How to Cite:
Ravishankar, V., & Kumar, G. S. (2021). Analysis of trematodes and cestodes in humans. *International Journal of Health Sciences*, *5*(S1), 770–781.
https://doi.org/10.53730/ijhs.v5nS1.14305

Analysis of trematodes and cestodes in humans

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***Abstract*---**The Phylum Platyhelminthes is divided into two groups: cestodes (tapeworms) and trematodes (flukes). Tapeworms live in vertebrate intestines, and their larval forms can be found in the flesh of animals that these animals eat. The adult tapeworm has no digestive tract and instead absorbs nutrients through its body surface. The worm's head, or scolex, has a mechanism for attaching to the host's intestinal wall. Knowledge of basic epidemiological characteristics and distinguishing radiographic findings can improve the chances of detecting and treating parasitic infections of the nervous system. This article discusses the clinical presentation, diagnosis, and treatment of some of the more a common cestode and trematode diseases of the central nervous system.

***Keywords*---**trematode, cestode, chemotherapy, adverse reaction, combined therapy, echinococcus granulosus.

Introduction

Cestodes and trematodes can infect either the central or peripheral nervous systems, resulting in a wide range of clinical symptoms and signs. Cestodes and trematodes are platyhelminthes, a phylum distinguished by its inability to live outside of a host (with one exception). Plathyhelminthes infections of the central nervous system occur all over the world. Cestodes, also known as "tapeworms," can be found as adults or larvae. Cestodes are ribbon-shaped, segmented worms with a scolex in the anterior portion that allows them to attach to a host. Because adult forms rarely spread beyond the gastrointestinal tract, larval forms are more infectious to the human nervous system than others. The cestode *Taenia solium* causes neurocysticercosis, which is discussed in this issue of *Seminars in Neurology*. [1-2]

Trematodes, also known as "flukes," can infiltrate the nervous system after being infected in the blood, liver, intestine, or lungs. Except for *Schistosoma*, most species are zygotic, meaning they can reproduce and survive within the host. Trematodes have two prior suckers that help them stick to their host.

Trematodes, also known as flukes, are flatworm parasites with distinct life cycles that include sexual reproduction in vertebrate definitive hosts and asexual reproduction in snail intermediate hosts. These living things are classified into four groups based on their ultimate human habitats: (1) hermaphroditic liver flukes that live in the bile ducts and infect humans when watercress (*Fasciola*) or raw fish (*Clonorchis and Opisthorchis*) is consumed; (2) the hermaphroditic intestinal fluke (*Fasciolopsis*), which affects humans on ingestion water-based chestnuts; (3) the hermaphroditic lung fluke (*Paragonimus*), which infects humans on ingestion of raw crabs or crayfish; and (4) the bisexual blood flukes (Schistosoma), which reside in the intestinal or vesical (urinary bladder) venules and infect humans by direct penetration through the skin (Figure-1).

Fascioliasis is a cosmopolitan zoonosis, with sporadic human cases appearing in the majority of the world. People hermaphroditic fluke infections are largely restricted to Asia. Schistosomiasis is found in South America, the Caribbean, Africa, the Middle East, and Asia, and it is becoming more prevalent in many areas as a result of the construction of dams and systems for irrigation.

Because flukes cannot reproduce in humans, the severity of infection is proportional to the level of exposure to the infective larvae. The majority of infected people in most endemic areas have light or moderate worm burdens. Overt disease occurs primarily in the relatively small proportion of the population with a high worm weight, though predisposition to it may play a role as well. Pathology can be caused by the worms themselves (such as liver flukes, which cause bile duct harm) or by their eggs (such as schistosome eggs, which cause granulomatous inflammation in the venules or tissues). The introduction of the anthelminthic drug praziquantel has significantly enhanced the treatment of all fluke infections.

In general, common gut-dwelling adult cestodes are well adapted to the human host, causing minimal symptoms and causing serious pathology only in rare cases. This reality contradicts numerous terrifying and largely fictitious stories of tapeworms stealing food and causing ravenous hunger (far more commonly, the appetite is suppressed). Larval cestodes, which on the other hand, develop in human organs or somatic tissues other than the gut and are thus far more pathogenic.

In contrast to the strong responses elicited by the larval stages in tissues, adult cestodes elicit little host inflammatory or immune system responses. Adult cestodes are frequently acquired through the consumption of meat from intermediate hosts. Ingestion of faecal eggs causes extraintestinal infection with larvae. Adult cestode infection is diagnosed by identifying eggs and segments (proglottides) in faeces (Figure-2). Larval infections are more difficult to diagnose; serology and biopsy are useful tools. Sanitation, personal hygiene, and thorough cooking of meat and fish are essential for control. [3-5].

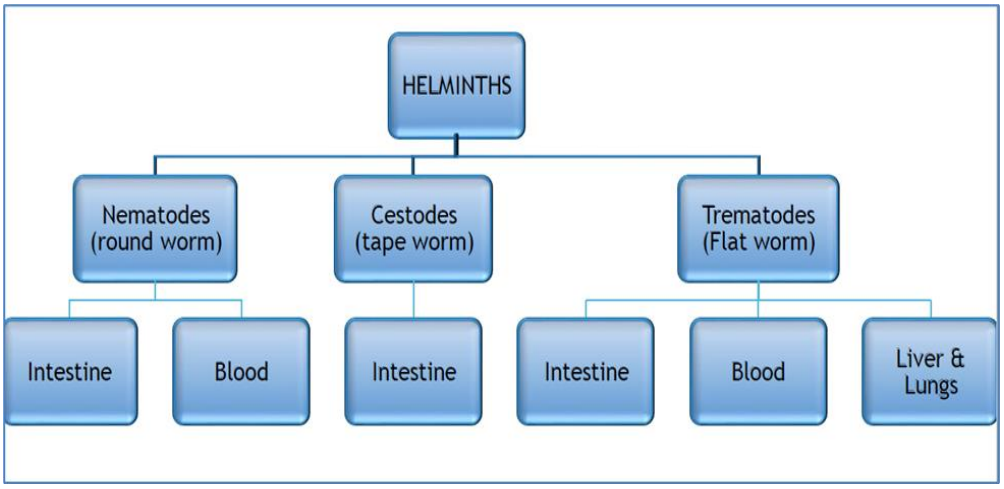

Figure-1. Different categories of Helminths

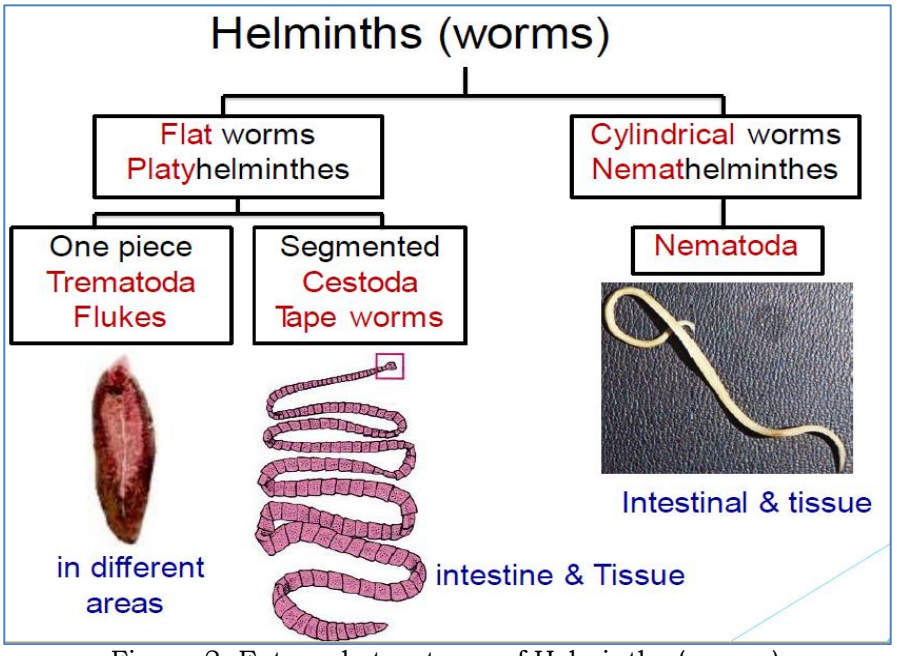

Figure-2. External structures of Helminths (worms)

Until recently, the medical and economic impact of cestode and trematode diseases was consistently ignored and severely underestimated. Food-borne trematodiases and cestode-borne diseases such as echinococcosis and cysticercosis have only recently been added to the World Health Organization's list of neglected tropical diseases (NTDs), with the exception of schistosomiasis, which affects around 250 million individuals worldwide (Hotez et al. 2009; Budke et al. 2009). This can be difficult to justify at times. According to the worldwide prevalence of echinococcosis, 50 million people in Asia and Africa are at risk of contracting the disease (Hemphill and Kern, 2008). The global burden of human cystic echinococcosis (disability-adjusted life years - DALYs) was estimated to be

comparable to or even greater than that of several other well-known NTDs such as Chagas disease, dengue fever, and African trypanosomiasis, all of which have been the subject of much larger scale intervention programmes much earlier (Budke et al. 2006, 2009). Thus, the significant impact of echinococcosis has been confirmed, but the appropriate officials have not adequately recognised it. There are no figures for DALYs lost due to food-borne trematodiasis, but they are likely to be in the same range or even higher, given that approximately 40 million people globally are infected (Keiser and Utzinger, 2007; Budke et al. 2009). An earlier study estimated that 400,000 people in Latin America alone have symptomatic neurocysticercosis (Bern et al. 1999). [6-11]

Result and Discussion

Helminthotoxic effects

Trematodes

Praziquantel's effects on helminth parasites have been studied both *in vitro* and *in vivo*. From 1978 to 1981, *Schistosoma mansoni*, *Schistosoma japonicum*, *Dicrocoelium dendriticum*, and *F. hepatica* were studied in vitro for the first time. In 1983, studies on *Clonorchis sinensis*, *Metagonimus yokogawai*, *Opisthorchis viverrini*, and *Paragonimus westermani* were conducted. Praziquantel concentrations were tested at 0, 1, 10, and 100 g/mL, with incubation times of 5, 15, 30, and 60 minutes. The most notable findings were rapid contraction of the worm musculature, which resulted in worm motion loss, and rapid bleb formation and vacuolization of the tegument, followed by bleb and vacuole rupture [12-14]. Most of these trematode species quickly adapted to praziquantel, and vacuolization began within a few seconds of contact. Adult *Fibricola seoulensis* (now *Neodiplostomum seoulense*) flukes exposed in vitro to 0.1-100 g/mL praziquantel solution for 5, 15, 30, and 60 minutes showed rapid contraction of the musculature and loss of movement, as well as remarkable tegumental and subtegumental changes, including bleb or blister formation followed by rupture and deformation of the tegumental integrity [15-16].

Structure and Life Cycle

Trematodes, also known as flukes, are multicellular flatworms that are The lengths of various species range from less than 1 mm to several centimetres. All medically significant flukes are digenetic, reproducing sexually in a definitive vertebrate host and asexually in a snail intermediate host. Flukes have several life cycle stages (Figures 3 and 4). Adult male and female or hermaphroditic flukes lay eggs in the definitive vertebrate host. The eggs hatch into free-swimming ciliated miracidia, which infect snails and give rise to sporocysts and rediae. The snails produce cercariae, which infect the vertebrate host directly or through an encysted form known as a metacercaria.

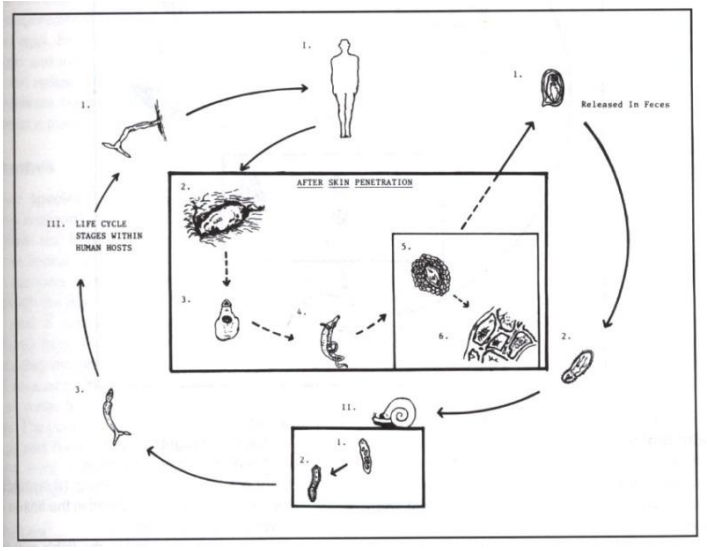

Figure 3: Life Cycle of Schistosome

I. Definitive host: humans passing eggs into the environment
   1. Mature eggs reach the freshwater environment in excreta.
   2. Miracidium hatches from the egg in ideal conditions of temperature, light, and fresh water, and then seeks an appropriate intermediate host. The intermediate host undergoes asexual reproduction.

II. Intermediate Host: aquatic snails
   1. Miracidium enters the soft tissue of the snail and differentiates into mother sporocysts, which produce a second order daughter sporocyst.
   2. The daughter sporocyst migrates to the digestive gland, where it reproduces cercariae asexually.
   3. Motile cercaria emerges from the snail in search of a vertebrate host.

III. Migrating larvae and other life cycle stages resident in human host tissue
   1. Cercaria infiltrates the skin of the vertebrate host, where it transforms into schistosomulum.
   2. The schistosomulum grows and differentiates as it migrates into the vasculature via the heart, lungs, and hepatic portal system.
   3. The juvenile worm lives in the hepatic portal system, where it matures into male and female adults.
   4. Adult worms' mate in the hepatic portal vessels before migrating to the mesenteric venules, where they lay eggs indefinitely.
   5. Some eggs are swept into the liver's precapillary sinusoids and become the nidus of a granulomatous reaction.
   6. Chronic hypersensitivity to soluble egg antigens results in the immunopathological condition known as "clay pipe-stem" fibrosis.

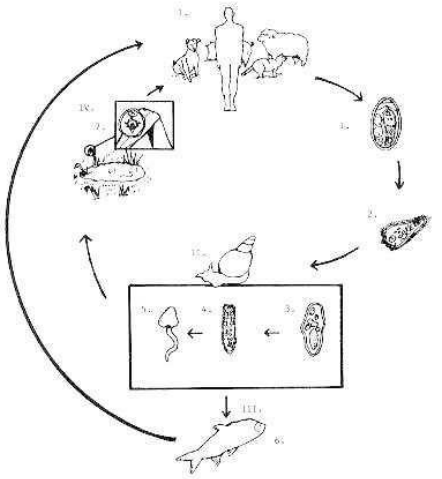

Figure 4: Life Cycle of other Trematodes of Human Health Significance

I. Definitive Host: humans, ruminants, dogs, cats and other companion animals
   a. Operculated - type mature trematode egg with miracidium
   b. Free swimming miracidium, life cycle stage infective to snail intermediate host
II. First Intermediate Hosts: operculated amphibious or semi-amphibious snail of the genera Bulimus sp; Pseudofossarulus sp; Lymnaea sp; Bithynia sp. and others
   a. Sporocyst
   b. Mother/daughter redia
   c. Free swimming cercariae
III. Second Intermediate Host: (if applicable, i.e., Opisthorchis spp.) encysted in the tissue of cyprinid - type freshwater fish
   a. Cercariae encysted in the fish's soft tissue
IV. Infective Stage to the Definitive Host
   a. Encysted metacercariae on aquatic/semi-acquatic vegetation, i.e., watercress, fodder

Cestodes

Praziquantel's therapeutic efficacy in the treatment of cestode infections was first documented in 1976-1977, a little before than its efficacy in the treatment of trematodes. However, detailed *in vitro* effects on morphological changes in worms were first studied on *Hymenolepis* nana in 1980, followed by *Hymenolepis diminuta*, *Hymenolepis microstoma*, E. *multilocularis*, and Taenia *taeniaeformis* in 1981. After 5 minutes incubation in 1 g/mL praziquantel, tegumental vacuolization was only observed in the neck region of *H. nana* tapeworms. The vacuolization disrupted the syncytial layer in the apical region of the tegument, but not the tegumental microtriches or the surface coat. The other four tapeworm species' adults' necks showed the same tegumental change. The tegument of *Diphyllobothrium latum* adults (obtained from experimentally infected hamsters) was expanded and desquamated for 4 hours after being incubated in concentrations greater than 0.1 g/mL. Even in these specimens, the scolex and

neck region remained viable and mobile, indicating that *D. latum* is resistant to praziquantel *in vitro*. Regardless of their susceptibility *in vitro*, human and animal infections with adult tapeworms were successfully treated *in vivo* with praziquantel. [17-19]

All cestodes go through three life stages: eggs, larvae, and adults. Adults live in the intestines of definitive hosts, which are mammalian carnivores such as humans. Several adult tapeworms that infect humans are named after their primary intermediate hosts (fish, beef, and pork tapeworms). The Asian tapeworm (*Taenia asiatica*) is an exception. It is similar to *T. saginata* in many ways, but it is acquired by eating pork in Asia.

Cestode infection spreads when eggs laid by adult tapeworms in the intestines of definitive hosts are excreted into the environment with faeces and consumed by an intermediate host (usually another species). Eggs hatch into larvae, which develop, enter the intermediate host's circulation, and encyst in the musculature or other organs. When the definitive host consumes the intermediate host raw or undercooked, the parasites are released from the ingested cysts in the intestines and develop into adult tapeworms, restarting the cycle. In the case of some cestode species (for example, *T. solium*), the definitive host can also serve as an intermediate host; that is, if eggs rather than tissue cysts are consumed, the eggs develop into larvae that enter the circulation and encyst in various tissues.

Adult tapeworms are flat, multisegmented worms that do not have a digestive tract and absorb nutrients directly from the host's small bowel. Adult tapeworms can grow to be quite large in the host's digestive tract; the world's longest parasite is the 40-m whale tapeworm, *Tetragonoporus calyptocephalus*. [20-21]

Tapeworms have 3 recognizable portions:

- The scolex (head) functions as an anchoring organ that attaches to intestinal mucosa.
- The neck is an unsegmented region with high regenerative capacity. If treatment does not eliminate the neck and scolex, the entire worm may regenerate.
- The remainder of the worm is made up of numerous proglottids (segments). Proglottids near the neck are not differentiated. Proglottids develop hermaphroditic sex organs as they move caudally. Distal proglottids are pregnant and have eggs in their uterus. mature proglottids have just one ovary, and their eggs are visible under a microscope.

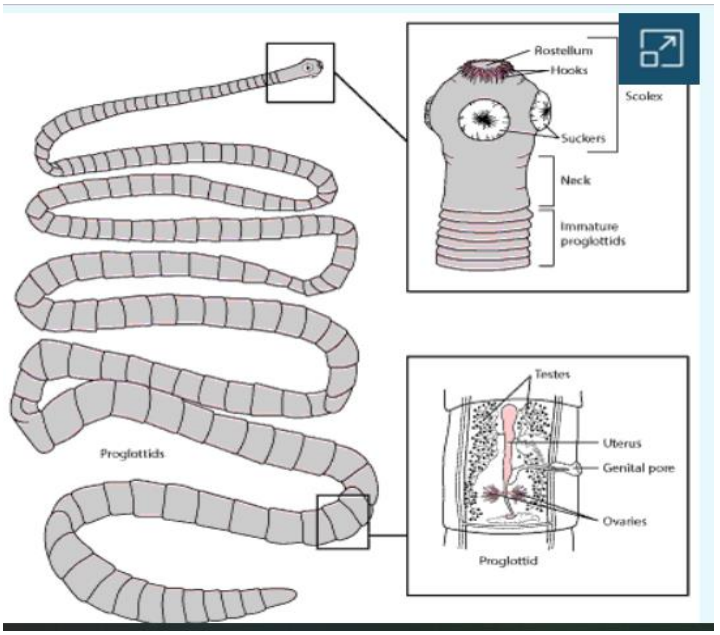

Figure 5: Representative structure of a tapeworm, based on *Taenia solium*

Symptoms and Signs of Tapeworm Infections

Size and morphology vary depending on species and maturity. Adult tapeworms are so well-adapted to their hosts' digestive tracts that they usually cause only minor symptoms. Some exceptions exist. Heavy *Hymenolepis* nana infections can cause abdominal pain, diarrhoea, and weight loss; members of the Diphyllobothriidae family can cause vitamin B12 deficiency and megaloblastic anaemia (Figure-5).

When larvae develop in extraintestinal sites, most notably the brain, but also the liver, lungs, eyes, muscles, and subcutaneous tissues, they can cause severe and even lethal disease. *T. solium* causes cysticercosis in humans, while *Echinococcus granulosus* and *Echinococcus multilocularis* cause cystic hydatid disease and alveolar disease. In humans, *T. saginata* does not cause cysticercosis. It is unknown whether T. asiatica causes cysticercosis in humans. *Spirometra* species, *Sparganum proliferum*, *Taenia multiceps*, *Taenia serialis*, *Taenia brauni*, and *Taenia glomeratus* larvae can infect humans on rare occasions, causing mass lesions in subcutaneous tissue or muscle, and less frequently, brain or eye, depending on the infecting species. [22-23]

Diagnosis of Tapeworm Infections

- For adult tapeworm infections, microscopic examination of stool
- For larval disease, imaging

Adult tapeworm infections are identified in stool by identifying eggs or gravid proglottid segments. Imaging (e.g., brain CT and/or MRI) is the best way to detect larval disease. Serologic tests may be useful as well.

Treatment of Tapeworm Infections

Praziquantel, an anthelmintic, is effective against intestinal tapeworm infections. Niclosamide is a substitute that is not available in the United States. Nitazoxanide can be used to treat infections caused by *H. nana*.

Some extraintestinal infections respond to albendazole and/or praziquantel anthelmintic treatment, while others need surgical intervention.

Tapeworm Infection Prevention

Prevention and control involve the following:

- Thorough cooking of pork, beef, lamb, game meat, and fish (recommended temperatures and times vary)
- Prolonged freezing of meat for some tapeworms (eg, fish tapeworm)
- Regular deworming of dogs and cats
- Prevention of recycling through hosts (eg, dogs eating dead game or livestock)
- Reduction and avoidance of intermediate hosts such as rodents, fleas, and grain beetles
- Meat inspection
- Sanitary treatment of human waste

Smoking and drying meat are ineffective in preventing infection.

Endoparasites: Trematodes and Cestodes
Intestinal Trematodes

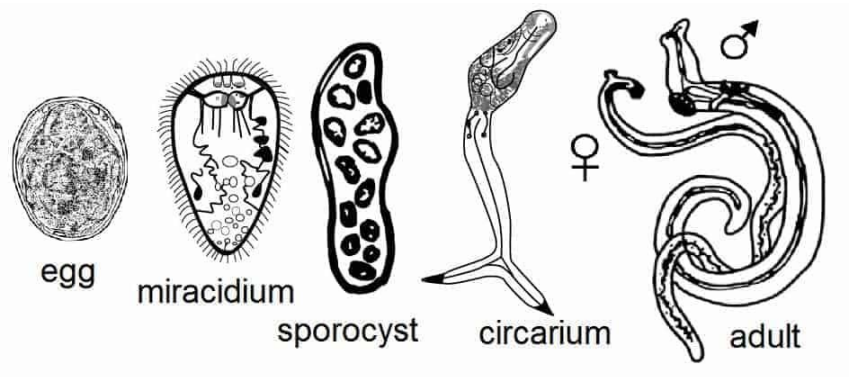

Figure-6. Trematodes stages

Trematodes, also known as flukes, are a type of parasite that is rarely found in companion animals. Unless there is a large infestation causing mild pathology, they usually raid the small intestines where they cause minimal damage (Figure-6).

Trematodes are a type of worm characterised by flat or oval-shaped bodies. There are over 10.000 fluke species with a global distribution. Their size can range from

5 mm to a few centimetres, but most are less than 1 cm. The majority of trematodes parasitize turtles, frogs, and fish. [23-24]

Intestinal Cestodes

Cestodes, also known as tapeworms, are a parasitic class with over 5000 species. Tapeworms are found all over the world and can range in size from 1 mm to 15 m, and sometimes even more. Internal parasites can affect certain invertebrates as well as the digestive tract and liver of all vertebrates, including humans. Some tapeworm species can attack a single host, whereas others have life cycles that require one or two intermediate hosts and a final host. (Figure-7).

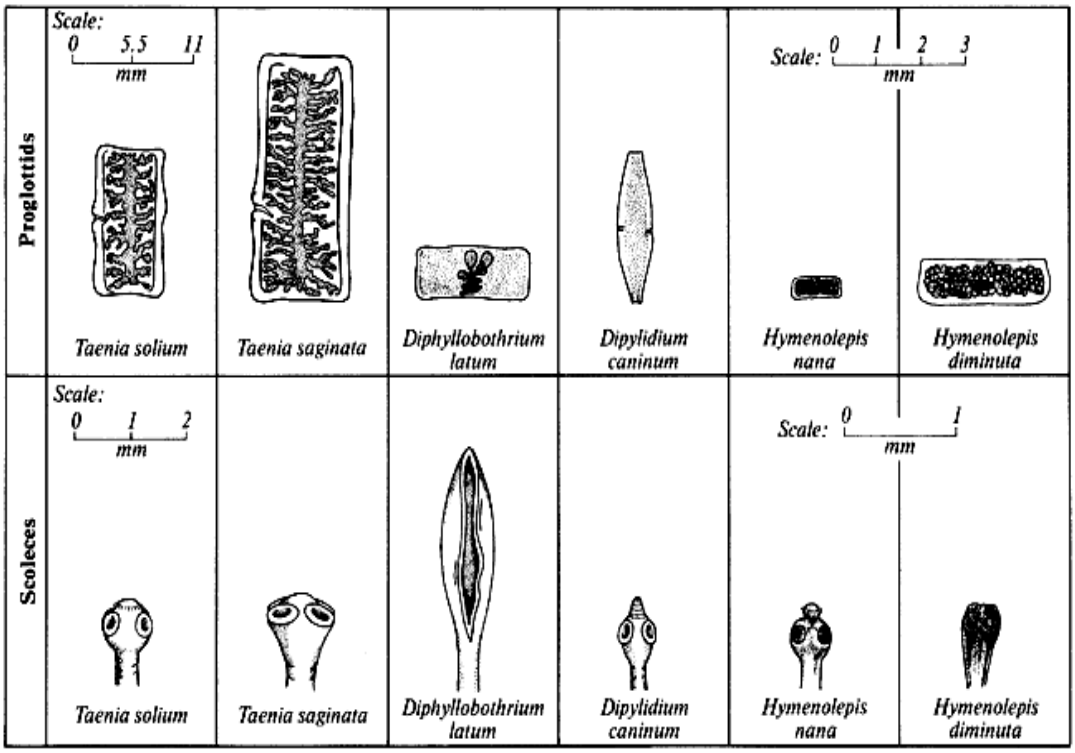

Figure-7. Intestinal cestodes

Morphologically cestodes are bilaterally symmetrical and consist of either only one body segment (long) or a series of identical ones (proglottids). Their heads are named scolexes, whose purpose is to attach to the host. They have no mouth, digestive tract, gas-exchanging organ, or circulatory system, and they absorb food and nutrients through the tough cuticle that covers their bodies. [25-26]

Conclusion

Praziquantel is a broad-spectrum anthelmintic that is both effective and safe against trematode and cestode infections in humans and animals. The only limitations for its use for treating human infections are fascioliasis, hydatid disease, and sparganosis, for which triclabendazole, a combination of

praziquantel and albendazole, and surgical parasite removal, respectively, may be used as an alternative treatment. Emerging issues include the appearance in the laboratory or in the field of praziquantel-resistant strains or isolates of *S. mansoni* and *S. japonicum*. Another emerging issue is the development of allergic, hypersensitive, or anaphylactic reactions to praziquantel therapy in some patients.

References

1. Andrews P, Thomas H, Pohlke R, Seubert J. Praziquantel. Medl Res Rev 1983;3:147-200.
2. Ash L, Orihel TC: Parasites: A Guide to Laboratory Procedures and Identification. American Society of Clinical Pathologists, Chicago, 1987 .
3. Becker B, Mehlhorn H, Andrews P, Thomas H, Eckert J. Light and electron microscopic studies on the effect of praziquantel on Schistosoma mansoni, Dicrocoelium dendriticum, and Fasciola hepatica (Trematoda) in vitro. Z Parasitenkd 1980;63:113–128.
4. Becker B, Mehlhorn H, Andrews P, Thomas H. Scanning and transmission electron microscope studies on the efficacy of praziquantel on Hymenolepis nana (Cestoda) in vitro. Z Parasitenkd 1980;61:121–133.
5. Becker B, Mehlhorn H, Andrews P, Thomas H. Ultrastructural investigations on the effect of praziquantel on the tegument of five species of cestodes. Z Parasitenkd 1981;64:257–269.
6. Bern, C., Garcia, H. H., Evans, C., Gonzales, A. E., Verastegui, M., Tsang, V. C. and Gilman, R. H. (1999). Magnitude of the disease burden from neurocysticercosis in a developing country. Clinical Infectious Diseases 29, 1203–1209.
7. Bogitsh BJ and Cheng TC: Human Parasitology. WB Saunders, Philadelphia, 1990 .
8. Budke, C. M., Deplazes, P. and Torgerson, P. R. (2006). Global socioeconomic impact of cystic echinococcosis. Emerging Infectious Diseases 12, 296–303.
9. Budke, C. M., White, A. C. and Garcia H. H. (2009). Zoonotic larval cestode infections : neglected, neglected tropical diseases? Plos Neglected Tropical Diseases 3, e319.
10. Bylund G, Bång B, Wikgren K. Tests with a new compound (Praziquantel) against Diphyllobothrium latum. J Helminthol 1977;51:115–119.
11. Castro GA: Trematodes: schistosomiasis. p 1710. In Kelly WN (ed): Textbook of Internal Medicine. JB Lippincott, Philadelphia, 1989 .
12. Chan JD, Zarowiecki M, Marchant JS. Ca(2+) channels and Praziquantel: A view from the free world. Parasitol Int 2012;pii:S1383-5769.
13. Hemphill, A. and Kern, P. (2008). Experimental studies in echinococcosis. Experimental Parasitology 119, 437–438.
14. Hörchner F, Langnes A, Oguz T. Die Wirkung von Mebendazole und Praziquantel auf larvale Taenienstadien bei Maus, Kaninchen und Schwein. Tropenmed Parasitol 1977;28:44–50.
15. Hotez, P. J., Fenwick, A., Savioli, L. and Molyneux, D. H. (2009). Rescuing the bottom billion through control of neglected tropical diseases. Lancet 373, 1570–1575.
16. Hunter GW, Swartzwelder JC, Clyde DF: A Manual of Tropical Medicine. 5th Ed. WB Saunders, Philadelphia, 1976 .

17. Jeffrey HC, Leach RM: Atlas of Medical Helminthology and Protozoology. Churchill Livingstone, Edinburgh, 1968
18. Keiser J, Utzinger J. Chemotherapy for major foodborne trematodes: a review. Expert Opin Pharmacother 2004;5:1711-26.
19. Keiser, J. and Utzinger, J. (2007). Advances in the discovery and development of trematocidal drugs. Expert Opinion in Drug Discovery 2 (suppl. 1), S9–S23.
20. Lee SH, Chai JY. Praziquantel in the treatment of trematode and cestode infections. J Korean Soc Chemother 1985;3:95- 118.
21. Lee SH. In vitro effects of praziquantel on Fibricola seoulensis. Seoul J Med 1985;26:41–52.
22. Mehlhorn H, Becker B, Andrews P, Thomas H, Frenkel JK. In vivo and in vitro experiments on the effects of praziquantel on Schistosoma mansoni. Arzneimittelforschung 1981;31:544–554.
23. Mehlhorn H, Kojima S, Rim HJ, Ruenwongsa P, Andrews P, Thomas H, Bunnag B. Ultrastructural investigations on the effects of praziquantel on human trematodes from Asia: Clonorchis sinensis, Metagonimus yokogawai, Opisthorchis viverrini, Paragonimus westermani and Schistosoma japonicum. Arzneimittelforschung 1983;33:91–98.
24. Pax R, Bennett JL, Fetterer R. A benzodiazepine derivative and praziquantel: effects on musculature of Schistosoma mansoni and Schistosoma japonicum. Naunyn Schmiedebergs Arch Pharmacol 1978;304:309–315.
25. Thomas H, Gönnert R. The efficay of praziquantel against cestodes in animals. Z Parasitenkd 1977;52:117–127.
26. Wang W, Wang L, Liang YS. Susceptibility or resistance of praziquantel in human schistosomiasis: a review. Parasitol Res 2012;111:1871-7.