fertilized eggs are discharged in the feces and take 2–5 weeks to develop into the infective stage in a moist, warm environment (usually soil or the perineum). Development time is temperature dependent and may be 4–6 months at 15°C, 3–4 weeks at 26°C, 17 days at 30°C, and 11 days at 35°C. The eggs of *Trichuris* are less resistant than those of *Ascaris*, but even so they may survive for several months in shaded, moist soil. Once ingested—from contaminated hands,

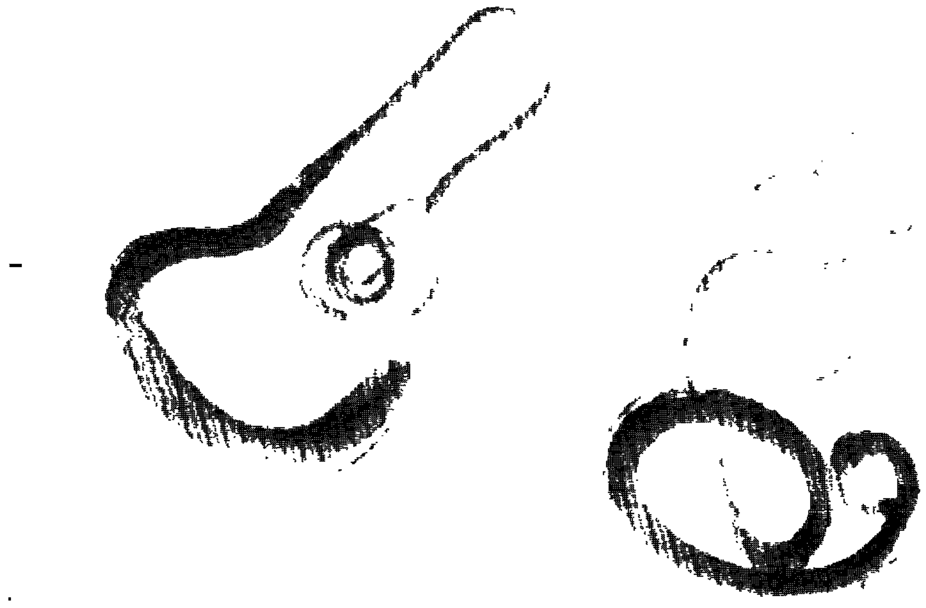

Figure 35-1. *A male (left) and female (right)* Trichuris trichiura *under a light microscope.* The worms are 30–50 millimeters in length. (Photo: Wellcome Museum of Medical Science)

food, or soil — infective eggs hatch in the intestine to liberate small larvae, which feed and grow in the small intestine before passing to the cecum to become mature adults. Adult worms anchor themselves to the large bowel mucosa by means of a spear-like projection at their anterior end. This process of maturity takes about 2 months, and the adult worm can live for 3–5 years in man. Heavy infections are associated with egg counts in excess of 30,000 per gram of feces.

Prepatent and incubation periods

A female worm may mature and start producing eggs about 2 months after the ingestion of infective eggs. Clinical symptoms may never develop or may develop gradually as a result of continuing reinfection and increasing worm burdens.

Period of communicability

Eggs are discharged in the feces as long as there is an adult fertilized female worm living in the cecum. The life span of an adult worm may be up to 8 years but is typically around 3 years. The eggs may develop and remain infective for several months in a moist environment.

Resistance

Little is known of the immunology of trichuriasis. Susceptibility is general, and the age distribution of infection may be due to the varying degrees of exposure at different ages.

Epidemiology

Trichuriasis is extremely common in some areas of the world, especially where the climate is wet and humid and where there is extreme poverty. Surveys of children 1–5 years old in Guatemala revealed trichuriasis prevalences of 33 percent among rural children, 9 percent among poor urban children, and 4 percent among more wealthy urban children (Pierce and others 1962). In one village in Guatemala, 48 percent of children became infected by *Trichuris* between birth and 3 years (Mata and others 1977).

A survey of children 4–6 years old in Kuala Lumpur (Malaysia) found a prevalence of trichuriasis of 84 percent among poor children and 8 percent among "upper middle class" children (Yan and others 1978). A study of rural schoolchildren (6–12 years old) 72 kilometers from Kuala Lumpur found an 85 percent prevalence of trichuriasis (Lo and others 1979).

In the late 1960s, trichuriasis was the most common intestinal worm infection in South Korea, with prevalence rates of 72 percent in Seoul and 75 percent in rural areas (Seo and others 1969). *Trichuris* was also the most common intestinal worm in Cali (Colombia) during 1956–61, when the prevalence among children 5–9 years old was 91 percent (Faust and Mugaburu 1965). Similarly, *Trichuris* was more prevalent than *Ascaris* or hookworm in Haiti, with an 85 percent prevalence among children 10–14 years old (Raccurt, Vial and Pierre-Louis 1977).

There are major unexplained variations among communities in the prevalence of trichuriasis and in the relative prevalence of *Trichuris*, *Ascaris*, and hookworm infections. It is often asserted that areas of high rainfall are associated with more *Trichuris* and less *Ascaris*, whereas in drier regions *Ascaris* may be expected to be the more prevalent worm (Spindler, 1929). Some data support this, and high prevalences are frequently found in hot wet climates, especially in areas of East Asia where night soil is widely used in agriculture. In Iran, the prevalence of trichuriasis was 6 percent in the dry southwest (Massoud and others 1980); compared with up to 60 percent in the wetter area bordering the Caspian Sea (Ghadirian, Croll and Gyorkos 1979). Low prevalences are reported, however, from areas with seasonally wet climates, such as Delhi (Biswas and others 1978) and Bengal (Nawalinski, Schad and Chowdhury 1978) in India and from areas with perennially wet climates, such as Papua New Guinea (Jones 1976).

As with ascariasis (chapter 23), both the prevalence and intensity of trichuriasis infection typically peak in the 5–15 age group. At older ages intensities decline, and prevalences either decline similarly or maintain fairly constant levels throughout later life.

Trichuriasis is common in some developed countries. There are an estimated 2.2 million people infected in the USA, and the disease is especially common in the southeast (Fulmer and Huempfner 1965; Warren 1974). Male homosexuality is associated with risk of trichuriasis in some developed countries (McMillan 1978). A survey of trichuriasis among mentally subnormal patients at seventeen hospitals in the UK revealed that the overall prevalence was 13 percent, with markedly more infection in southern England than northern England and no infection in Scotland (Lynch and others 1972).

The epidemiology of trichuriasis is closely similar to that of ascariasis, and the remarks made on epidemiology in chapter 23 are applicable. A major difference is the greater longevity of the adult *Trichuris* worm, which provides greater opportunity for accumulating high worm burdens and delays the effects of any control program.

Students of trichuriasis epidemiology, and of the comparative epidemiology of ascariasis, trichuriasis, and hookworm infection, should read the early accounts of these infections from China, Panama, and the USA (Cort, Otto and Spindler 1930; Cort, Schapiro and Stoll 1929; Cort and Stoll 1931; Cort and others 1929; Otto 1932; Otto, Cort and Keller 1931).

Control Measures

Only environmental and behavioral changes can have a sustained impact on trichuriasis, but mass chemotherapy may be used to reduce infection rates in the short term.

Individual

No prophylactic drugs or vaccines are available. Mass chemotherapy has not been as successful in controlling trichuriasis as it has been with ascariasis and hookworm infection, because until recently safe and effective drugs were not available. With the advent of new drugs, especially mebendazole and oxantel-pyrantel, mass chemotherapy has become an important control strategy.

Environmental

The remarks made about the environmental control of ascariasis (chapter 23) apply to trichuriasis. The major difference is that the longer life span of *Trichuris* in the human host results in prevalence rates falling more slowly following a successful campaign to control transmission.

Control rests upon major improvements in excreta disposal, especially for children, and changes in behavior associated with defecation. In areas where night soil is used in agriculture, it is necessary to treat the night soil thoroughly before application to the fields. Environmental measures that interrupt transmission will reduce prevalence rates slowly, and it may be many months before measurable reductions in trichuriasis in the community are obtained. Therefore environmental and behavioral modifications should be combined with periodic mass chemotherapy in any trichuriasis control program. This integrated approach to control has been successful in several countries; for instance in South Korea (Soh 1973).

Some studies on environmental interventions and trichuriasis are listed in table 35-1. The discussion of table 23-2 applies fully to these findings.

In the city of Kermanshah (Iran), Ghadirian and others (1973) recorded trichuriasis prevalences of 72 percent in a low-income area near an open sewer and 58 percent in a high-income area far from the sewer. This latter high prevalence in a more wealthy section of the city was attributed to the irrigation of vegetables with night soil and sewage. In South Africa it was reported that Xhosa children (6–9 years old) living in Cape Town (piped water and sewer connections to every house) had a trichuriasis prevalence of 89 percent, whereas rural Xhosa children in villages in the Transkei (water collected from streams and sanitation comprising pit latrines or indiscriminate defecation) had a prevalence of only 3 percent (van Niekerk and others 1979). The reason for this strange finding was not known but may be connected with the wetter climate of Cape Town. Both the Iranian and South African data strongly suggest that limited environmental improvements may not be sufficient to control *Trichuris* transmission.

Occurrence and Survival in the Environment

There is considerably more information on the occurrence and survival of *Ascaris* eggs in the environment than on the survival of *Trichuris* eggs. This is partly because, worldwide, *Ascaris* is probably the more common worm and also because *Ascaris* eggs are more resistant to hostile environments than *Trichuris* eggs. *Ascaris* eggs therefore provide a better parasitological indicator than *Trichuris* eggs in areas where both are endemic. *Ascaris* eggs are better able to survive both warm and cold temperatures than *Trichuris* eggs (Nolf 1932); and the latter require a higher moisture level in soil to develop than *Ascaris* eggs (Spindler 1929).

A few studies on *Trichuris* eggs in the environment are mentioned below. It may be assumed that the comments on *Ascaris* eggs in the environment made in chapter 23 apply to *Trichuris*, except that *Trichuris* eggs will typically remain viable for shorter periods.

In water

Yarulin (1955) isolated *Trichuris* eggs from 3 percent of Caspian Sea water samples near a sewage outfall in the USSR. Usacheva (1951) isolated *Trichuris* eggs from river water and river sediment in the USSR. Iwańczuk (1969) found *Trichuris* eggs in greater numbers than *Ascaris* eggs on public beaches on the River Vistula (Poland), but these probably derived from promiscuous defecation by visitors rather than from the river water. Livingstone (1978) reported that *Trichuris* eggs rapidly swelled and died in seawater.

In feces and night soil

Some *Trichuris* eggs in pit latrines remained viable for over 18 months but died sooner than *Ascaris* eggs (Biziulevicius 1965).

In sewage

Reported concentrations of *Trichuris* eggs per liter of sewage include 10–20 in Tokyo (Japan; Liebmann 1965) and 41 in San Juan (Puerto Rico; Rowan and Gram 1959). Many accounts of *Trichuris* eggs in

Table 35-1. *Some studies on environmental influences on trichuriasis*

Country	*Result*	*Source*
Costa Rica	Trichuriasis prevalence was the same among individuals with or without a latrine but was lower among those having a septic tank system.	Moore, de la Cruz and Vargas-Mendez (1965)
Japan	Night soil treatment with thiabendazole reduced trichuriasis prevalence from 65 percent to 47 percent over 2 years.	Kutsumi (1969)
Singapore	Poor families rehoused for 1 year in modern flats had a trichuriasis prevalence of 28 percent; in comparison squatter families had a 58 percent prevalence.	Kleevens (1966)
USA	*Trichuris* transmission was interrupted when adult female mental patients were moved from old unsanitary quarters to a modern building.	Jeffery (1960)

sewage in the German Democratic Republic (for instance, Kalbe 1956; Sinnecker 1958), and the USSR (for instance, Vassilkova 1936) have been published.

In sludge

Trichuris eggs, like *Ascaris* eggs, tend to settle in primary and secondary sedimentation tanks and are therefore concentrated in the sludge from sewage treatment plants. *Trichuris* eggs have been found in sludges in Czechoslovakia (Králová and Šafránek 1957) and the USA (Theis, Bolton and Storm 1978), and may be expected at every sewage treatment plant serving a population with endemic trichuriasis.

In soil

Trichuris eggs, like *Ascaris* eggs, can remain alive in soil for extended periods, especially if conditions are moist, cool, and shaded. A study at a hospital near London (England) showed that 21 percent of *T. trichiura* eggs were still potentially infective after 18 months in "clay-flint" soil (Burden and others 1976).

On crops

Where trichuriasis is endemic and fecal materials (sewage, night soil, or sludge) are used in agriculture, *Trichuris* eggs may be found on crops, and this may play some role in transmission. *Trichuris* eggs on vegetables have been extensively studied in the USSR (Barchenko 1953; Biziulevicius 1954; Khaustov 1935; Romanenko 1971; Vassilkova 1941) and other East European countries. Sinnecker (1958) isolated *Trichuris* eggs from sewage-irrigated lettuce in the German Democratic Republic and reported that prevalences of trichuriasis were higher (20 percent) among irrigation workers than among sewermen (8 percent) or sewage treatment plant operators (0 percent). *Trichuris* contamination of vegetables is especially common in areas of East Asia—for instance, in South Korea (Choi 1970), where untreated night soil is a commonly used fertilizer.

The prominence of contaminated vegetables in trichuriasis transmission is partly dependent on the level of domestic hygiene and sanitation, and thus on the degree to which yard transmission among children is taking place. In more wealthy communities where hygiene and sanitation are good, it is possible that contaminated vegetables may be a major transmission route. This was thought to be the situation among the Jewish residents of Jerusalem (Israel), where trichuriasis prevalence fell from 13 percent in 1947 to 5 percent in 1960, possibly owing to the cessation of the supply of sewage-irrigated vegetables from Jordan (Ben-Ari 1962).

Crops may be decontaminated by soaking in an ovicidal chemical, although *Trichuris* eggs are more resistant to iodine than are *Ascaris* eggs (Thitasut 1961). It will usually be more reliable and appropriate to immerse the vegetables in warm water (60°C) for 10 minutes (see chapter 23).

Inactivation by Sewage Treatment Processes

Little information is available on *Trichuris* egg removal by sewage treatment processes because most researchers have focussed on *Ascaris* egg removal. The data presented for *Ascaris* egg removal (chapter 23) may be assumed to apply to *Trichuris* egg removal.

Indian data assembled by Panicker and Krishnamoorthi (1978) are presented in table 22-4 and show that *Trichuris* and *Ascaris* removals are similar. This is also shown by studies on sedimentation and activated sludge treatment in Calcutta (Bhaskaran and others 1956). Correctly designed and operated waste stabilization ponds remove all *Trichuris* eggs (table 22-4 and Lakshminarayana and Abdulappa 1972). Vassilkova (1936) studied *Trichuris* eggs in sewage treatment plants near Moscow (USSR), and Plyushcheva (1974) experimented with ionizing radiation to kill *Trichuris* eggs in sewage.

Inactivation by Night Soil and Sludge Treatment Processes

Trichuris eggs tend to be concentrated in the sludge of all sewage treatment processes, and high concentrations may be expected in night soil in areas where trichuriasis is endemic. The data presented on *Ascaris* egg removal (chapter 23) may be assumed to apply to *Trichuris* egg removal, except that *Trichuris* eggs are probably eliminated somewhat earlier than *Ascaris* eggs during storage, digestion, or composting.

Reports on *Trichuris* eggs in sludge following various forms of treatment are available from the USA (Wright, Cram and Nolan 1942), the USSR (Vassilkova 1936), China (Szechwan Research Institute 1974), and other countries. Most research has concentrated on *Ascaris* eggs in sludge and night soil treatment processes because they are usually more numerous and are believed to be more persistent than *Trichuris* eggs. Contrary evidence is provided by Enigk and others (1975), who found that *Trichuris* eggs survived thermophilic digestion for up to 5 days, whereas *Ascaris* eggs were eliminated within 3 days.

Trichuris eggs in sludge and night soil can be eliminated by the addition of appropriate ovicides (table 23-4). Kutsumi and Komiya (1965) experimented with thiabendazole and found that, under similar conditions, *Trichuris* eggs were killed by the application of concentrations one-sixth to one-sixteenth of those required for *Ascaris* egg destruction.

Literature Cited

Barchenko, I. P. (1953). The importance of some food products as possible factors in the geohelminth infection of a population. In *Papers in Helminthology Presented to Academician K. I. Skryabin on his 75th Birthday*, pp. 39–43. Moscow: Izdatelstvo Akademii Nauk SSR.

Ben-Ari, J. (1962). The incidence of *Ascaris lumbricoides* and *Trichuris trichiura* in Jerusalem during the period of 1934–1960. *American Journal of Tropical Medicine and Hygiene*, **11**, 366–368.

Bhaskaran, T. R., Sampathkumaran, M. A., Sur, T. C. and Radhakrishnan, I. (1956). Studies on the effect of the sewage treatment processes on the survival of intestinal parasites. *Indian Journal of Medical Research*, **44**, 163–180.

Biswas, H., Saraljit, S., Arora, R. R. and Mathur, K. K. (1978). Intestinal parasites and different species of hookworm in slum dwelling people around Delhi. *Journal of Communicable Diseases*, **10**, 234–237.

Biziulevicius, S. (1954). Role of vegetables and berries in the epidemiology of helminthiasis in the population of Lithuania. *Meditsinskaia Parazitologiia i Parazitarnye Bolezni*, **23**, 124–126.

———(1965). Studies on the viability of *Ascaris* and *Trichuris* eggs in buried lavatory pits. *Acta Parasitologica Lithuanica*, **5**, 77–84.

Burden, D. J., Whitehead, A., Green, E. A., McFadzean, J. A. and Beer, R. J. S. (1976). The treatment of soil infested with the human whipworm *Trichuris trichiura*. *Journal of Hygiene*, **77**, 377–382.

Chanco, P. P. and Vidad, J. Y. (1978). A review of trichuriasis, its incidence, pathogenicity and treatment. *Drugs*, **15** (Suppl. 1), 87–93.

Choi, D. W. (1970). Incidence of parasite eggs attached to vegetable leaves, water cress and carrots. *Korean Journal of Parasitology*, **8**, 19.

Cort, W. W., Otto, G. F. and Spindler, L. A. (1930). Investigations on *Ascaris lumbricoides* and the associated intestinal helminths of man in southwestern Virginia. *American Journal of Hygiene*, **11**, 1–55.

Cort, W. W., Schapiro, L. and Stoll, N. R. (1929). A study of reinfection after treatment with hookworm and *Ascaris* in two villages in Panama. *American Journal of Hygiene*, **10**, 614–625.

Cort, W. W. and Stoll, N. R. (1931). Studies on *Ascaris lumbricoides* and *Trichuris trichiura* in China. *American Journal of Hygiene*, **14**, 655–689.

Cort, W. W., Stoll, N. R., Riley, W. A. and Sweet, W. C. (1929). VIII. Quantitative studies on the distribution of *Ascaris lumbricoides* and *Trichuris trichiura* in Panama. *American Journal of Hygiene, Monographic Series No. 9*, 161–209.

Enigk, K., Thaer, R., Dey-Hazra, A. and Ahlers, R. (1975). Survival of resistant external stages of parasites during fermentation of liquid cattle manure at raised temperatures. *Zentralblatt für Veterinärmedizin, Reihe B*, **22**, 687–702.

Faust, E. C. and Mugaburu, L. G. (1965). Parasitologic surveys in Cali, Departamento del Valle, Colombia. XI. Intestinal parasites in Ward Siloé, Cali, during a four-year period 1956–1960. *American Journal of Tropical Medicine and Hygiene*, **14**, 276–289.

Fulmer, H. S. and Huempfner, H. R. (1965). Intestinal helminths in eastern Kentucky: a survey in three rural counties. *American Journal of Tropical Medicine and Hygiene*, **14**, 269–275.

Ghadirian, E., Arfaa, F., Missaghian, Gh. and Bahrani, H. (1973). Prevalence of intestinal helminthiasis in Kermanshah City and some villages in the province. *Iranian Journal of Public Health*, **2**, 90–101.

Ghadirian, E., Croll, N. A. and Gyorkos, T. W. (1979). Socio-agricultural factors and parasitic infections in the Caspian littoral region of Iran. *Tropical and Geographical Medicine*, **31**, 485–491.

Iwańczuk, I. (1969). Exploration of river shores for the presence of human intestinal parasite. *Wiadomości Parazytologiczne*, **15**, 67–70.

Jeffery, G. M. (1960). A three-year epidemiologic study of intestinal parasites in a selected group of mental patients. *American Journal of Hygiene*, **71**, 1–8.

Jones, H. I. (1976). A study of human intestinal helminthiases on Kar Kar Island, Madang Province. *Papua New Guinea Medical Journal*, **19**, 165–172.

Jung, R. C. and Beaver, P. C. (1951). Clinical observations on *Tricocephalus trichiurus* (whipworm) infestation in children. *Paediatrics*, **8**, 548–557.

Jung, R. C. and Jelliffe, D. B. (1952). The clinical picture and treatment of whipworm infection. *West African Medical Journal*, **1**, 11–15.

Kalbe, I. (1956). Investigations of parasites in sewage in several towns in East Germany. *Zeitschrift für die Gesamte Hygiene und ihre Grenzgebiete*, **2**, 334–343.

Kamath, K. R. (1973). Severe infection with *Trichuris trichiura* in Malaysian children. *American Journal of Tropical Medicine and Hygiene*, **22**, 600–605.

Khaustov, J. M. (1935). Vegetables as a factor in transmission of *Trichocephalus (Trichuris) trichiurus*. *Trudy Leningradskogo Instituta Epidemiologii i Bakteriologii imeni Pastera*, **2**, 148–152.

Kleevens, J. W. L. (1966). Re-housing and infections by soil-transmitted helminths in Singapore. *Singapore Medical Journal*, **7**, 12–29.

Králová, E. and Šafránek, V. (1957). Helminthological investigation of sediments from the wastewater refining station at Kouřim. *Československá Hygiena*, **2,** 399–404.

Kutsumi, H. (1969). Epidemiological study on the preventive effect of thiabendazole as an ovicide against human hookworm, *Trichuris* and *Ascaris* infections. *Japanese Journal of Medical Science and Biology*, **22,** 51–64.

Kutsumi, H. and Komiya, Y. (1965). Effect of thiabendazole as an ovicide on helminth eggs in nightsoil. *Japanese Journal of Medical Science and Biology*, **18,** 203–224.

Lakshminarayana, J. S. S. and Abdulappa, M. K. (1972). The effect of sewage stabilization ponds on helminths. In *Low Cost Waste Treatment*, ed. Sastry, C. A., pp. 290–299. Nagpur, India: Central Public Health Engineering Research Institute.

Liebmann, H. (1965). Investigations about helminth ova in sewage and wastes in Japan. *Berliner und Münchener tierärztliche Wochenschrift*, **78,** 106–108.

Livingstone, D. J. (1978). Decay of micro-organisms in the marine environment. In *Proceedings of a Symposium on Disinfection of Water*. Pretoria, South Africa: National Institute for Water Research.

Lo, E. K. C., Varughese, J., Ghouse, A. and Noor, M. (1979). Helminthiases in peninsular Malaysia: prevalence and density of infestation of hookworm, *Ascaris* and *Trichuris* in rural school children. *Medical Journal of Malaysia*, **34,** 95–99.

Lynch, D. M., Green, E. A., McFadzean, J. A. and Pugh, I. M. (1972). *Trichuris trichiura* infestations in the United Kingdom and treatment with difetarsone. *British Medical Journal*, **4,** 73–76.

McMillan, A. (1978). Threadworms in homosexual males. [Correspondence.] *British Medical Journal*, **1,** 367.

Mahmoud, A. A. F. (1979). Intestinal nematodes. In *Principles and Practice of Infectious Diseases*, eds. Mandell, G. L., Douglas, R. G. and Bennett, J. E., pp. 2157–2164. New York: John Wiley.

Massoud, J., Arfaa, F., Jalali, H. and Keyvan, S. (1980). Prevalence of intestinal helminths in Khuzestan, Southwest Iran, 1977. *American Journal of Tropical Medicine and Hygiene*, **29,** 389–392.

Mata, L. J., Kromal, R. A., Urrutia, J. J. and Garcia, B. (1977). Effect of infection on food intake and the nutritional state: perspectives as viewed from the village. *American Journal of Clinical Nutrition*, **30,** 1215–1227.

Moore, H. A., de la Cruz, E. and Vargas-Mendez, O. (1965). Diarrheal disease studies in Costa Rica. IV. The influence of sanitation upon the prevalence of intestinal infection and diarrheal disease. *American Journal of Epidemiology*, **82,** 162–184.

Nawalinski, T., Schad, G. A. and Chowdhury, A. B. (1978). Population biology of hookworms in children in rural West Bengal. I. General parasitological observations. *American Journal of Tropical Medicine and Hygiene*, **27,** 1152–1161.

Nolf, L. O. (1932). Experimental studies on certain factors influencing the development and viability of the ova of human *Trichuris* as compared with those of the human *Ascaris*. *American Journal of Hygiene*, **16,** 288–322.

Otto, G. F. (1932). *Ascaris* and *Trichuris* in southern United States. *Journal of Parasitology*, **18,** 200–208.

Otto, G. F., Cort, W. W. and Keller, A. E. (1931). Environmental studies of families in Tennessee infested with *Ascaris*, *Trichuris* and hookworm. *American Journal of Hygiene*, **14,** 156–193.

Panicker, P. V. R. C. and Krishnamoorthi, K. P. (1978). Elimination of enteric parasites during sewage treatment processes. *Indian Association for Water Pollution Control Technical Annual*, **5,** 130–138.

Pierce, V., Ascoli, W., de Leon, R. and Gordon, J. E. (1962). Studies of diarrheal disease in Central America. III. Specific etiology of endemic diarrhea and dysentery in Guatemalan children. *American Journal of Tropical Medicine and Hygiene*, **11,** 395–400.

Plyushcheva, G. L. (1974). The effect of ionizing radiation on *Trichuris trichiura* and *Diphyllobothrium latum* eggs in domestic sewage: an experimental study. *Meditsinkaia Parazitologiia i Parazitarnye Bolezni*, **43,** 463–468.

Raccurt, C., Vial, P. and Pierre-Louis, J. M. (1977). Étude épidémiologique des helminthiases intestinales à l'île de la Tortue (Haiti). *Bulletin de la Société de Pathologie Exotique et des ses Filiales*, **70,** 240–249.

Romanenko, N. A. (1971). Sanitary-helminthological evaluation of new methods of irrigation with sewage. *Meditsinskaia Parazitologiia i Parazitarnye Bolezni*, **40,** 361–362.

Rowan, W. B. and Gram, A. L. (1959). Quantitative recovery of helminth eggs from relatively large samples of feces and sewage. *Journal of Parasitology*, **45,** 615–621.

Seo, B. S., Rim, H. J., Loh, I. K., Lee, S. H., Cho, S. Y., Park, S. C., Bae, J. W., Kim, J. H., Lee, J. S., Koo, B. Y. and Kim, K. S. (1969). Study on the status of helminthic infections in Koreans. *Korean Journal of Parasitology*, **7,** 53–70.

Sinnecker, H. (1958). The epidemiological significance of urban sewage in the spread of possible zooparasitic infections. *Zeitschrift für die Gesamte Hygiene und ihre Grenzgebiete*, **4,** 98–115.

Soh, C. T. (1973). Control of soil-transmitted helminths in Korea: a progress report. *Yonsei Reports on Tropical Medicine*, **4,** 102–125.

Spindler, L. A. (1929). The relation of moisture to the distribution of human *Trichuris* and *Ascaris*. *American Journal of Hygiene*, **10,** 476–496.

Szechwan Research Institute of Antiparasitic Diseases and Mienchu County Antischistosomiasis Office, Szechwan (1974). Digestion of nightsoil for destruction of parasite ova: a report of investigation and experimental observation. *Chinese Medical Journal*, **93,** 31.

Theis, J. H., Bolton, V. and Storm, D. R. (1978). Helminth ova in soil and sludge from twelve US urban area. *Journal of the Water Pollution Control Federation*, **50,** 2485–2493.

Thitasut, P. (1961). Action of aqueous solutions of iodine on fresh vegetables and on the infective stages of some common intestinal nematodes. *American Journal of Tropical Medicine and Hygiene*, **10,** 39–43.

Usacheva, A. M. (1951). Survival of helminth ova in water and river sediment. *Gigiena i Sanitaria*. Part 2, no. 12, 12–17.

van Niekerk, C. H., Weinberg, E. G., Shore, S. C. L. and Heese, H. de V. (1979). Intestinal parasitic infestation in urban and rural Xhosa children: a comparative study. *South African Medical Journal*, **55,** 756–757.

Vassilkova, Z. (1963). On the dehelminthisation of purified sewage waters by intensive methods. *Meditsinkskaia Parazitologiia i Parazitarnye Bolezni*, **5,** 671–674.

——— (1941). Evaluation of the contamination of vegetables with eggs of helminths in sewage farms with different methods of cultivation. *Meditsinskaia Parazitologiia i Parazitarnye Bolezni*, **10,** 217–225.

Warren, K. S. (1974). Helminthic diseases endemic in the United States. *American Journal of Tropical Medicine and Hygiene*, **23,** 723–730.

Wolfe, M. S. (1978). *Oxyuris*, *Trichostrongylus* and *Trichuris*. *Clinics in Gastroenterology*, **7,** 201–217.

Wright, W. H., Cram, E. B. and Nolan, M. O. (1942). Preliminary observations on the effect of sewage treatment processes on the ova and cysts of intestinal parasites. *Sewage Works Journal*, **14,** 1274–1280.

Yan, C. W., bin Ishak, F., Hee, G. L., Devaraj, J. M., bin Ismail, K., Jalleh, R. P., Peng, T. L. and Jalil, T. M. bin A. (1978). The problem of soil transmitted helminths in squatter areas around Kuala Lumpur. *Medical Journal of Malaysia*, **33,** 34–43.

Yarulin, G. R. (1955). Contamination of the coastal zone of the Caspian Sea with eggs of geohelminths. *Meditsinskaia Parazitologiia i Parazitarnye Bolezni*, **24,** 117–120.