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Trematodes Transmitted to Man by Fish, Frogs, and Crustacea

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ABSTRACT

There are approximately 43 species of trematodes which man acquires from eating improperly cooked fish, frogs, or crustaceans. A variety of wild and domestic mammals and birds also serve as the definitive host for the flukes. The organisms acquired from the ingestion of fish, parasitize the bile ducts and liver, all parts of the intestine as well as taking up residence in ectopic sites. The flukes acquired from ingesting crustacea parasitize the lungs and ectopic sites while those acquired from eating tadpoles or frogs inhabit the intestines of the host.

There are approximately 43 species of trematodes which man acquires inadvertently by ingesting raw or improperly cooked fish, frogs, or crustacea. General sources of information for this brief review were the publications by Alicata,[2] Ching,[3] Faust and Russell,[4] Healy and Gleason,[5] Hoffman[6] and Watson.[15] The recent article by Witenberg[17] contains much information about the trematodes and the excellent review by Sprent[13] is the most up to date treatise on the subject of helminth zoonoses. Some of the flukes are almost exclusively parasites of man; others inhabit lower mammals or birds and are found in humans only on rare occasions. For convenience, they are discussed in five natural groupings.

Clonorchis and Allies

Those flukes which are acquired by man from eating fish and which inhabit the bile duct and liver are shown in Table 1. *Clonorchis sinensis,* a common parasite of man over a wide geographic area, is also found in a number of animal hosts. Stoll,[14] in his classic paper "This Wormy World," published in 1947, estimated that the world prevalence of *C. sinensis* in humans was about 19 million. Approximately 40 species of fresh water fish have been incriminated as the second intermediate hosts by which man and animals bcome infected with *Clonorchis.* The subject has recently been reviewed by Komiya.[9]

Opisthorchis felineus, a parasite of the cat, dog, and fox, has an extensive distribution in parts of central Siberia in the Soviet Union as well as in other areas of Asia and Europe. Stoll[14] in 1947 estimated that 1.7 million people were infected with *O. felineus.* In some regions of central Siberia, large numbers of humans have been reported to be infected. In other regions of Russia, over 85% of the cats have been found to harbor adult opisthorchids, and a great many of the fish have been found infected with metcercarial stages of this organism.

TABLE 1. *Trematodes acquired by man from fish: inhabitants of bile ducts and liver.*

Organism	Animal Host	Geographic Distribution
Clonorchis sinensis	dog, cat, pig, mink, weasel, rat, badger	S.E. Asia, China, Japan, Indochina, Formosa
Opisthorchis felineus	cat, dog, fox	Europe, Asia
Opisthorchis viverrini	civet cat	China, Laos, Vietnam, Thailand
Opisthorchis novocerca	pig, dog, wolverine	India
Metorchis conjunctus	cat, dog, fox, mink, raccoon	North America
Pseudamphistomum trauncatum	cat, dog, fox, seal, wolverine	USSR (Siberia)

Opisthorchis viverrini occurs in China and in the Indo-Chinese Peninsula in Laos, Vietnam, and Thailand. Wyckoff et al.[18] estimated that 3.5 million persons were infected in Thailand along with several additional millions in the rest of Indo-China. Nine species of fresh water fish have been implicated as harboring metacercariae of *O. viverrini*. According to Wyckoff et al.,[18] both the adult and egg stages of *O. felineus* and *O. viverrini* look very much alike, and these two worms may be the same species, although somewhat separated geographically.

Opisthorchis novocerca is a human parasite of rare occurrence, having been reported from man in India on only a few occasions.

Metorchis conjunctus is a common parasite of North American felines, canines, and mustelids, but it has only been reported once as a parasite of man.

Pseudamphistomum truncatum was reported once from man in Siberia.

The six species of biliary flukes listed in Table 1 are sometimes difficult to differentiate from each other by egg morphology. In many cases definite diagnosis and the recognition of a particular species depends upon the recovery of adult specimens passed after therapy or found at postmortem examination.

Heterophyids

A large number of trematodes acquired by man from fish inhabit the intestines and occupy other "ectopic" sites. Most of those reported from man are shown in Table 2. These organisms have a wide geographic distribution; most are found in the Far East and Middle East, with large numbers being reported in Japan, the Philippines, and Formosa. The fluke family of Heterophyiidae, to which most of these genera belong, is composed of relatively small trematodes, many of which are only a few millimeters in length.

In infected individuals, the worms may cause enteritis and colicky pain. They often occur in large numbers, literally by the hundreds. They are also unusual in that they can cause a great deal of pathology when occuping ectopic sites. Interesting work by Africa[1] and his associates in the 1930's indicated that heterophyiasis was of considerable importance in the etiology of human cardiac pathology in the Philippines.

The parasites are easily acquired by ingesting raw or pickled fish which are a staple in the diet over large areas of the Middle ast and the Mediterranean. All the

TABLE 2. *Trematodes acquired by man from fish: inhabitants of small, large intestine and ectopic sites.*

Organism	Animal Host	Geographic Distribution
Heterophyes heterophyes	dog, cat, fox, rat, wildcat, pelican, hawk kite	Mediterranean & Far East
Heterophyes dispar	dog, cat, fox, rat, wildcat, pelican, hawk, kite	Egypt
Heterophyes equalis	fish eating mammals and birds	Egypt
Heterophyes katsuradai	fish eating mammals and birds	Japan
Heterophyes brevicaeca	fish eating mammals and birds	Philippines
Haplorchis calderoni	fish eating mammals and birds	Philippines
Haplorchis pumilio	fish eating mammals and birds	Philippines, Formosa
Haplorchis taichui	fish eating mammals and birds	Philippines, Formosa
Haplorchis yokogawai	fish eating mammals and birds	Far East
Haplorchis vanissimus	fish eating mammals and birds	Philippines
Stamnosoma formosanus	fish eating mammals and birds	Formosa, Philippines, China
Stamnosoma armatum	fish eating mammals and birds	Japan
Toctotrema lingua	fish eating mammals and birds	Greenland
Metagonimus yokogawai	dog, cat, pig, fox	Far East, Europe
Apophallus venustus	dog, cat, raccoon, heron	North America
Stellantchasmus falcatus	dog, cat	Japan, Hawaii
Stellantchasmus formosanus	dog, cat	Formosa
Stellantchasmus amplicaecalis	dog, cat	Formosa
Stellantchasmus pseudocirratus	dog, cat	Philippines, Hawaii, Palestine

species listed in Table 2 have been reported at least once in man. It is also sometimes difficult to differentiate the various species of these intestinal flukes because the eggs are small and look similar. The present prevalence of these parasites in man is difficult to state with certainty, since reports in the literature are often not very descriptive as to fluke species or number of persons infected.

In the opinion of some workers, the species which normally parasitize non-human, fish eating mammals and birds are more apt to elicit severe reactions and to parasitize ectopic sites in man.

In a recent article bearing directly on the subject, Witenberg[16] reflected on the changing prevalence of heterophyid infections in man in Israel. He indicated that 20 years ago eggs of *Heterophyes* were found in approximately 2% of the stool specimens in Jerusalem and Tel Aviv. However, in the intervening years, fewer and fewer infections have been found, primarily because fewer metacercarial-infected fish are imported from various endemic areas such as Egypt. Witenberg also noted that many years ago women bore the burden of heterophyiasis because they habitually tasted raw fish in the preparation of such delicacies as gefüllte fish. Many of the species of *Heterophyes, Haplorchis,* and *Stellantchasmus* listed in Table 2 are probably synonymous and could be reduced to fewer species within their respective genera.

Other Fish-Acquired Intestinal Flukes

An additional group of six organisms acquired by man from eating fish, and found parasitizing the small and large intestines are listed in Table 3. In most cases, they do not occupy extra-intestinal "ectopic" sites to the extent that the *Heterophyes* group does.

Nanophyetus salmincola is a rare parasite of man. The organism has been reported from the dog, the coyote, the fox, and other animals in North America and Siberia. For many years the trematode was thought to be the cause of salmon poisoning in dogs, but it was later shown to be a vehicle for the transmission of the causative organism, a rickettsia, *Neorickettsia helminthoeca.*[12] Although the fluke was reported in man, symptoms of the rickettsial disease were not noted in the infected individual.

Echinochasmus perfoliatus is a member of that large group of flukes, the echinostomes, which possess a collar of spines at their anterior end. *E. perfoliatus* has been reported from man several times and is found in the dog, cat, and fox throughout Asia and in parts of Europe.

Echinostoma malayanum, another echinostome fluke, is primarily a parasite of the dog, although in parts of India and in the Chinese-Tibetan area, it was formerly reported as a common parasite of man. It is transmitted by the ingestion of metacercaria-infected snails as well as fish.[10]

Prohemistomum vivax is a parasite of birds, such as the kite. Experimentally, it has developed to the adult stage in other animals, such as the dog. The fluke which belongs to the Strigeid family of trematodes was reported once as a human parasite.

TABLE 3. *Trematodes acquired my man from fish: inhabitants of small and large intestine.*

Organism	Animal Host	Geographic Distribution
Nanophyetus salmincola	dog, coyote, fox, mink, lynx, raccoon	North America, Siberia
Echinochasmus perfoliatus	dog, cat, fox	Northern Asia, Europe
Echinostoma malayanum	dog	India, China, Tibet, Malaysia
Prohemistomum vivax	kite, other fish eating birds	Japan, Middle East
Isoparorchis hypselobagri	siluroid fish	India, Far East
Clinostomum complanatum	heron, pelican	Japan, Israel

Isoparorchis hypselobagri is normally a parasite of catfish and has been recovered twice from man. It is found in India and other parts of the Far East. Man becomes infected by ingesting fish containing the infective metacercarial stage and perhaps the young adult stage of the parasite. It is unique among the fish-acquired parasites in that it lives as an adult in the swim bladder of various species of catfish.

Clinostomum complanatum inhabits the small intestine of birds but does not occupy this site in man. Three human infections with *Clinostomum* (presumably *C. complanatum)* have been recorded, the last in 1962.[7] These infections have been associated with a syndrome known as "parasitic laryngo-pharyngitis", similar to the "halzoun" syndrome reported in man in the Near East and Middle East. Halzoun caused by parasitization of parts of the buccal area, nasopharynx, and eustachian tube has been attributed to a number of organisms. Among them are young sheep liver flukes *(Fasciola hepatica),* the leech *Limnatis nilotica* and, at least in parts of Lebanon, the pentastome worm *Linguatula serrata.*[8]

A species of Clinostomum, *C. marginatum,* in the adult stage is a common parasite of herons and other water birds in the United States. The metacercarial or infective larval stages known as "yellow grubs" are quite common in perch and other fish in this country. No human infections with *C. maginatum* have been reported.

Lung Flukes and Crustacea

According to a recent review by Yokogawa,[10] approximately 31 species of *Paragonimus* are found in animals. In a recent paper, Miyazaki[11] summarizes current information about the species of *Paragonimus* parasitizing man. Miyazaki lists six species as *bona fide* human parasites. The paragonimids which are primarily acquired by eating crabs, and to a lesser extent, crayfish, inhabit the lungs and/or ectopic sites (Table 4).

P. westermani is widely distributed throughout Asia and is an inhabitant of a variety of animals in addition to man. Stoll[14] estimated the human infections in Asia at 3.2 million.

For several years *P. skrjabini* has been recognized as a human parasite in China. Recent studies have indicated also that *P. heterotremus* is an important human parasite in China and is one of 6 species of *Paragonimus* found in Thailand. *P. kellicoti,* found in a variety of animals in North America, has been recorded only once as a parasite of man.

TABLE 4. *Trematodes acquired by man from crustacea: inhabitants of lung and ectopic sites.*

Organism	Animal Host	Geographic Distribution
Paragonimus westermani	tiger, lion, leopard, cat, dog, fox, badger, marten	Asia
Paragonimus skrjabini	cat, dog	China
aragonimus heterotremus	cat, dog, rat	China, Thailand
Paragonimus mexicanus	opossum	Central America
Paragonimus africanus	cat, dog, mongoose	Africa
Paragonimus kellicoti	mink, cat, dog, pig, muskrat, goat	North America
Spelotrema brevicaeca	sea birds	Far East

The *Paragonimus* flukes parasitize the lung, but are capable of penetrating, and in many human infections do occupy, a variety of sites outside the respiratory tract. Several of the human cases recorded, including the recent single case of *P. heterotremus* found in Thailand, have involved subcutaneous nodules. The organisms are also known to occupy organs of the abdominal viscera such as the pancreas, liver, and spleen. They have also been found in the brain, causing symptoms in humans comparable to cysticercosis. Many of the infections are caused by the young flukes which migrate into these ectopic sites on their way to eventual residence in the lungs. Once in what we presume to call their "normal" site of infection, they excrete eggs into the respiratory tract. The eggs are found in sputum or after being swallowed, can be recovered in stool specimens.

Spelotrema brevicaeca, a relatively rare intestinal parasite of man, was formerly listed among the heterophyids; however, studies on the life cycle indicated that the fluke belonged to a different family. The parasite is transmitted to humans by eating raw crustacea, particularly isopods and amphipods which serve as intermediate hosts. The worms are very small and may provoke extraintestinal as well as intestinal symptoms because of their small size and the fact that their eggs, like the heterophyid forms, when liberated into the circulatory system, can lodge in vital organs.

Echinostomes and Amphibia

Five species of Echinostomes implicated as parasitizing man, are acquired by ingestion of metacercarial intermediate stages in frogs, particularly the tadpole stage.

Echinostoma revolutum has been reported no more than four or five times in man, and the infections have been confined to the Far East.

E. melis has been reported in man in Rumania and China. *E. cinetrochis* and *E. macrorchis* have been reported as occasional parasites of man in China, Japan, and, in a few records in the older literature, in Java.

E. recurvatum is a very common parasite of wild and domestic fowl. It has been occasionally reported as a human parasite in China and Japan.

TABLE 5. *Trematodes acquired by man from amphibia (frogs): inhabitants of small intestine.*

Organism	Animal Host	Geographic Distribution
Echinostoma revolutum	ducks, geese, poultry	Cosmopolitan
Echinstoma melis	mink, otter	Cosmopolitan
Echinostoma cinetrochis	rat	Far East
Echinostoma macrorchis	rat	Far East
Echinostoma recurvatum	duck, fowl, pigeon	Cosmopolitan

Discussion

Obviously, man may acquire a great variety of digenetic trematodes when ingesting fish, frogs, or crustacea. The 43 species noted herein are recorded in rather scattered reports. In surveys, a true picture of the specific prevalence in humans is difficult to attain because of the similarity of the egg or diagnostic stages of many species. A greater degree of certainty of specific identification is possible when the adult flukes are identified after therapy or at autopsy.

In endemic areas where culture and custom permit the ingestion of uncooked fish, frogs, and crustacea, the prevalence of some of those listed as "of rare occur-

rence" may be much higher than shown. Low-level, subclinical infections with a few worms will not elicit symptoms and, unless the infected person is a participant in a survey, he may never be found harboring the fluke.

Dr. Stoll noted only three of the parasites mentioned herein, *Clonorchis sinensis, Opisthorchis felineus,* and *Paragonimus westermani,* in his assay of our wormy world. Yet certain facts do present themselves: namely, that Dr. Stoll's oft quoted assessment is now 23 years old and the habits, life style, and physical surroundings of a great many people have changed since then. One would expect that the human fluke fauna has also altered somewhat. Dr. Witenberg's timely thoughts[16] on the present status of *Heterophyes* in Israel may be a clear indication that the list is historical in many aspects and needs extensive revision. Thus, with many others, we can eagerly await the next "Stollian" estimate of our wormy world of the fish-, frog-, and crustacean-acquired flukes.

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