# EPIDEMIOLOGY AND MORBIDITY OF FOOD-BORNE INTESTINAL TREMATODE INFECTIONS

by

Dr Yu Sen-Hai and Dr K.E. Mott
Schistosomiasis Control Unit, Division of Control of Tropical Diseases
World Health Organization, Geneva, Switzerland

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1. INTRODUCTION

The intestinal trematodes (flukes) are less well known than the trematodes of the liver \textit{(Fasciola, Clonorchis and Opisthorchis)} and the lung \textit{(Paragonimus)}. The public health importance of these latter parasites is due to their wide geographical distribution, high prevalence and severe morbidity. In contrast although the intestinal trematode infections are more focal in distribution, they have been reported from a larger number of countries, represent a far greater number of species and are acquired from a wider range of intermediate hosts.

All food-borne intestinal trematodes are more adapted to a wider range of first and second intermediate hosts than one might suspect from the general scientific literature. Freshwater fish are the major source of infections due to intestinal trematodes. However, certain intestinal trematodes are transmitted through plants, snails, crustacea, amphibians, reptiles and insects. Our current understanding of the distribution, epidemiological characteristics and pathology of intestinal trematodes is generally based on individual case reports rather than on systematic investigations in populations with specific high risk food habits.

About 70 species of intestinal flukes have been reported to infect people. Only a few species cause significant clinical manifestations or morbidity, and mortality has rarely been reported. The morphological differences between the eggs of the major groups of intestinal trematodes are minimal. Definitive diagnosis requires recovery and identification of the adult worm and confirmation by expert opinion. The current effective treatment of all intestinal trematode infections with praziquantel, which expels the adult worm, has resulted in the identification of a number of new species, particularly those designated as minute intestinal flukes. These intestinal trematodes belong to the families Heterophyidae, Echinostomatidae and to a lesser extent, the Diplodocidae, Fasciolidae, Gastrophidae, Gyosphallidae, Lecithodendriidae, Microphallidae, Nanophyllidae, Paramphistomatidae, Plagiorchiidae, and Strigeidae.

Strategies for control of intestinal trematode infections can be oriented towards reducing the risk of infection of the second intermediate hosts which harbour the infective metacercariae. These are part of the basic traditional diets in endemic areas and hence are a constant source of infection. The hosts of a few intestinal trematodes have not yet been conclusively identified. Intestinal trematode infections are reviewed here according to the source of infection and in their order of frequency and public health importance.

2. DISTRIBUTION AND EPIDEMIOLOGY

2.1. FISH-BORNE INTESTINAL TREMATODE INFECTIONS
2.1.1 ECHINOSTOMIASIS

Echinostome trematodes of the family Echinostomatidae (Poche, 1926) are mainly intestinal parasites of birds and mammals. There are at least 30 genera in the family and a dozen different species have been reported to infect people. A wide range of freshwater snails are the first intermediate hosts including Lymnaea, Radix, Gyraulus, Cipangopaludina, and Hippopus. The second intermediate hosts of most of the species in this family are freshwater fish, particularly loach (Misgurnus sp.), while snails and amphibians have rarely been found to be infected from the same habits.

Most human echinostome infections have been reported from Asia and the Western Pacific. Human echinostome infection has not been reported from Africa and Latin America. However, Poland and his associates (1985) reported an outbreak of parasitic gastroenteritis among 20 American tourists returning from Kenya and the United Republic of Tanzania. Upon their return to the United States, 10 members of the group developed moderately severe abdominal cramps and loose or watery stools, several others had mild abdominal complaints. Helminth eggs were observed in fecal specimens from 18 of the 20 tourists. The eggs resembled those of an echinostome and were tentatively identified as Echinostoma sp. but no adult flukes were recovered. The two egg-negative tourists also had eosinophilia which suggested that they had been infected simultaneously. Parasitological and clinical cure were achieved by treatment with praziquantel.

- Echinostoma hortense Asada, 1926

This species was first described from house rats in Japan, and reported from Korea (Chai & Lee, 1990) and China (Fan & Sun, 1989). Human infection was also found in these countries. An infection rate of 22.4% was reported among residents of Cheongsong-gun, southern Korea. In a survey in Liaoning province of northeast China, 6 out of 10 hospitalized hepatitis patients who had eaten raw loach were found infected by Echinostoma hortense, as there is a folk prescription of treating jaundice by eating raw loach (Chen et al., 1993). Dog and Rattus norvegicus are the other definitive hosts.

The second intermediate hosts are fish (Misgurnus anguillicaudatus, Odontobutis obscura interrupta, Morroco oxycephalus, Coreoperca kawamebahi, Squalius coreanus), frog and tadpole (Rana catesbiana). In one survey, 69.7% of loach (Misgurnus anguillicaudatus) from a market in Liaoning province were infected.

- Echinostoma cinetorchis Ando and Ozaki, 1923

This parasite was first discovered in rats and then described in people in Japan, Taiwan and Korea (Seo et al., 1980a). The parasite was found postmortem at autopsy in rural areas of Java, Indonesia. Dog and Rattus norvegicus are the natural final hosts.

Its second intermediate hosts are loach (Misgurnus anguillicaudatus), freshwater snails (Radix auricularia coreanus, Physa acuta, Planorbis compressus, Lymnaea japonica and Cipangopaludina sp.), tadpoles and frogs (Rana nigromaculata, R. catesbiana), or larva of salamander. First intermediate host snails, (Hippopus cantori, Segmentina nilidella) have been experimentally shown to also serve as the second intermediate host (Beaver et al., 1984; Chai & Lee, 1990; Yamaguti, 1958).

- Echinoparyphium paralum Dietz, 1909; Probably a synonym of Echinostoma revolutum

The first human infection was described in the former USSR. Human infections were also found in Yunnan, China. It is a natural parasite of ducks, geese, swans, and doves (Shen, 1979).

- Episthmium caninum (Verma, 1935) Yamaguti, 1958
The dog is the definitive host. Three human cases were reported from northeast Thailand. The sources of infection are freshwater fish (Harinasuta et al., 1987; Radomyos et al., 1991).

* Echinococclus perfoliatus (Ratz, 1908) Dietz, 1910

It is a common parasite of the small intestine of dogs and cats in Hungary, Italy, Romania, former USSR, and the Far East (Japan, Taiwan). Fox, rat, hog, and wild boar are also found infected (Beaver et al., 1984). Human infection was reported from China (Guangdong, Fujian, Anhui and Hubei) including a child who died from the infection. About 14,000 worms were once found in the child at autopsy, and the prevalence in the area of residence of this case was 1.84% (34/1846) (Anonymous, 1979; Wang et al., 1979).

Many species of freshwater fish like Carassius sp. harbour the metacercariae, which are encysted only on the gills.

* Echinococclus japonicus Tanabe, 1926

People acquire infection by eating at least 18 species of raw or improperly cooked fish, such as Pseudorasbora parva, Hypomesus olidus and Gnathopogon striatus. Human infections have been reported from Anhui, Fujian, Guangdong, Guangxi, and Jiangsu provinces in China and in Korea (Lin et al., 1985; Chai & Lee, 1990).

Experimental infections were first described in dog, cat, rat, mouse, and birds in Japan. In 6 counties of Fujian and Guangdong, China, the rate of infection in one study was 4.9% (178/3639) among people, 39.7% among dogs and 9.5% among cats. Metacercariae were observed in 80.1% of seven species of fish examined. Chickens and ducks are naturally infected (Lin et al., 1985).

* Echinococclus liliputanus (Looss, 1896) Odhner, 1910

The dog, cat, fox and badger are natural hosts. Human infection was first reported from Hexian, Anhui province of China in 1991. The prevalence among 2426 persons was 13.4%. Higher infection rates were recorded in groups 3-15 years of age (22.7%) and 16-30 years of age (16.4%). Infection rates in dogs and cats were 60% and 45% respectively (Xiao et al., 1992).

The life cycle has not been completely described. In Fujian province of China, Parafossarubus striatulus and Pseudorasbora parva were found to be the first and second intermediate host respectively. Besides dog and cat, badger (Meles meles leptoeryhntus), fox (Vulpes vulpes hoole) and racoon (Nyctereutes procyonoides procyonoides) also serve as reservoir hosts.

* Echinococclus jiufensis sp. nov.

At autopsy, this parasite was discovered in the intestine of a six month old girl who died from pneumonia and dehydration in the suburb of Guangzhou, China. Morphologically, the new species is closely allied to Echinococclus becliocephalus Dietz 1909, but is distinguished from the latter. The life cycle of the parasite and route of infection of the infant are unknown (Liang & Ke, 1988).

* Echinococclus fiujianensis sp. nov.

This is a new species reported recently from Fujian Province, China. Its life cycle, including different stages of the parasite, the intermediate and definitive hosts, has been studied experimentally. The prevalence among the inhabitants in 5 counties/cities of southern Fujian was 3.2% (1.6% - 7.8%), two-thirds of the infected
persons were in the 3-15 year age group. Its first intermediate host is *Bellamya aeruginosa* and the second intermediate hosts are *Pseudorhabdophora parva*, *Cyprinus carpio*, etc. In one survey the infection rate in dogs was 29.2%, and cat, pig, *Rattus rattoides losea* and *Rattus norvegicus* were the other natural definitive hosts (Cheng et al., 1993).

* Echinostoma angustitestia sp nov.

This parasite was first described in 1977 by Wang Pu-Qin who infected dogs experimentally with metacercariae isolated from freshwater fish. Two human infections were reported in Fujian, China (Wang, 1977; Cheng et al., 1992).

2.1.2 HETEROPHYIASIS AND METAGONIMIASIS

Heterophiysis (in a broad sense) is an infection caused by small or minute intestinal flukes of the family *Heterophyidae* (Odhner, 1914) usually in birds and mammals. Around 30 species of heterophyids have been found in humans; *Heterophyes heterophyes* and *Metagonimus yokogawai* are the two most important species.

*Heterophyes heterophyes* (v. Siebold, 1852) Stiles and Hassall, 1900
Synonyms: *Distoma heterophyes* v. Siebold, 1852; *Heterophyes aegyptiaca* Cobbold, 1866; *Heterophyes nocens* Onji and Nishio, 1915.

This fluke was first discovered by Bilharz in 1851 at autopsy of an Egyptian in Cairo, and now known as a common human intestinal trematode infection in the Nile Delta of Egypt and reported up to Sudan. It is also present in Iran, Turkey, Tunisia. In Asia, several foci have been reported in Japan, southern China including Taiwan, the Philippines, and Indonesia. Human infections were reported in Korea but these were not acquired indigenously. Infection occurs in dogs in India (Beaver et al., 1984; Harinasuta et al., 1987).

In Egypt, infection due to *Heterophyes* is prevalent among the inhabitants of the northern part of Nile Delta, particularly around the Lakes Manzala, Borollos and Edco where fishermen and the domestic animals frequently consume fish. During 1987-1991, the prevalence of heterophiysis in the 5 Governorates of the Delta ranged between 0.01-1%. It was estimated that the population at risk was 933 000 persons and the number of infected persons reported to the Ministry of Health was about 10 000 in 1992 (Taha El-Khoby, 1993, personal communication). A demographic investigation of 229 cases of heterophiysis in Dakahlia Governorate indicated that the disease is common in both urban and rural localities due to the habit of consuming recently salted or insufficiently baked infected fish (Sheir & Aboul-Enein, 1970).

The mean prevalence of heterophyid infections in the villages of Khuzestan, Islamic Republic was found to be 8% (range 2-24%). In postmortem examination of carnivores in the same areas, 14.2% of jackals, 33.3% of foxes, 2.5% of dogs were infected with heterophyid flukes including *H. heterophyes*, *Metagonimus yokogawai* and *H. katsuradai* in order of frequency (Massoud et al., 1981). Human infections have also been reported from the provinces of Guangdong, Hubei, Beijing and Taiwan, China (Xu & Li, 1979).

The important intermediate fish hosts reported are: *Mugil cephalus*, *Tilapia nilotica*, *Aphanopus fasciatus* and *Acanthogobius* sp. Man becomes infected by eating parasitized fish raw, inadequately cooked, or improperly salted or pickled. The metacercariae are capable of surviving up to 7 days in salted fish. In addition to its presence in man, *H. heterophyes* infects a number of other mammals.

* Metagonimus yokogawai Katsurada, 1913
Synonyms: *Loestrema ovatum* Kobayashi, 1912; *Metagonimus ovatus* Yokogawa, 1913; *Loossia romanica* Ciurea, 1915.
In 1911 Yokogawa isolated the larvae stages from experimentally infected dogs and the adult worm from a Taiwanese man. He forwarded the specimens to Katsurada who later named the parasite after the discoverer.

This is probably the most common intestinal fluke infecting man in the Far East. It is endemic in China, Japan, Korea and Indonesia. Human infection has also been reported from northern provinces of Siberia, Israel, the Balkan states, and Spain. The eggs of this species are confounded with many other species of heterophyid flukes acquired by eating raw freshwater fish, thus the accuracy of the data on the incidence and prevalence of this infection is limited.

In the Republic of Korea, almost all the large and small streams in eastern and southern coastal areas are endemic foci of metagonimiasis. The nationwide egg positive rate of people residing in the river basins was once estimated at 4.8%. In most endemic villages, 10-20% or higher egg-positive rates were reported (Chai & Lee, 1990).

Human infection has been recorded in the provinces of Guangdong, Anhui, Hubei, Zhejiang and Taiwan, China (Xu & Li, 1979).

In the Russian Federation, Metagonimus yokogawai is endemic in the Amur and Ussuri valleys of Khabarovsky territory where the prevalence ranges between 1-2% in the total population; in the northeast of the territory, the prevalence in the ethnic minority groups varies between 20% and 70%. In the north of Sakhalin Island the infection rate was 1.5% in Russians and 10% in ethnic minorities. Sporadic cases were registered in Amur district and Primorye territory. In total, the population at risk is estimated to be 859,000, 14.7% of the total population; and the number of infected persons, 12,530, 0.2% of the population in the above-mentioned territories/districts (Iarotsky & Pirogovskaya, 1993).

Human infection is attributed primarily to eating raw or undercooked freshwater fish: sweet oriental trout (Plecoglossus altivelis), dace (Triobolodon taczanowskii), perch (Lateolabrax japonicus), Salmo perryi, Odontobutis obesus, etc. The dog, cat, pig and other fish-eating mammals, and even pelicans are reservoir hosts of the infection.

Potentially, all species of the family Heterophyidae may become human intestinal parasites. The following species have been discovered from man, either in natural infections or occasionally by experimental infections.

* **Heterophyes nocens** Onji and Nishio, 1916

The validity of this species has been questioned. Korean parasitologists have agreed to use the name of *H. heterophyes nocens* as a subspecies and believe that it is a distinct parasite. The prevalence on one Korean island was 43%. It has also been reported in Japan (Seo et al., 1980b; Chai & Lee, 1990).

The second intermediate hosts are brackish water fish such as Mugil cephalus, Liza sp, Acanthogobius sp and Chaenogobius sp. The dog and cat are the mammalian reservoirs.

* **Heterophyes dispar** Looss, 1902

It was first isolated from dogs and cats in Egypt, then from various carnivorous mammals including foxes and wolves in north Africa and the Eastern Mediterranean. Human infections were reported in Korea and Thailand. The major sources of infection are Mugil, Epinephelus, Tilapia, Lichia and Barbus (Chai & Lee, 1990; Kaewkes et al., 1992).
* Heterophyes katsuradai Ozaki et Asada, 1926
  Human infection was reported from Japan (Cross, 1974).
  Source of infection: Mugil cephalus.
  Reservoir: dog.

* Centrocestus armatus Tanabe, 1922
  Human infection: Korea and a volunteer in Japan.
  Source of infection: cyprinoid fish such as Pseudorasbora parva.
  Reservoirs: dog, cat, rabbit and the rat; the mouse has been infected experimentally (Chai & Lee, 1990).

* Centrocestus formosanus Nishigori, 1924
  Human infection: China including Taiwan and the Philippines.
  Source of infection: freshwater fish (Macropodus opercularis, Puntius semifasciolatus, Carassius auratus, Misgurnus anguillicaudatus), frogs (Rana limnocharis, Bufo melanostictus).
  Reservoirs: rat, cat, dog, chicken, duck (Harinasuta et al., 1987; Yamaguti, 1958).

* Centrocestus cuspidatus Looss, 1896¹
  Human infection: Egypt, Taiwan.
  Source of infection: freshwater fish.
  Reservoirs: Miltus parasiticus, chicken, rat.

* Centrocestus caninus Leiper, 1912²
  Human infection: Taiwan.
  Source of infection: fish (Channa formosana, Cyprinus carpio, C. auratus, Gnathopogon elongatus) and frog (Rana limnocharis, Bufo melanostictus).
  Reservoirs: dog, cat, rat.

* Centrocestus kurokawai Kurokawa, 1935¹
  Human infection: Japan.
  Source of infection: freshwater fish.
  Reservoirs: unknown

* Centrocestus longus Onji et Nishio, 1916¹
  Probably a synonym of C. caninus.
  Human infection: Taiwan.
  Source of infection: freshwater fish.
  Reservoirs: unknown

¹Cited from Beaver et al., 1984 and/or Harinasuta et al., 1987
* **Haplorchis pumilio** Looss, 1896

  Synonym: *Monorchotrema taihoku* Nishigori, 1924; *Haplorchis taihoku* Nishigori, 1924.
  Human infection: Taiwan and Guangdong of China, Philippines and Egypt. In a hospital in Thailand, among 411 patients who were treated for opisthorchiasis with praziquantel, *H. pumilio* adults were found in the faeces of 12 cases (Radomyos et al., 1983; Xu & Li, 1979).
  Reservoirs: dog, cat, night heron.

* **Haplorchis yokogawai** Katsuta, 1932

  Human infection: the Philippines, Indonesia, Thailand, south China including Taiwan.
  Source of infection: mullet, shrimp (*Penaeus* sp.)
  Reservoirs: dog, cat.

* **Haplorchis taichui** Nishigori, 1924

  Human infection: the Philippines, Thailand, Laos, Taiwan, Bangladesh.
  Source of infection: *Cyprinus carpio, Carassius auratus, Gambosia affinis, Ctenopharyngodon idellus*.
  Reservoirs: dog, cat (Kuntz, 1960; Harinatsuta et al., 1987; Giboda et al., 1991).

* **Haplorchis pleurolophocerca** Sonsino, 1896

  Human infection: Egypt.
  Source of infection: *Gambosia affinis*.
  Reservoir: cat.

* **Haplorchis vanissimus** Africa, 1938

  Human infection: Philippines.
  Source of infection: freshwater fish.
  Reservoir: unknown

* **Haplorchis mirorchis** Matsuda, 1932

  Human infection: Japan.
  Source of infection: mullet.
  Reservoirs: dog, cat.

* **Diorchitrema formosanum** Katsuta, 1932

  Human infection: Taiwan.
  Source of infection: *Mugil* sp.
  Reservoirs: cat, rat.
  Yamaguti (1958) considered *Diorchitrema* a synonym of *Stellantchasmus*. 
* **Diochitrema amplicaecele** Katsuta, 1932
  Synonym: **Stellantchasmus amplicaecele**.
  
  Human infection: Taiwan.
  Source of infection: Mugil sp.
  Reservoirs: dog, cat, rat.

* **Diochitrema pseudocirratum** Witenberg, 1929
  
  Human infection: Hawaii, Philippines.
  Source of infection: Mugil sp.
  Reservoirs: dog, cat.

  Synonym: probably **Heterophyopsis expectans** Africa and Garcia, 1935, reported from the Philippines.
  
  Human infection: Japan, Korea and China.
  Source of infection: Mugil cephalus, Mugil affinis, Larus argentatus, Cyprinus carpio.

* **Metagonimus takahashii** Suzuki, 1930
  
  This parasite was described from experimentally infected mice after isolation from dogs in Japan.
  Human infections were reported from Korea, but confirmation is required. Furthermore, two intermediate types between *M. yokogawai* and *M. takahashii*, i.e., *Metagonimus* Miyata type and *Metagonimus* Koga type (Saito, 1984) have been reported, thus the taxonomic position of *M. takahashii* and two intermediate types require further study (Chai & Lee, 1990).
  
  Source of infection: *Cyprinus carpio, Carassius carassius, C. auratus, Gnathopogon* sp.

* **Metagonimus minutus** Katsuta, 1932
  
  Human infection: Taiwan.
  Source of infection: mullet.
  Reservoirs: cat, mouse experimentally.

* **Stellantchasmus falcatus** Onji and Nishio, 1916
  
  Source of infection: Mugil cephalus.
  Reservoirs: cat, dog, birds.

* **Stictodora fuscata** (Onji and Nishio, 1916) Yamaguti, 1958
  
  Human infection: reported in a young Korean who was fond of eating raw mullet or goby, subsequently 13 more cases were found in a seashore village of Korea (Chai & Lee, 1990).
  Source of infection: Metacercariae were found in *Pseudorasbora parva*.
  Reservoirs: unknown; cats were experimentally infected in Japan.
* Procerovum calderoni Africa et Garcia, 1935

Human infection: Philippines, China, Africa (Cross, 1974; Harinasuta et al., 1987).
Source of infection: Ophiocephalus striatus, Glossogobius giurus, Creisson sp, Mugil sp.
Reservoirs: cat, dog.

* Procerovum varium Onji et Nishio, 1916

Human infection: Japan.
Source of infection: Mugil affinis.
Reservoirs: cat, dog.

* Pygidioptis summa Onji and Nishio, 1916

Human infection: Japan, Korea (seashore villages) (Seo et al., 1981; Chai & Lee, 1990).
Source of infection: Mugil cephalus, Liza menada, Acanthogobius flavimanus.
Reservoirs: cat naturally, rat and mouse experimentally.

* Phagicola sp.

The genus Phagicola is the parasite of fish-eating birds or mammals found in Europe, Asia, Africa and the Americas. Human infection was reported recently in Brazil (Chieffi et al., 1992).

In 1988, faecal specimens from 92 adults who lived in Sao Paulo State, Brazil, and usually ate raw fish were examined and 9 were found egg-positive of Phagicola sp. Of stool examinations of sixty-one dogs and 11 cats, only one dog (1.6%) showed Phagicola eggs in the stool.

The source of infection is freshwater fish (Mugil sp.).

* Apponhalus donicus (Skrj. et Lindtrop, 1919) Price, 1931

Human infection: USA.
Source of infection: Percia sp, Lusioperca sp, Ruccia sp, Scardinius sp.
Reservoirs: dog, cat, rat, fox, rabbit (Harinasuta et al., 1987; Yamaguti, 1958).

* Cryptocotyle lingua (Crepl., 1825) Fischeder, 1903

Human infection: Greenland.
Source of infection: Gobius ruthensparri, Labrus bergylta.
Reservoirs: cat, dog, rat (Harinasuta et al., 1987; Yamaguti, 1958).

2.1.3 NANOPHYETIASIS

Infections with Nanophyetus salmincola (Chapin, 1927) of the family Nanophyetidae are acquired by ingestion of the metacercariae in raw salmon (Salmo sp, Oncorhynchus sp, Brachymystax sp, Coregonus sp.) and non-salmonid fishes. The synonyms include: Nanophyes salmincola Chapin, 1926 (of the family Heterophyidae);
Troglotrema salmincola (Chapin, 1926) Witenberg, 1932, Witenberg considered Nanophyetus to be a synonym of Troglotrema Odhner 1914 of the family Troglotrematidae; Wallace (1935) restudied the type species and considered the genus Nanophyetus to be valid. Beaver (1984) believed that N. salmincola was a synonym of Troglotrema salmincola.


Nanophyetiasis is endemic in Amur and Ussuri valleys of Khabarovsk territory, Russia where the average prevalence is 5%. In the local ethnic minorities, the average prevalence is 20% and reaches up to 60% in some localities. In Primorye territory the prevalence was 16% and 5% in north Sakhalin in 1970. The population at risk is estimated to be 4 793 000 persons or 22.8% of the total population in these areas and the estimated number of infected persons, 18 500, 0.4% of the total population (Iarotsky & Pirogovskaya, 1993).

It is assumed that the range of this parasite is now spreading. Twenty human cases were reported in the United States since 1974 (Eastburn et al., 1987).

Human acquires the infection by ingestion of improperly cooked salmon or trout. The fluke itself is probably not clinically important, but has been proven to be the vector of a rickettsial organism, Necrotettisia helminthoece, which does cause a serious and often fatal systemic infection known as "salmon poisoning" disease of dogs, foxes and coyotes. This pathogen has not been associated with human disease. Clinical findings in human nanophyetiasis included increased frequency of bowel movements or diarrhea, abdominal discomfort, eosinophilia, etc.

The major difference between the two subspecies of Nanophyetus is that N. salmincola schikhobalowi apparently is not a vector for the rickettsial organism (Milleman & Knapp, 1970).

2.2 SNAIL, MOLLUSC and CRUSTACEA-BORNE INTESTINAL TREMATODE INFECTIONS

2.2.1 ECHINOSTOMIASIS

These intestinal flukes of the family Echinostomatidae are infrequently transmitted to man through a wide range of snails and certain crustaceans which are rarely eaten raw.

* Echinostoma ilocanum (Garrison, 1908) Odhner, 1911
  Synonyms: Fasciola ilocanum, Euparyphium ilocanum.

Human infection was first described in the Philippines and endemic foci have been reported in Luzon, Mindanao and Leyte, where the prevalence in various stool surveys ranged from 1% to 44% between 1967 and 1972. The prevalence averaged 5% (range 0-11%) among the Ilocano populations of northern Luzon (Cross & Basaca-Sevilla, 1981). Human infections have also been reported in the Celebes and Java, Indonesia, and Yunnan, China. A new endemic area was noted in northeast Thailand where the worms were recovered from 10 of 253 residents who were treated with praziquantel for opisthorchiasis (Radomyos et al., 1982). Enzootic infection in 13.5% of the indigenous dog population was reported in Guangdong (Canton), China (Zhao, 1983).

Discharged by planorbid snails, Gyraulus or Hippeutis sp., the first intermediate host, the cercariae may encyst in any freshwater mollusc such as Pila conica, Viviparus javanicus, Lymnaea rubiginosa brevis, which are the sources of infection. Human infection is acquired by eating raw snails harbouring encysted metacercariae.

* Paryphostomum sufartvyfex (Lane, 1872) Bhalerao, 1931
  Synonyms: Artyechinostomum sufartvyfex Lane, 1915; Euparyphium malayanum Leiper, 1911;
Echinostoma sufratyfex Lane, 1915.

This was first observed in an Assamese girl, then found in pigs in India (Beaver et al., 1984). The hog, dog and rat are the natural definitive hosts. Lie Kian Joe (1963) believes this species to be synonymous with Echinostoma malayanum. The life cycle has not been described. The source of infection is Digenoestoma pulchella (Harinasuta et al., 1987).

* Echinostoma malayanum Leiper, 1911

Human infections were reported from Singapore and Kuala Lumpur in 1911, Chiangmai, Thailand in 1915, then from Sumatra, Indonesia. It is endemic in northeast and northern Thailand, northern Luzon of the Philippines. Dogs, rats, mice and hamsters can be infected experimentally (Lie Kian Joe, 1963; Waikagul, 1991; Tangrongchitr & Monzon, 1991).

The cercariae may encyst either in the same species of mollusc which concurrently acts as its first intermediate host (Indoplanorbis exustus, Gyraulus convexiusculus) or in different species of snails (Pila scutata, Lymnaea (Bullastra) cunningiana). Man is an incidental host who acquires the infection by eating raw snails.

* Echinostoma macrorchis Ando and Ozaki, 1923

Originally reported from Japan, it was described together with E. cinetorchis by Beaver (1984). Cysts were found from snails, Gipangopaludina malacata, C. japonica, Segmentina nitidella, Viviparus malacatus and the frog, Rana sp.

* Echinostoma revolutum (Froelich, 1802) Looss, 1899

Synonym: Echinostoma echinatum Zeder, 1803.

This is normally a parasite in the ceca of the duck, goose and muskrat, and was first recovered from a Taiwanese woman in 1929. The prevalence of infection in Taiwan has been estimated to be between 2.8% to 6.5%. It is endemic in northeast Thailand but the prevalence is unknown. Human cases were recorded in Yunnan and Guangdong, China and in Indonesia (Beaver et al., 1984; Shen, 1979).

After infection in the first intermediate snail host (Lymnaea sp, Physa sp, Paludina sp, Segmentina sp and Heliosaoma sp), a second host including mollusc (Physa occidentalis, Lymnaea sp) or tadpole in Thailand, or clam (Corbicula producta in Taiwan) is required for the encystment of the metacercariae, which is the source of infection.

* Hypoderaeum conoides (Block, 1872) Dietz, 1909

It is usually a parasite of birds including duck, goose, and fowl, and a common human parasite in northeast Thailand, where 55% of 254 persons examined were found to be infected (Harinasuta et al., 1987). Planorbius corneus, Lymnaea stagnalis, L. limosa and L. ovata serve as both the first and second intermediate hosts (Yamaguti, 1958).

* Artylechinostomum methrai

A probable synonym of Paryphostomum sufratyfex.

This was recorded as human parasite on two occasions in India, one of which died from malnutrition and anemia caused by the infection, several hundred worms were found upon autopsy. Rats and pigs are the animal reservoirs. Man may acquire infection by eating raw snails (Indoplanorbis exustus).
* Echinostoma lindoense Sandground and Bonne, 1940

It closely resembles E. revolutum morphologically. In the period of 1937 through 1956, the ethnic groups in the central Celebes, Indonesia, were heavily infected with this worm. The prevalence in some villages ranged from 24 to 96%. Since 1970s, due to changes in eating habits, human infection has vanished, although it is still prevalent in animals. Another factor for the disappearance of human infection is the decline or almost extinction of Corbicula, a mussel which is the main source of infection, as a result of failure in competition with the Mujair fish (Tilapia mossambica) for phytoplankton (Carney et al., 1980).

Eating raw or insufficiently cooked mussels, Corbicula lindoensis, C. sucplanta and Ixiopoma javanica, is a common practice of the native peoples, which is the essential mode of infection (Beaver et al., 1984).

* Himasthla muchloni Vogel, 1933

The adult worms were obtained from a German who had lived in Colombia for 6 years but believed he acquired the infection from eating raw clams in New York City.

Bivalve molluscs (Mytilus, Mya sp) are the hosts for metacercariae. Natural final hosts are gulls and other birds.

2.2.2 INFECTIONS DUE TO FAMILY MICROPHALLIDAE

The Microphallidae includes a group of minute intestinal parasites of a wide range of vertebrates. Morphologically, worms in this family resemble the Heterophyidae; its life cycle resembles the Plagiorchiidae.

* Spolotrema brevicaeca (Africa and Garcia, 1935; Tubangui and Africa, 1939)
  Synonym: Heterophyes brevicaeca Africa and Garcia, 1935. The position of this species changed many times within the family Microphallidae. In 1975, Velasquez placed it under the genus Carneophallus.

It has been reported on several occasions in humans in the Philippines. Its eggs were found in lesions of the heart, brain, and spinal cord of persons died of acute cardiac dilatation. The complete life cycle is unknown. Encysted metacercarial stages of Spolotrema sp. have been found in the crab Cararius maenas and shrimp Macrobrachium sp. which are the source of infection for Filipinos (Beaver et al., 1984; Wakiagul, 1991).

2.2.3 INFECTIONS DUE TO FAMILY GYMNOPHALLIDAE

* Gymnothallidoides seoi n. sp.

By finding the first case of human infection with a new species G. seoi, further survey in the seashore villages, southwestern Korea, showed that the faecal egg positive rate among the inhabitants was 49.0%, and worm burden per individual ranged between 1-26,373 with an average of 3,119.

Oysters, Crassostrea gigas, collected from the area were found to carry an average of 610 metacercariae each (Lee et al., 1992).

2.3 PLANT-BORNE INTESTINAL TREMATODE INFECTIONS

2.3.1 FASCIOLOPSIASIS
* **Fasciolopsis buski** (Lankester, 1857) Odhner, 1902

Fasciolopsiasis is caused by the giant intestinal fluke **Fasciolopsis buski** (Lankester, 1857) Odhner, 1902 of the family Fasciolidae. The synonyms of *F. buski* are *Distomum crassum* Busk, 1859; *D. rathouisi* Portal, 1887; *F. rathouisi* Portal, 1887; Ward, 1903; *F. fulleborni* Rodenwaldt, 1909; *F. goddardi* Ward, 1910. The life cycle includes Segmentina sp. and Hippoidea sp. snails as the first intermediate hosts and aquatic plants as the second intermediate host and the food sources of infection.

*F. buski* is a common intestinal parasite of people and pigs in central and south China (including Taiwan), Thailand, Vietnam, Laos, Cambodia, Bangladesh, India and Indonesia. The distribution of infections within these countries is focal.

Fasciolopsiasis seems to be restricted to areas where people raise pigs and eat the water plants grown in proximity, and to the populations that commonly eat freshwater plants. The drainage of pig excreta in many farms creates or flows into the ponds where the water plants are grown.

Infection in man is associated with edible aquatic plants such as the water chestnut (*Elcocharis tuberosa*), water caltrop (*Trapa natans*), roots of lotus, water bamboo and other aquatic vegetation that are cultivated in endemic foci. People become infected from consuming raw water plants on which the metacercariae encysted, or from peeling off the hull or skin of the plants by mouth before eating the raw nut.

A wide range of prevalence of *Fasciolopsis buski* infection has been observed:

<table>
<thead>
<tr>
<th>STUDY GROUP</th>
<th>PREVALENCE</th>
<th>LOCATION</th>
<th>REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Villagers</td>
<td>29%</td>
<td>Bombay, India</td>
<td>Shah (1966)</td>
</tr>
<tr>
<td>Villagers</td>
<td>70.1%</td>
<td>Maharashtra, India</td>
<td>Manjarumkar (1972)</td>
</tr>
<tr>
<td>Villagers</td>
<td>22.4%</td>
<td>Uttar Pradesh, India</td>
<td>Chandra (1984)</td>
</tr>
<tr>
<td>Villagers</td>
<td>8.6-39.2%</td>
<td>Dacca, Bangladesh</td>
<td>Muttalib (1975)</td>
</tr>
<tr>
<td>Villagers</td>
<td>4.7%</td>
<td>Rural area, Bangladesh</td>
<td>Muttalib (1976)</td>
</tr>
<tr>
<td>Villagers</td>
<td>69.6%</td>
<td>Jiangxi, China</td>
<td>Chen (1986) (cited from Yuan, 1992)</td>
</tr>
<tr>
<td>Villagers</td>
<td>8.5%</td>
<td>Zhejiang, China</td>
<td>He (1985)</td>
</tr>
<tr>
<td>Pupils</td>
<td>17-33.7%</td>
<td>Fujian, China</td>
<td>Weng (1989)</td>
</tr>
<tr>
<td>Villagers</td>
<td>17%</td>
<td>Supanburi, Thailand</td>
<td>Paut (1969)</td>
</tr>
<tr>
<td>Pupils</td>
<td>10.4%</td>
<td>Ayudhaya, Thailand</td>
<td>Bunnag (1983)</td>
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<tr>
<td>Villagers</td>
<td>27%</td>
<td>Kalimantan, Indonesia</td>
<td>Handoyo (1986)</td>
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<tr>
<td></td>
<td>(56.8% in 5-14 year old age group)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pupils</td>
<td>23.3%</td>
<td>Kalimantan, Indonesia</td>
<td>Handoyo (1986)</td>
</tr>
<tr>
<td>Villagers</td>
<td>3.8%</td>
<td>Vientiane, Laos</td>
<td>Giboda (1991)</td>
</tr>
</tbody>
</table>

### 2.3.2 INFECTIONS DUE TO FAMILY PARAMPHISTOMATIDAE

* **Watsonius watsoni** (Conyngham, 1904) Stiles and Goldberger, 1910

Human infection was reported only once at the autopsy of an emaciated West African Negro who died of a severe diarrhea. Many worms were recovered from the intestine, some attached to the duodenal and jejunal wall, others free in the lumen of the colon. Various species of primates in eastern Asia and Africa are natural hosts of this parasite.

Its life cycle is unknown, but infection is probably acquired by ingesting vegetation on which the metacercariae have encysted.
* Fischoederius elongatus (Poirier, 1883) Stiles et Goldberger, 1910

It is a parasite of ruminants infected by ingesting aquatic plants with the encysted metacercariae. The first human infection was reported from Guangdong, China (Huang et al., 1992). A 35 year old woman complained of epigastric pain for months and vomited a worm one morning while brushing her teeth, after which the symptoms disappeared. The worm was identified as Fischoederius elongatus. It is unknown how the patient became infected.

2.4 AMPHIBIAN-BORNE INTESTINAL TREMATODE INFECTIONS

2.4.1 ECHINOSTOMIASIS

* Echinoparyphium recurvatum von Linstow, 1873
  Synonym: Echinoparyphium kokizumi Tsukimochi, 1924

It is a cosmopolitan intestinal parasite of birds and mammals, and wild rats in Egypt. Human infections were recorded in Taiwan, Indonesia (at autopsy) and Egypt.

The metacercariae encyst in tadpole and frog (Rana temporaria), also in Planorbus planorbis, Lymnaea sp.

* Euparyphium melis Leon and Ciurea, 1922
  According to Beaver (1984), E. jassovense is its synonym.

It was first found from diarrheic stools of a Rumanian patient, and then at autopsy of a Chinese patient. Beaver found this parasite in northern Michigan in 1939 and observed that tadpoles were the host for the metacercarial stage. Yamaguti (1958) considered the American form to be a separate species and so named it Euparyphium beaveti.

In Liaoning province of China, Huang (1963) reported an infection due to Euparyphium melis, a synonym of Ichthyophora melis in author's opinion, presumably acquired by eating raw loach. Human infection was also reported from Taiwan (Cross, 1974).

2.4.2 INFECTIONS DUE TO FAMILY DIPLOSTOMIDAE

The adult worms of the Diplostomidae are usually found in the intestine of birds and mammals. There are two species in this family which have been reported to infect humans: Alaria americana and Fibricola seoulensis.

* Alaria americana Hall et Wigdor, 1918

In North America, the adult stage of various species of Alaria resides in the intestine of wild carnivores such as wolves, foxes, raccoons, etc. The eggs hatch in water, and miracidia invade freshwater snails of the genus Helisoma from which the cercariae eventually emerge and infect frog tadpoles.

A massive fatal human infection with mesocercariae (mesocercariae are non-encysted free parasite forms in the tissue) of A. americana reported from Ontario, Canada, is assumed to have resulted from eating inadequately cooked frogs' legs. Nine days from the onset of symptoms death resulted from severe respiratory failure due to extensive pulmonary hemorrhage. Several thousand mesocercariae were estimated to be present in the peritoneal cavity, bronchial aspirate, brain, heart, kidney, liver, lung, lymph node, pancreas, retroperitoneal adipose tissue, spinal cord, spleen, and stomach. It is presumed that metacercariae penetrated
the stomach wall and spread to the various organs both directly and via the circulatory system (Freeman et al., 1976).

Another patient had an eye infection which was probably due to direct penetration by the infective mesocercariae while frogs were being prepared for the table. A third human case of mesocercaria infection was reported from Louisiana. A man who had eaten baked raccoon showed small intradermal swellings on the upper left thigh and at the iliac crest. The worm was identified as *Alaria marciana* (cited from Beaver et al., 1984).

Recently, two more cases of intraocular infection with *Alaria* sp. mesocercariae were reported from California. These 2 unrelated Chinese males presented for ophthalmologic examination because of unilateral decreased vision. An encapsulated worm was removed by vitrectomy surgery from one of the cases and identified as an *Alaria* sp. mesocercaria. Both patients periodically ate various undercooked or raw oriental dishes, including frogs legs, which were considered to be the likely source of infection (McDonald et al., 1993).

* Fibricola seoulensis* Seo, Rim and Lee, 1964

First described in Korea, this is the only diplostomatid fluke known to infect and to achieve the adult stage in man (Seo et al., 1982). It is widely prevalent among house rats in inland Korea. The frog (*Rana nigromaculata*) and its tadpole are known as the second intermediate hosts and several kinds of terrestrial snakes (*Rhabdophis tigrina* etc.) are regarded as the paratenic host.

Two hundred and forty-four Korean males who had ingested the snakes or frogs were examined and 15 of them showed eggs of *F. seoulensis* in their feces (Hong et al., 1984). No clinical manifestations related to *Fibricola* infection were observed in these cases, although the first case reported in 1982 complained epigastric discomfort or pain, diarrhea, fever and eosinophilia.

### 2.4.3 INFECTIONS DUE TO FAMILY STRIGEIDAE

* Corylus japonicus* Ishii, 1932

Species of the family Strigeidae are normally intestinal parasites of aquatic birds. The first human infection was reported from Hunan province in China (Chen & Cai, 1985). Eggs resembling those of this family were initially observed in the necrotic tissue of liver cysts and pericardium of a 13-year-old girl who was diagnosed as having hepatic cysts and chronic constrictive pericarditis of unknown etiology and consented to exploratory surgery. An adult worm was eventually found in the feces of the patient. After comparison of the eggs and adult worm with those collected from the local infected ducks, its identification was confirmed as *C. japonicus*. The mode of infection of the girl is unknown.

### 2.5 INSECT-BORNE INTESTINAL TREMATODE INFECTIONS

#### 2.5.1 INFECTIONS DUE TO FAMILY PLAGIORCHIIDAE

Species of *Plagiorchis* occur in a wide range of vertebrate hosts, mostly in the intestine. Four species infect humans: *Plagiorchis philippinensis*, *P. javensis*, *P. muris* and *P. harinasutai*.

* Plagiorchis philippinensis* Sandground, 1940

The adult worm was recovered during autopsy in Manila on a local resident from Ilocano region of the Philippines. Infection was acquired by eating larvae of certain insects which are believed to be the second intermediate host of this fluke. The reservoirs are birds and rats.
* Plagiorchis javensis Sandground, 1940

This was found on a single occasion at postmortem of a native Indonesian who was also heavily infected with *E. helocanum*. Later, two other cases were reported from Indonesia. Larval insects are the source of infection, and reservoirs are birds and bats.

* Plagiorchis muris Tanabe, 1922

This parasite was reported in a Japanese patient who was under treatment for heavy *M. yokogawai* infection. The freshwater snail, *Lymnaea* sp. is both the first and second intermediate host; certain insects (*Chironomus dorsalis* and *Anisogammarus annandalei*) also serve as second intermediate hosts, and birds, dog, and rat as reservoirs.

* Plagiorchis harinasutai n. sp.

During a clinical trial of praziquantel for opisthorchiasis in Thailand, six *Plagiorchis* worms were discovered from four patients. Based on the morphological features, this fluke was designated as a new species. Its life cycle is unknown (Radomyos et al., 1989).

2.5.2 INFECTIONS DUE TO FAMILY LECITHODENDRIIDAE

* Phaneropsolus bonnei* Lie Kian Joe, 1951

* Prosthodendrium molenkampi* Lie Kian Joe, 1951

*P. bonnei* was first discovered in Indonesia at autopsy. Among 24 cases, 15 were found harbouring parasites in their small intestines. It was also recovered from the stools of persons living in northeast Thailand, large number (up to 4356) of flukes was detected from a patient after treatment with praziquantel (Radomyos et al., 1984).

*P. molenkampi* was also found in an Indonesian at autopsy. In 14 of 24 autopsies in northeast Thailand, eggs in feces and adult parasites were recovered from the intestines and also in human stool specimens from Laos.

Their life cycles are not completely known. *Bithynia goniocephalus* was thought to be the snail intermediate host, but has not been confirmed. The odonate insects, dragonflies and damselflies, are the second intermediate hosts. Monkeys, bats and rats are the natural reservoirs.

Both flukes are prevalent in rural populations of northeast Thailand and adjacent Laos, who become infected by consumption of raw small fish contaminated with infected naiads (water nymph of dragonflies). In certain areas the prevalence of infection varies from 10% to 40%. It was suggested that the flukes are present in a sylvatic cycle throughout southeast Asia, and humans are only infected when they eat naiads with encysted metacercariae (Manning & Leritrasert, 1973).

There are no definite pathological findings of the intestine caused by these flukes although heavy worm loads have sometimes been recovered following treatment. It is difficult to separate the clinical symptoms caused by the lecithodendriids from those caused by other helminth infections, particularly in areas where polyparasitism is common in rural population. Eggs of both species are very similar, and are difficult to differentiate from the eggs of *Opisthorchis* sp. and heterophyids.

* Phaneropsolus spinicirrus* n. sp.
This is a new species of the genus *Phaneropsolus* Looss, 1899 reported as a human parasite from northeast Thailand.

An epidemiological investigation on the minute intestinal flukes was carried out in a village of Kalasin Province, Thailand. Two hundred and forty-four villagers were treated with praziquantel and then purged using magnesium sulphate. The egg output and the worm burden were determined from the purged faeces. Five species of lepidodendrid (including *P. spinicirrus* n. sp.), five species of heterophyid and one species of plagiocladid trematodes were identified from a total of 108,661 minute flukes. The prevalences of infection determined by faecal egg detection and worm recovery were 43.7% and 52.3%, respectively (Kaewkes et al., 1991; Kaewkes et al., 1992).

* Paralepidodendrium obtusum
* Paralepidodendrium glandulosum

These two new species causing human infection were recorded during the same investigation as *P. spinicirrus* in Thailand. Their characterization is incomplete.

2.6 WIDE RANGE FOOD-BORNE TREMATODE INFECTIONS

This last group of intestinal trematode infections are acquired from a wide range of food sources, including both plants and animal sources.

2.6.1 GASTRODISCOIDIASIS

* Gastrodiscoides hominis* (Lewis and McConnell, 1876; Leiper, 1913)

This parasite is a representative of the family Gastrodiscidae that is pathogenic to man. Synonyms: *Amphistoma hominis*; *Gastrodiscus hominis* (Lewis and McConnell, 1876) Fiscoederer, 1902.

The trematode may be acquired by ingestion of metacercariae encysted on aquatic plants, frogs, tadpoles and crayfish, as the known species in the same family. It was first found and described from the cecum of an Indian patient. It was a relatively common human parasite in Assam where a prevalence of 41.2% was once reported. Human infections have also been reported from Bengal, Bihar and Orissa in India, from Vietnam, the Philippines, Burma, Thailand, China, Kazakhstan, and Indian immigrants in Guyana (Ahlulwalia, 1960; Harinasuta et al., 1987).

The pig is the common reservoir host, while napu mouse deer (*Tragulus napu*) in Malaysia, field rat (*Rattus brevicaudatus*) in Java and Japan, and the rhesus monkey in India have also been found infected.

The complete life cycle is unknown, but in India the planorbid snail, *Helicorbis coenosus*, has been found experimentally to serve as an intermediate host (Beaver et al., 1984).

3. PATHOLOGY AND SYMPTOMATOLOGY

In the usual infection due to intestinal flukes, the person may have abdominal symptoms and signs derived from the mechanical and toxic effects of the parasites, but most persons are asymptomatic. Occasionally, the infections have been reported to be fatal, either due to extremely heavy infection, particularly in children, or due to ectopic localization of the parasites in various developmental stages in the important organs, such as brain and heart.
3.1 ECHINOSTOMIASIS

The pathology of echinostomiasis has not been well studied. The flukes attach themselves to the mucosa of the small intestine where inflammatory lesions may develop at the sites of attachment, together with a generalized toxic process. Heavy infections may produce focal necrosis and increased cellular infiltration in the intestinal mucosa.

Experimentally, Korean parasitologists have shown that the worms (E. hortense) dwell in the lumen of the upper small intestine of the rat and pathological changes are chiefly confined to the mucosa. However, the changes may be very severe accompanying marked destruction of villi and loss of mucosal integrity (Chai & Lee, 1990).

There is no well-documented study on the clinical aspects of the infection, and apparently morbidity is limited. In heavy infections there are vague abdominal manifestations such as flatulence, intestinal colic, and loose bowel movements. In children, diarrhea, abdominal pain, anaemia, and oedema have been reported. A Chinese parasitologist swallowed voluntarily 113 metacercariae of E. japonicus, and developed abdominal discomfort and pain, intestinal gurgling and diarrhea in about ten days after infection (Lin et al., 1985).

3.2 HETEROPHILIASIS AND METAGONOMIASIS

Mild inflammatory reaction occurs at the sites of attachment of the minute Heterophyes heterophyes adult worms to the intestinal mucosa or where they have burrowed into the mucosa. Shallow ulcers and mild irritation or superficial necrosis of the mucosa can occur.

Following ingestion and the prepatent period, which averages 9 days, mild, intermittent and mucous diarrhea, dyspepsia, and colicky pain are sometimes noted. Eosinophilia may be present. In the Philippines, Africa and his associates (cited from Beaver et al., 1984) reported that the eggs of this parasite may infiltrate through the intestinal wall, enter the mesenteric lymphatics, and eventually penetrate the cardiac valves and myocardium. Myocarditis leading to cardiac failure, or cerebral lesions may result. They estimated that up to 15% of fatal heart disease in the Philippines may result from heterophyd myocarditis. Neurological manifestations have also been observed and surgical intervention demonstrated adult H. heterophyes or eggs of heterophyd encapsulated in the brain (Zhang & Fan, 1990).

Metagonimus yokogawai infection in man shows similar pathological features as heterophiliasis. Experimentally and clinically these worms parasitize the middle section of the small intestine, within the crypts of Lieberkühn at early stage of infection or between the villi at later stages. The pathological changes were characterized by villous atrophy and crypt hyperplasia, with variable degree of inflammatory cell infiltration. The invasion of worms was confined to the outer mucosa and were never found in the submucosa of immunocompetent hosts.

The most frequent symptoms of the patients infected with M. yokogawai were abdominal pain, diarrhea and lethargy. The extent of the symptoms depends on the number of worms present, the depth of their penetration into the wall, and the individual susceptibility or resistance of the patient. However, even the most heavily infected individual may not always manifest severe clinical symptoms. There was a report in the Korean literature that a man who harboured as many as 63,587 worms at one time, complained only of minor symptoms such as mild indigestion and epigastric pain (Chai & Lee, 1990). Incidentally, the eggs infiltrate into the intestinal capillaries and lymphatics and are carried to the myocardium, brain, spinal cord, and other tissues where granulomatous changes or embolisms may be provoked by their presence.

The intestinal lesions produced by other small heterophyids are similar to those described for H. heterophyes and M. yokogawai (Tantachamrun & Kiks, 1978). Africa et al. (cited from Beaver, 1984) found eggs of Hablorchis yokogawai, H. pulilho, H. taichui, and Diochloroema pseudocirratum in cardiac lesions of persons who died of cardiac failure and, in one case, an adult heterophyd was found in the epicardium of the
heart. Likewise, eggs tentatively diagnosed as those of Haplorchis pumilio were found in sections of the spinal cord at the levels where the causative lesions were responsible for the loss of motor and sensory function.

3.3 FASCIOLOPSIASIS

The larvae excyst in the duodenum and attach to the duodenal and jejunal mucosa and reach maturity in about 3 months. The pathology is due to traumatic, obstructive and toxic effects of the parasite. Inflammation occurs at the sites of attachment of the adult worms, usually followed by ulceration of the mucosa with occasional submucosal and external hemorrhage. Submucosal microabscesses may also develop. In massive infection, large numbers of worms provoke increased mucus secretion and may cause intestinal obstruction. Systemic absorption of the metabolic products of the adult worm are suspected to cause the profound intoxication and the sensitization observed in severe infections.

Most of the infections are light and asymptomatic. In heavier infections the first symptoms are diarrhea with epigastric pains, simulating a peptic ulcer. The generalized toxic and allergic symptoms appear in the form of oedema, particularly of the face, abdominal wall, and lower limbs. Ascites and extreme prostration may develop. The appetite is usually not affected, but anorexia, nausea and vomiting are pronounced in some patients. The peripheral blood count shows slight macrocytic anaemia and moderate leucocytosis with eosinophilia.

Mortality has been reported in children with heavy infections due to profound intoxication in India, China, and Thailand (Sadun & Maiphoon, 1953; Beaver et al., 1984). However, a case-control study in a community in Supanburi, Thailand showed no significant differences between infected and control subjects in clinical examination, evaluation of growth and development, haematological studies and screening tests for the intestinal malabsorption syndrome. It was concluded that in the area studied, the usual level of F. buski infection is not associated with overt clinical disease or malabsorption (Plaut et al., 1969).

3.4 GASTRODISCOIDIASIS

Infection in man is associated with inflammation of the mucosa of the caecum and the ascending colon with attendant symptoms of diarrhoea. The specimens can be collected from the caecum, especially near the ileocaecal valve and at the site of its attachment a deep imprint of the fluke is seen. The mucosa shows desquamation, eosinophilic infiltration with lymphocytes and plasma cells. The submucosa, in addition to being more heavily infiltrated with eosinophils, lymphocytes and plasma cells, is oedematous and thickened. These changes lead to a subacute inflammation of the caecum and mucoid diarrhea. The above-mentioned pathological changes have been described in the experimentally infected pig which is believed to be a natural host (Ahluwalia, 1960; Harinasuta et al., 1987).

4. CONCLUSIONS

The intestinal trematode infections in humans have long been neglected even for those which were proved to be relatively widespread and highly prevalent such as fasciolopsiasis, heterophyiasis and echinostomiasis in Asia and some other regions. Most recently, the adult stage of several intestinal trematodes were first observed following praziquantel treatment in China, Korea and Thailand and new species were thus confirmed.

About 70 species of intestinal flukes have been reported to infect people, including 31 species in the family Heterophyidae, 21 in Echinostomatidae, 5 in Lecithodendridae, 4 in Plagiorchiidae, 2 in Diplostomidae, Nanophyetidae, Paramphistomatidae and 1 in Fasciolidae, Gastrodiscidae, Gymnophallidae, Microphallidae and Strigeidae respectively. Synonymy remains a problem in a few species. Our current knowledge of the distribution, epidemiological characteristics and pathology of most intestinal flukes are mainly based on
individual case reports. Consequently, our current understanding of their epidemiology and public health importance is limited.

The clinical and pathological manifestations of echinostomiasis, heterophyiasis, fasciolopsiasis and gastrodiscoidiasis were reviewed. Although it is generally accepted that the infections are asymptomatic, this conclusion is based on individual case reports or observations on small numbers of infected persons in endemic communities. Death due to these infections is rare but does occur because of either heavy infection, especially in children, or ectopic parasitism in the organs such as brain and heart.

Control of intestinal trematodes is not addressed in this review. Improved food preparation and processing will eliminate the infection in the intermediate hosts and tools for parasitological diagnosis and treatment are available. The real challenges of control focus on health education and food safety since people contract the infection by eating raw or improperly prepared fish, snails, crustaceans, aquatic plants, amphibians and insects with encysted metacercariae.

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REFERENCES

1. The frequent references to publications by Beaver et al. (1984) and/or Harinasuta et al. (1987) are footnoted.


