Review Paper:

A critical review on the classification of helminths and their mode of transmission in human beings

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Abstract

This review clearly states the classification of helminths and their mode of transmission in human-beings. Helminths are both hermaphroditic and bisexual species and classification is based on the external and internal morphology of egg, larval and adult stages.

Generally, helminths are classified into three major types based on their external shape and the host organ they inhabit. They are Flukes (Trematodes); Tapeworms (Cestodes) and Roundworms (Nematodes). This review clearly describes the impact of these types of helminths and their mode of transmission on human-beings starting from children to adults. The classification and identification of helminths are dependent on numerous factors including body shape, body cavity, body covering, digestive tubing, sex and type of attachment organs.

Keywords: Helminths, Roundworms, Tapeworms, Trematoda, Platyhelminths, Acanthocephalans.

Introduction

Recently, helminths are great threat to human beings due to their health impact on humans. Helminths are worm like-parasites. The helminths are invertebrates characterized by elongated, flat or round bodies. The most important class of parasitic helminths contain: Nematodes (roundworms), cestoda (tapeworms), trematoda (flukes), platyhelminths (flatworms) and acanthocephalans (thorny headed worms). Helminths categorization and recognition are based on several aspects like external and internal morphology of egg, larval, adult stages, gender and nature of accessory organ. The parasitic worms interrupt the capability of a host cell to obtain and acquire sustenance.

Generally, mode of transmission is based on these three categories acetabulum, tegument, bothridia.

(i) **Acetabulum**: Saucer shaped organ of attachment in worms like leech. It is a specialized sucker for parasitic adaption,
(ii) **Tegument**: The outer body covering among the members of platyhelminths,
(iii) **Bothridia**: A specialized attachment organ of an animal. It acts as adhesion device in parasitic worm. Helminths are huge, multicellular organisms, proficient to be glimpse to the eye formerly in the grown-up stage of their life series. The multicellular eukaryotes and helminthes are capable of free-living or parasitic worms.

The adult stage of helminthes is unable to multiply in human beings and utilizes huge process of transference to make possible generative attainment. Parasites stay alive by obtaining food supplement from the host while troublemaking the hosts' nutrient absorption. The parasitic worms are frequently originated inside the intestine and these types are called intestinal parasites. They are capable to survive in mutually human being and animals.

Classification and mode of transmission: The categorization and recognition of helminths are reliant on abundant factors containing body form, digestive tubing, body cavity, body covering, sexual category and kind of attachment organs. The Platyhelminths (flatworms) contain both trematodes (flukes) and cestodes (tapeworms). Particularly, tapeworms are characterized using the above criteria and are organized in a segmented plane. They lack a body cavity and have a tegument body covering. Tapeworms lack a digestive tube and are hermaphroditic. They utilize suckers or bothridia and rostellum with hooks for an attachment organ. Trematodes are characterized by an unsegmented plane for body shape. They also lack a body cavity and have a tegument for body covering.

However, the digestive tube for trematodes ends in the cecum. Trematodes are hermaphroditic and utilize oral suckers, ventral suckers or acetabulum for attachment organs. The Nematodes are characterize by a body shape, it is cylindrical and has a body cavity. Its body covering is a cuticle and the digestive tube ends in the anus. The sex of nematodes is dioecious (distinct male and female organisms). Lastly, their attachment organs range from lips, teeth, filariform extremities and dentary plates[16].

Impact of Protozoan organisms on human beings: Protozoan are classified under the group of animal kingdom of the basal members. Protozoa are categatorized in both algal and fungal groups. Basically the protozoans are eukaryotic organism and it is structurally and functionlly individual in cell. Generaly the protozoan organism groups are microscopic and some species are large in size and visible to naked eye. Protozoans are categorized into four groups.

Amoebae- Entamoeba histolytica
Flagellates-Giardia lambila

Ciliates- Batantidium coli
Sporoza- Plasmodium knowlesi

In protozoans some are free-living commonly in salt, fresh and brackish water.The common symptoms of protozoa are episodic diarrhea, liver tenderness, malabsorption syndrome, stomach cramps and greasy stool. The drug used to treat the protozoan infection is metronidazole, paromonycin, nitazoxamide and tinidazole.

Fig. a: Roundworm

Fig. b: Tapeworm

Fig. c: Hookworm

Fig. d: Pinworm

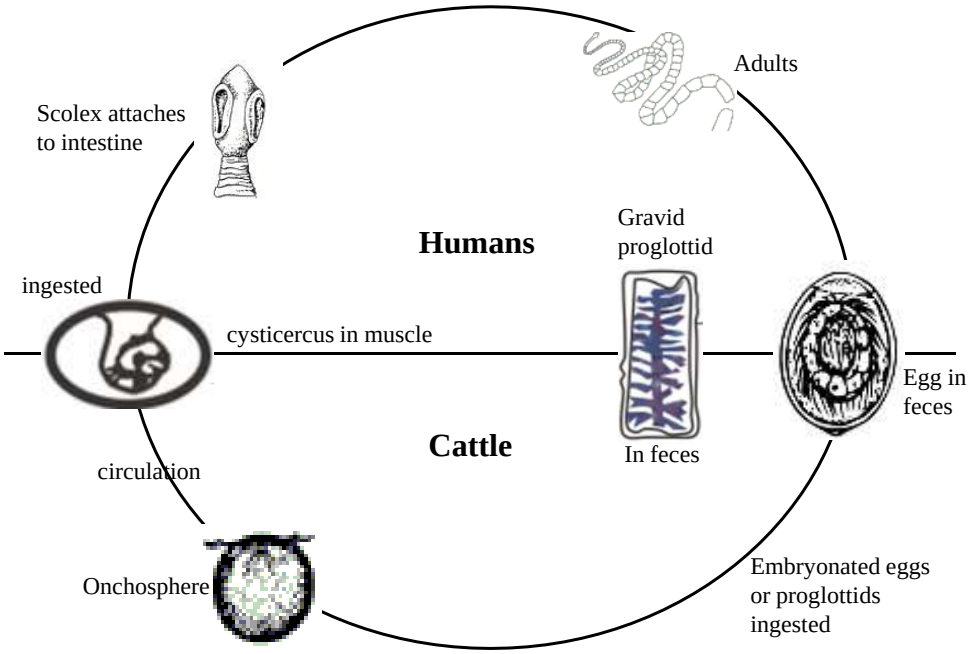
Fig. e: Fluke

COMMON NAME OF ORGANISM	***LATIN NAME (SORTED)***	***BODY PARTS AFFECTED***	***DIAGNOSTIC SPECIMEN***	***MODE OF TRANSMISSION***
Granulomatous amoebic encephalitis *Acanthamoeba*keratitis	*Acanthamoeba* spp.	Eye, brain, skin	Culture	Contact lenses cleaned with contaminated tap water
Granulomatous amoebic encephalitis	*Balamuthia mandrillaris*	Brain, skin	Culture	Via inhalation or skin lesion
Babesiosis	*Babesia B. Divergens, B. Bigemina, B. Equi, B. Microfti, B. Duncani*	Red blood cells	Giemsa-stained thin blood smear	Tick bites, e.g. *Ixodes scapularis*
Balantidiasis	*Balantidium coli*	Intestinal mucosa	Stool (diarrhea - ciliated trophozoite; solid; stool- large cyst with horseshoe shaped nucleus)	Ingestion of cyst, zoonotic infection acquired from pigs (feces)
Blastocystosis	*Blastocystis* spp.	Intestinal	Direct microscopy of stool (PCR, antibody)[2,16]	Eating food contaminated with feces from an infected human or animal[8,10]
Cryptosporidiosis	*Cryptosporidium* spp.	Intestines	Stool	Ingestion of oocyst (sporulated), some species are zoonotic (e.g. Bovine fecal contamination)
Cyclosporiasis	*Cyclospora cayetanensis*	Intestines	Stool	Ingestion of oocyst thru contaminated food
Dientamoebiasis	*Dientamoeba fragilis*	Intestines	Stool	Ingesting water or food contaminated with feces
Amoebiasis	*Entamoeba histolytica*	Intestines (mainly colon, but can cause liver failure if not treated)	Stool (fresh diarrheic stools have amoeba, solid stool contain cyst)	Fecal-oral transmission of cyst, not amoeba

Giardiasis	*Giardia lamblia*	Lumen of the small intestine	Stool	Ingestion of water containing deer or beaver feces
Isosporiasis	*Isospora belli*	Epithelial cells of small intestines	Stool	Fecal oral route – ingestion of sporulated oocyst
Leishmaniasis	*Leishmania* spp.	Cutaneous, mucocutaneous, or visceral	Visual identification of lesion or microscopic stain with Leishman's or Giemsa's stain	*Phlebotomus, Lutzomyia* – bite of several species of phlebotomine sandflies
Primary amoebic meningoencephalitis(PAM)	*Naegleria fowleri*	Brain	Culture	Nasal insufflation of contaminated warm fresh water, poorly chlorinated swimming pools, hot springs, soil
Malaria	*Plasmodium falciparum*(80% of cases), *Plasmodium vivax, Plasmodium ovale curtisi,*	Red blood cells, liver	Blood film	*Anopheles* mosquito
Rhinosporidiosis	*Rhinosporidium seeberi*	Nose, nasopharynx	Biopsy	Nasal mucosa came into contact with infected material through bathing in common ponds
Sarcocystosis	*Sarcocystis bovihominis,Sarcocystis suihominis*	Intestine, muscle	Muscle biopsy	Ingestion of uncooked/undercooked beef/pork with *Sarcocystis* sarcocysts
Toxoplasmosis (Acute and Latent)	*Toxoplasma gondii*	Eyes, brain, heart, liver	Blood and PCR	Ingestion of uncooked/undercooked pork/lamb/goat with *Toxoplasma* bradyzoites, ingestion of raw milk with *Toxoplasma* tachyzoites, ingestion of contaminated water food or soil[17,21] with oocysts in cat feces that is more than one day old
Trichomoniasis	*Trichomonas vaginalis*	Female urogenital tract (males asymptomatic)	Microscopic examination of genital swab	Sexually transmitted infection – only trophozoite form (no cysts)
Sleeping sickness	*Trypanosoma brucei*	Brain and blood	Microscopic examination of chancre fluid, lymph node aspirates, blood, bone marrow	Tsetse fly, day-biting fly of the genus *Glossina*
Chagas disease	*Trypanosoma cruzi*	Colon, esophagus, heart, nerves, muscle and blood	Giemsa stain – blood	*Triatoma*/Reduviidae – "kissing bug" insect vector, feeds at night

Impact of Tapeworms on human-beings: Tapeworm is a class of (platyhemlninths) group and it is also called as flatworm. The subclass of parasite is Eucestoda. The mature tapeworm has head with short neck, scolex and segmented body formed by proglottids. This parasite is mostly present in the human digestive tracts. The tapeworm infection is spread by eating uncooked meat of pork, fish and poor hygenic foods. The tapeworm infection is mostly caused by

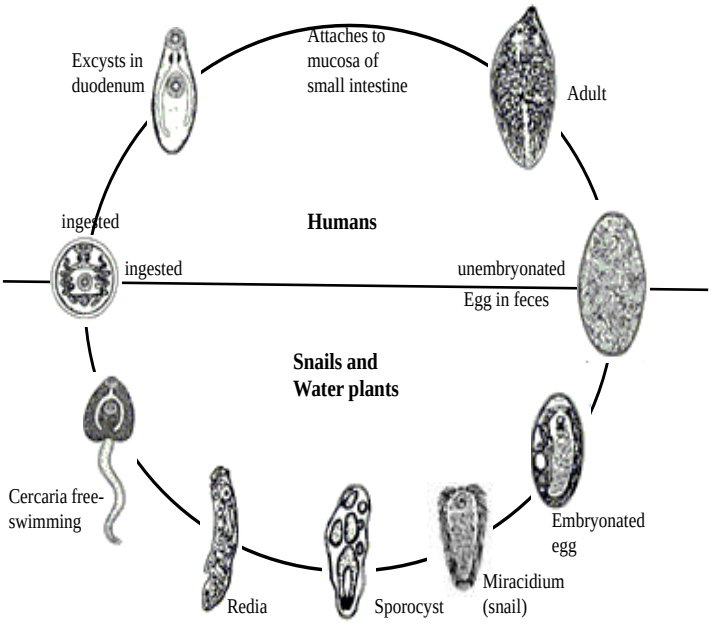
animals. The animals are easily infected when they are grazing in pastures. The humans are affected by eating the contaminated animal meat and drinking contaminated water. There is no symptom often the tapeworm. The indication of tapeworm infection is segments of worms moving on bowel movement.



COMMON NAME OF ORGANISM	LATIN NAME (SORTED)	BODY PARTS AFFECTED	DIAGNOSTIC SPECIMEN	MODE OF TRANSMISSION
Tapeworm – Tapeworm infection	*Cestoda, Taenia multiceps*	Intestine	Stool	Ingestion of fish
Diphyllobothriasis– tapeworm	*Diphyllobothrium latum*	Intestines, blood	Stool (microscope)	Ingestion of raw fresh water fish
Echinococcosis – tapeworm	*Echinococcus granulosus, Echinococcus multilocularis, E. Vogeli, E. Oligarthrus*	Liver, lungs, kidney, spleen	Imaging of hydatid cysts in the liver, lungs, kidney and spleen	As intermediate host, ingestion of material contaminated by feces from a carnivore; as definite host, ingestion of uncooked meat (offal) from a herbivore
Beef tapeworm	*Taenia saginata*	Intestines	Stool	Ingestion of undercooked beef
Cysticercosis-Pork tapeworm	*Taenia solium*	Brain, muscle, Eye (Cysts in conjuntiva/anterior chamber/sub-retinal space)	Stool, blood	Ingestion of undercooked pork
Bertielliasis	*Bertiella mucronata, Bertiella studeri*	Intestines	Stool	Contact with non-human primates
Sparganosis	*Spirometra erinaceieuropaei*			Ingestion of material contaminated with infected dog or cat feces (humans: dead-end host)

Impact of Flukes on human-beings: Fluke infects the human liver and other mammals. The name of the parasite is Fasciola heptica, commonly called liver fluke. The parasite causes a disease called Fasciolosis or Fascioliasis. This type of infection is categorized as tropical disease. The liver fluke is commonly distributed throughout the world and it was an important parasite in sheep and cattle. The fasciola heptica is common species of fluke category. It is largest one and the maximum length of the species is 30mm and width 13mm naturally. But it will grow upto 75mm length. The adult flukes are thick and fleshy, the shape of parasite is oval, reddish brown in colour. It look like a leaf-shaped, flat and the back is pointed (posterior) and the front is wide (anterior). It has a powerful part that is oral sucker and it is small and cone-shaped projection. The fluke lays the egg it is golden brown in colour.

The liver fluke infection is not a communicable disease. The infection is spread by drinking contaminated water and eating infected fish in a freshwater. The indication of fluke infection is yellow-brown eggs present in stool. The Enzyme-linked immunosorbent assay (ELISA) test is also prescribed for the diagnosis of fluke infection. The major symptoms of fluke infection is weight loss, hives, fever, malaise and abdominal pain. The drug triclabendazole is used to treat fluke infection. Wash the fruits, vegetables properly before cooking.



Common name of organism	Latin name (sorted)	Body parts affected	Diagnostic specimen	Mode of Transmission
Clonorchiasis	*Clonorchis sinensis*; *Clonorchis viverrini*	Gall bladder ducts and inflammation of liver		Ingestion of under prepared freshwater fish
Lancet liver fluke	*Dicrocoelium dendriticum*	Gall bladder		Ingestion of ants
Liver fluke – Fasciolosis[10]	*Fasciola hepatica*, *Fasciola gigantica*	Liver, gall bladder	Stool	Freshwater snails
Fasciolopsiasis – intestinal fluke[11]	*Fasciolopsis buski*	Intestine	Stool or vomitus (microscope)	Ingestion of infested water plants or water (intermediate host: amphibic snails)
Metagonimiasis – intestinal fluke	*Metagonimus yokogawai*		Stool	Ingestion of undercooked or salted fish
Metorchiasis	*Metorchis conjunctus*			Ingestion of raw fish
Paragonimiasis, lung fluke	*Paragonimus westermani*; *Paragonimus africanus*; *Paragonimus caliensis*; *Paragonimus kellicotti*; *Paragonimus skrjabini*; *Paragonimus uterobilateralis*	Lungs	Sputum, feces	Ingestion of raw or undercooked freshwater crabs crayfishes or other crustaceans

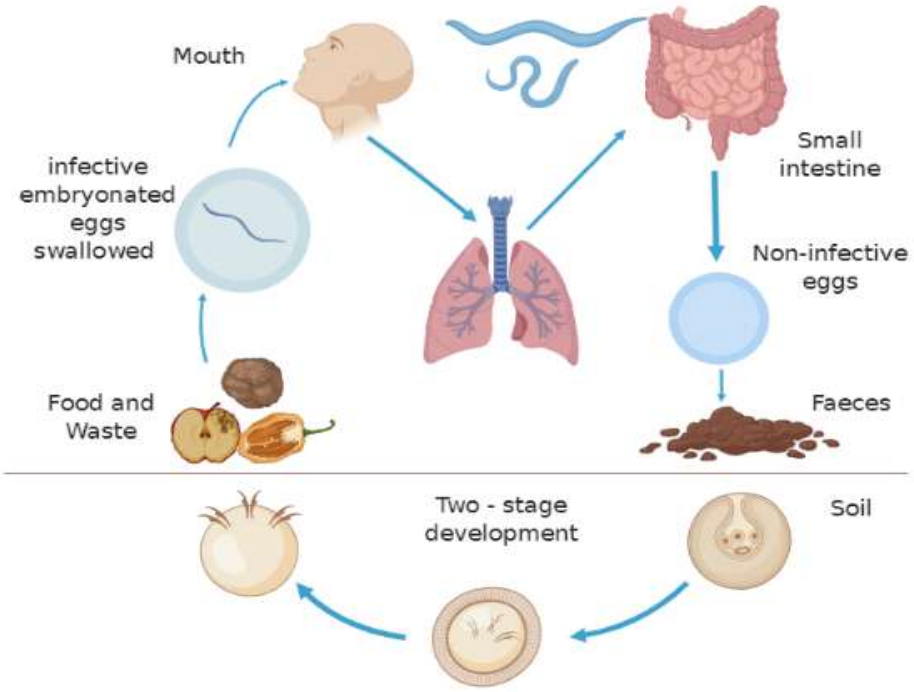
Intestinal schistosomiasis	*schistosoma mansoni* and *schistosoma intercalatum*	Intestine, liver, spleen, lungs, skin, rarely infects the brain	Stool	Skin exposure to water contaminated with infected *biomphalaria* freshwater snails
Urinary blood fluke	*schistosoma haematobium*	Kidney, bladder, ureters, lungs, skin	Urine	Skin exposure to water contaminated with infected *bulinus* sp. Snails
Schistosomiasisby *Schistosoma japonicum*	*Schistosoma japonicum*	Intestine, liver, spleen, lungs, skin	Stool	Skin exposure to water contaminated with infected *Oncomelania*sp. Snails
Asian intestinal schistosomiasis	*Schistosoma mekongi*	Intestine, liver, spleen, lungs, skin	Stool	Skin exposure to water contaminated with infected *Neotricula aperta* – freshwater snails
Swimmer's itch	*Trichobilharzia regenti*, Schistosomatidae	Intestine, liver, spleen, lungs, skin	Stool	Skin exposure to contaminated water (snails and vertebrates)

Impact of Roundworms on human-beings: Round worms are commonly classified as Nematoda family. It is large in size and the normal growing length of the worm is 25 to 35cm. Ascaris are most common parasitic worms in humans. It cause infectious disease- Ascariasis. Round worm is milk white in colour but normally it presents as a reddish-yellow shade. The shape of the body is cylindrical, elongated and gradually tapering at both ends.

It has multicellular smooth insects and unsegmented bodies. Round worms mostly cause soil transmitted infections. Because the soil is contaminated by faeces, in that live eggs of parasitic worms are present. The round worm can live in small intestine up to 2 years and it can grow 12 to 14 inches long inside the human intestine. The worms reproduce quickly, particularly the female worms will lay above 200,000 eggs in a day.

The parasitic infection of Round worm can be spread from person to another person through infected faeces. The major symptoms of this paraite infection are Vomiting, stomach pain, fever, worms in a bowel movement that look like earthworms, loss of appetite.

Round worms are treated by taking medicines like Albendazole, Mebendazole, Pyrantel. The infection is prevented by taking care of personal hygine. Fruits and vegetables are washed thoroughly and cooked well before eating. Wash yours hands with disinfectants. It will help to prevent the humans from soil transmitted parasitic infections.



Common name of organism or disease	**Latin name (sorted)**	**Body parts affected**	**Diagnostic specimen**	**Mode of Transmission**
Ancylostomiasis/Hookworm	*Ancylostoma duodenale*, Necator americanus	Lungs, small intestine, blood	Stool	Penetration of skin by L3 larva
Angiostrongyliasis	*Angiostrongylus costaricensis*	Intestine	Stool	Ingestion of infected faeces or infected slugs
Anisakiasis[12]	*Anisakis*	Allergic reaction	Biopsy	Ingestion of raw fish, squid, cuttlefish, octopus
Roundworm – Parasitic pneumonia	*Ascaris* sp. *Ascaris lumbricoides*	Intestines, liver, appendix, pancreas, lungs, Löffler's syndrome	Stool	Ingestion of raw fish, squid, cuttlefish, octopus
Roundworm – Baylisascariasis	*Baylisascaris procyonis*	Intestines, liver, lungs, brain, eye	Stool	Stool from raccoons
Roundworm-lymphatic filariasis	*Brugia malayi*, *Brugia timori*	Lymph nodes	Blood samples	Arthropods
Dioctophyme renalis infection	*Dioctophyme renale*	Kidneys (typically the right)	Urine	Ingestion of undercooked or raw freshwater fish
Gnathostomiasis	*Gnathostoma spinigerum*, *Gnathostoma hispidum*	Subcutaneous tissues (under the skin)	Physical examination	Ingestion of raw or undercooked meat (e.g., freshwater fish, chicken, snails, frogs, pigs) or contaminated water
Halicephalobiasis	*Halicephalobus gingivalis*	Brain	Scanning	Soil-contaminated wounds
Loa loa filariasis, Calabar swellings	*Loa loa filaria*	Connective tissue, lungs, eye	Blood (Giemsa, haematoxylin, eosin stain)	Tabanidae – horsefly, bites in the day
Mansonelliasis, filariasis	*Mansonella streptocerca*	Subcutaneous layer of skin		Insect
River blindness, onchocerciasis	*Onchocerca volvulus*	Skin, eye, tissue	Bloodless skin snip	*Simulium*/black fly, bites during the day
Strongyloidiasis – Parasitic pneumonia	*Strongyloides stercoralis*	Intestines, lungs, skin (Larva currens)	Stool, blood	Skin penetration
Thelaziasis	*Thelazia californiensis*, *Thelazia callipaeda*	Eyes	Ocular examination	*Amiota (Phortica) variegata*, *Phortica okadai*
Toxocariasis	*Toxocara canis*, *Toxocara cati*	Liver, brain, eyes (*Toxocara canis* – visceral larva migrans, ocular larva migrans)	Blood, ocular examination	Pica, unwashed food contamined with *Toxocara* eggs, undercooked livers of chicken
Trichinosis	*Trichinella spiralis*, *Trichinella britovi*, *Trichinella nelsoni*, *Trichinella nativa*	Muscle, periorbital region, small intestine	Blood	Ingestion of undercooked pork
Whipworm	*Trichuris trichiura*, *Trichuris vulpis*	Large intestine, anus	Stool (eggs)	Accidental ingestion of eggs in dry goods such as beans, rice and various grains or soil contaminated with human feces

Elephantiasis – Lymphatic filariasis	*Wuchereria bancrofti*	Lymphatic system	Thick blood smears stained with hematoxylin.	Mosquito, bites at night

Impact of Other organisms on human-beings

Common name of organism or disease	Latin name (sorted)	Body parts affected	Diagnostic specimen	Transmission/Vector
Acanthocephaliasis	Archiacanthocephala, *Moniliformis moniliformis*	Gastrointestinal tract, peritoneum, eye	Faeces, parasite itself	Ingestion of intermediate hosts
Halzoun syndrome	*Linguatula serrata*	Nasopharynx	Physical examination	Ingestion of raw or undercooked lymph nodes (e.g. meat from infected camels and buffaloes)
Screwworm, Cochliomyia	*Cochliomyia hominivorax* (family Calliphoridae)	Skin and wounds	Visual	Direct contact with fly
Chigoe flea	*Tunga penetrans*	Subcutaneous tissue	Physical examination	
Human botfly	*Dermatobia hominis*	Subcutaneous tissue	Physical examination	Mosquitoes and biting flies

Levels of infectiousness: Helminth eggs contained in wastewater, sewage sludge or human excreta are not always infectious i.e. able to cause the disease helminthiasis. Fertilized eggs and unfertilized eggs can exist side by side. Unfertilized eggs are identifiable under the microscope by their elongated shape. No larvae can hatch from these kinds of eggs. Therefore, unfertilized eggs do not pose a danger to human health.

In the case of Ascaris lumbricoides (giant roundworm), which has been considered the most resistant and common helminth type, eggs are fertilized and deposited in the soil opposing to desiccation but are, at this stage of development, very sensitive to environmental temperatures: The reproduction of a fertilized egg within the eggshell develops at an environmental soil temperature about 25 °C which is lower than the body temperature of the host (i.e. 37 °C for humans)[5].

However, development of the larvae in the egg stops at temperatures below 15.5 °C and eggs cannot survive temperatures much above 38 °C. If the temperature is around 25 °C, the infectiousness occurs after nearly 10 days of incubation.[1,4,18] Finally, after 2 to 4 weeks in moist soil at optimal temperature and oxygen levels, the embryo develops into an infective larva, named "second-stage larva". This larva has the ability to get out of the egg, hatch in the small intestine and migrate to different organs. These infective larvae (or "infective eggs") may remain possible in soil more than a years or longer[5].

Indicator organism: Helminth eggs (or ova) are a good indicator organism to assess the safety of sanitation and reuse systems because they are the most environmentally resistant pathogens of all pathogens (viruses, bacteria, protozoa and helminths) and can in extreme cases survive for several years in soil[15]. Therefore, the presence or absence of viable helminth eggs ("viable helminth egg" means that a larva would be able to hatch from the egg) in a sample of dried fecal matter, compost or fecal sludge is often used as an indicator to assess the efficiency of diverse wastewater and sludge treatment processes in terms of pathogen removal.

In particular, the number of viable Ascaris eggs is often taken as an indicator organism for all helminth eggs in treatment processes as they are very common in many parts of the world and relatively easy to identify under the microscope. However, the exact inactivation characteristics may vary for different types of helminth eggs.[1]

Conclusion

The review study concludes helminths classification and its impact on human beings. This study clearly concluded the helminths like flukes (Trematodes), Tapeworms (Cestodes) and Roundworms and their mode of transmission in humans. Helminthiasis is of chronic disease which causes more morbidity. Based on the nature of the species, helminths drugs can be used for the treatment of helminthiasis.

The Anthelmintics drug treatment must be used in chemotherapy programmes in those regions where clinical support is sparse and where drugs are very well tolerated in humans. For the last few years a small quantity of drugs especially ivermectin, albendazole, piperazine, emodepside have addressed the need whereas ivermectin has been hugely successful both in veterinary and tropical medicine.

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