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HELMINTHES THAT ARE TRANSMITTED THROUGH FOOD TO HUMANS

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Abstract

Helminthes which contaminate food cause different diseases in humans and animals, many of which are zoonoses. The largest number of species of parasites infect humans and animals entering through the contaminated food and water, but it is possible infection through skin - by arthropods.

Helminthes are mostly parasites of the small intestine and people from the body eliminate eggs or larvae of helminths through faeces. In order these eliminated forms of the parasites to became infectious for susceptible animals, they have to perform part of its development freely in the external environment or in one or two transitional host. Helminths are divided into two phylums: *Plathelmintes* (tapeworms - flukes and cestodes) and *Nemathelmintes* (roundworms). The most common helminths that can be transmitted through food to humans are flukes (*Fasciola hepatica, Dicrocoelium lanceolatum, Opistorchis felineus, Paragonimus* spp., *Fasciolopsis buski*), cestodes (*Taenia solium, Taenia saginata, Diphyllobotrium latum, Echinococcus granulosus, Dipilidium caninum, Taenia multiceps, Spirometra* spp., *Hymenolepis nana)*, nematodes (*Anisakis simplex, Ascaris lumbricoides, Enterobius vermicularis, Trichuris trichiura, Trichinella spiralis, Gnathostoma* spp., *Toxocara canis, Ancylostoma duodenale, Necator americanus)*. Some of them are described in this paper. In order to prevent the diseases, it is necessary to know well all possibilities of contamination of food by these parasites, their life cycle and resistance in the environment.

Significant measures to prevent the occurrence helminthoses transmitted through food and water are: adequate implementation of hygiene measures during production, processing, preparation and consumption of food, appropriate thermal treatment of food, personal hygiene measures, hygiene of environment, bio-thermally treatment of manure and others.

***Key words**: Helminthes, Food, Flukes, Cestodes, Nematodes, Diseases, Life cycle.*

1. Introduction

A large number of parasitic diseases in humans and animals are caused by helminths, many of which are zoonoses. The largest number of species of parasites infect humans and animals entering the contaminated food and water, but it is possible and infection through skin - by arthropods. Infected animals and people eliminate from the body eggs or larvae of helminths. In order to eliminated forms of the parasite became infectious for susceptible animals, must to perform part of its development freely in the external environment or in one or two transitional host. Helminths are multicellular beings in which has occurred differentiation of certain organs. They have bilateral symmetry and bodily layer - the cuticle. The cuticle can be very strong and armed with various formations. Under the cuticle is layer of connective tissue, and below it is the muscle layer. They have not bloodstream. Size of the body of helminths is different, ranging from 2 mm to 12 m. These are mostly parasites of the small intestine. Helminths are divided into two phylums: *Plathelmintes* and *Nemathelmintes*. Phylum *Plathelmintes* are flat blade worms. Their body is flattened, body cavity does not exist, mainly hermaphrodites (class *Trematoda*, *Cestoda*). They have no digestive organs, feed via osmosis through porous cuticle entire surface of the body. Phylum *Nemathelmintes* are cylindrical worms, there is a body cavity, sexual dimorphism is clearly pronounced. They have the digestive tract and feed through the mouth; undigested

fraction is excreted from the body through the anus of the parasite - cloaca or via the mouth, if there is no anus (Kulišić [3], Parija [4]).

The most common helminths that can be transmitted through food to humans are flukes: *Fasciola hepatica, Dicrocoelium lanceolatum, Opistorchis felineus, Paragonimus spp., Fasciolopsis buski;* cestodes: *Taenia solium, Taenia saginata, Diphyllobotrium latum, Echinococcus granulosus, Dipilidium caninum, Taenia multiceps, Spirometra spp., Hymenolepis nana)*; nematodes: *Anisakis simplex, Ascaris lumbricoides, Enterobius vermicularis, Trichuris trichiura, Trichinella spiralis, Gnathostoma* spp., *Toxocara canis, Ancylostoma duodenale, Necator americanus* (Koneman *et al.,* [1], Mahon and Manusels [2], Kulišić [3], Parija [4], Dimitrijević [5]). Some of them are described in this paper.

2. The most important helminthes that transmitted through food to humans

2.1 Phylum *Plathelmintes*

2.1.1 Class *Trematoda*

Around the mouth of trematoda are leeches of circular muscle fibers; abdominal leech used for fixing to the substrate. The cuticle can be smooth or have barbs or hooks. They have digestive and genital organs. They are hermaphrodits (Kulišić [3], Mehlhorn [6]).

2.1.1.1 Fasciola hepatica

The most common trematode that transfers by food to people is a big fluke, *Fasciola hepatica*. Adults parasite causes fascioliasis of people and animals; is leaf shape, a length of about 30 mm and a width of 13 mm (Figure 1); parasitizes in the bile ducts of sheep, cattle, man. The most common clinical symptoms in a human are severe headache, back pain, fever, abdominal pain, diarrhea, icterus, hepatomegaly, ascites, anemia, abscess and liver cirrhosis (Espinosa *et al.,* [7]).

Figure 1. *Fasciola hepatica* - adult parazite (Source: https://www.k-state.edu/parasitology/625tutorials/Hepatica.html [28])

Adult liver fluke damages bile ducts, liver cells, resulting in bleeding, swelling and inflammation of the connective tissue. This parasite produce toxic metabolites that additional damage of bile ducts and the liver. It can that come up to its penetration in other organs and tissues. As a result of tissue damage, the liver becomes a place for reproduction bacteria present in the bloodstream that are coming in the digestive tract, which leads to further complications. For his development is essential real – definitive host (sheep, cattle, man) and transitional host - freshwater snail *Galba truncatula*. Adult forms in the bile ducts secrete eggs, which come in intestine, and are excreted from the digestive tract with feces (Šibalić and Cvetković [8], Dimitrijević [5]).

In the external environment, in the water, the eggs are developing in larva - miracidium. To survive, miracidium need to find a water snail maximum for 8 hours. When penetrates into the water snail, are developed in the larval forms: sporocysts, rediae and cercariae. Cercariae leave the snail and swim to plants. On plants attach, lose tail and obtain a protective membrane. Encapsulated larva is called metacercaria. Metacercaria are resistant to the effects of external factors and in the hay can remain in life and up to 8 months. When a man, cattle, sheep enter metacercaria with the food, they penetrate through the mucous membrane of the intestine and through the circulation to the liver. In the bile ducts larva continues its development to the adult stage. Liver fluke occurs in underwater areas that are favorable for the development of the freshwater snail. Most often they catch people who entered into the digestive tract of wild edible plants with flood areas that are contaminated with metacercariae. For the purpose of prevention of these diseases in humans should avoid feeding plant foods contaminated with metacercaria (Kulišić [3]).

2.1.2 Class *Cestoda*

Cestode are flat worms whose body was divided into segments called proglottids. Their length ranges is from 5 mm to 12 m. The first part is called scolex (head) and may be different sizes. Behind scolex continues neck and body (strobila). Scolex have a leech that may be elongated or circular, with the muscle fibers which are used for fastening. Some tapeworm leeches are armed with hooks lined up in several wreaths. Some cestodes leeches are in the form of longitudinal pits or cracks and called botridiae. It can be found and creation – rostrum (rostellum) at the front scolexes, which can be of different shapes: round, square and the like. Rostrum is armed by prickle or hooks that are chitinous and dark brown. Strobila consists proglottids. Excretory organs excreted metabolites through the *foramen caudale*. Some of the metabolites cause haemolysis and other severe consequences for the host (Kulišić [3], Mehlhorn [6]).

2.1.2.1 Taenia solium and *Taenia saginata*

These are large tapeworms parasitize in the small intestine of humans. Cause a disease called teniaza. Adult cestodes with the help of the rostrum (rostellum) and bothridia (bothria) are fixed to the mucosa of the digestive tract and lead to intestinal mucosal damage. Only one larva is sufficient to reach the digestive tract of a man, to develop an adult tapeworm. Symptoms of the disease are abdominal pain, weight loss, and in particular the symptoms are expressed in persons of weak immunity and suffering from some disease.

The real host is man, in which it develops an adult tapeworm; transitional host for *T. saginata* are cattle, and for *T. solium* pig. Humans ejected eggs of adult tapeworms with faeces, which are infective for transitional hosts. When the intermediate host, cattle or swine, enter the eggs of tapeworms, egg comes out the larva oncospheres that through the intestinal mucosa enter in circulation and reach to other tissues and organs, in particular the muscles, the connective or intramuscular tissue. Here, the larvae attach and receive a form of berries that are filled with watery fluid that is under pressure. When a person enters inadequately cooked pork or beef contaminated meat, larvae are attached to the wall of the small intestine. Feeding by the juices of the intestinal contents, from larva develops fully mature tapeworm. Tapeworm *T. solium* is usually the length of 180-400 cm and was recorded and its length of 800 cm. It contains 800 to 900 proglottids (Figure 2).

Figure 2. *Cestoda Taenia solium* - adult vorm (Source: http://www.infectionlandscapes.org/2012/08/tapeworms.html [29])

Gravid proglottids that are filled with mature eggs are removed from the body of tapeworms and together with faeces are excreted into the environment. *T. solium* is additionally dangerous for man, because a man can be a transitional host - from an egg that man eats can develop berries - cysticerci most often in brain tissue, as well as to any other tissues. The disease is most common in developing countries where people are in close contact with pigs or consume inadequately cooked berries meat of pigs and cattle (García *et al.,* [9], Nunes *et al.,* [10]).

2.1.2.2 Diphylobotrium latum

This tapeworm in the larval stage parasites in freshwater fish, and as adults form in different mammals, bears, humans and others. In humans causes a disease called difilobotriaza. The adult tapeworm is long and up to 10 m, and parasites in the jejunum and ileum, grasping with bothridia to the intestinal wall. The most common clinical signs of disease are enlarged abdomen, abdominal bloating, abdominal cramps, diarrhea, weight loss, weakness, anemia, nervous disorders. Most of the characters are created as a result of the toxic effects of metabolic products tapeworms. Anemia is due to the lack of vitamin B12.

From pregnant proglottids adult tapeworm released eggs which are excreted together with the faeces of diseased man. In water, larva develops in coracidium which, in order to survive, must swallow freshwater crayfish of the genus *Cyclops*. In the crayfish is develops larval stage procercoid. Feeding the crayfish, in the muscle tissue of fish for 1 - 4 weeks developing plerocercoid size 2 - 4 cm. Definitive host, man and other mammals are invaded by consumption of fish meat with plerocercoid. From plerocercoid in the gut develops adult tapeworm. For the invasion of the definitive host is sufficient only one plerocercoid. Clinical symptoms usually occur after ten days of eating raw, insufficiently cooked or canned fish. The disease is most common in areas where the population is predominantly food raw or inadequately cooked, short-dried, also inadequately canned or improperly frozen fish. Freezing temperatures must be at least -18 ^{0}C (Baltić and Teodorović [11], Chiodini *et al.,* [12], Scholz *et al.,* [13]).

2.1.2.3 Echinococcus granulosus

This is the tapeworm that causes disease in humans and animals that is called echinococcosis or hydatidosis. An adult tapeworm (Figure 3) parasites in the small intestine of the dog that is the definitive host, whereas larval stage develops in the tissues of intermediate host (man, cattle, pigs, sheep, etc.), which is in the form of cysts (hydatid bubble). The man was infected when through the digestive tract brought eggs tapeworms - which secretes with dog faeces into the environment. When the eggs reach in the small intestine of man, out of them exit oncospheres penetrating the mucosa, and via the bloodstream comes in all tissues and organs. Most often stops in the liver and in the kidneys, lungs, spleen, heart, muscle, brain, bone marrow. The cysts develop protoscolex - head of the parasite, which are infective for the definitive host - dog. The disease can be induced with a one egg. Larva in tissues and organs done mechanically pressure on them, due increase cyst. Symptoms of the disease can occur earliest if the cyst develops in the eye or brain. If the cysts found in the bones, the disease is manifested by severe pain

and bone fractures. Spraying cyst located in the lungs can leads to serious complications and suffocation due to obstruction of the airways. To suffocation can cause and allergic - anaphylactic reaction on exempt the contents of cysts. This disease occurs more frequently in people who have poor hygiene (washing hands before eating), as well as eating unwashed vegetables and fruits that can be potentially contaminated with eggs that are excreted dogs. Sheepdogs who feed thermally untreated sheep offals can be a significant source of infection for humans and other animals - transitional hosts. Order problem and reservoir tapeworms are stray dogs. How could the the danger of this disease maximally reduce or to eradicate the disease, it is important to conduct regular dehelmintization dogs, control of stray dogs, control of slaughter and prevention of nutrition dogs hygienically unfit meat and offals (Milačić [14], Šibalić and Cvetković, [8], Harandi *et al.,* [15], Rigano *et al.,* [16]).

Figure 3. *Cestoda Echinococcus granulosus* - adult worm (Source: http://www.k-state.edu/ parasitology/546tutorials/PlatyQuery26 [30])

2.2 Phylum *Nemathelmintes* - roundworms

Roundworms are parasites cylindrical and elongated shapes, different sizes. Females can be oviparous, ovoviviparous and viviparous. Oviparous lay only eggs that are not embryonated. Ovoviviparous laid embryonated eggs and viviparous lay live larvae.

2.2.1 Class *Secernentea*

2.2.1.1 Anisakis simplex

Larval form of a roundworm causes disease of people called anisakiasis. The man is invaded when eaten raw or inadequately roasted fish containing live *Anisakis larvae*. In order to the disease of humans appeared is sufficient consumption of a single parasite larvae. By the penetration of the intestinal mucosa causes inflammatory reaction, formation granuloma and bleeding tumor. As a result inflammation comes till of the wall thickening of the bowel, intestinal obstruction, and the occurrence of peritonitis and abscess. The disease is characterized by vomiting, diarrhea, stomach pain, fever, bloody diarrhea, throat inflammation etc. Since at anisakidosis generally occurs very strong pain, it is very often the larvae must be surgically removed. Except for the herring (what is called the herring worm) this parasite is found in other species of marine fish, such as mackerel, hake, grouper, as well as freshwater fish such as salmon and other salmonids. Adult parasite is normally found in the digestive tract of marine mammals (whale, seal, dolphin). Development cycle begins by excretion eggs of adult parasites in the faeces of marine mammals in the sea water. The first transitional host crayfish of the genus *Cyclops* is brought embryonated eggs, larvae in them further develop and become infectious for marine fish and molluscs. Infested fish eat other fish, marine mammals, birds or man. Evisceration of internal organs of fish immediately after the catch prevents the possibility of migration of larvae from the abdominal cavity in the muscle tissue. By cutting of muscle tissue of the belly is reduced number of larvae in the meat. Salting, marinating and cold smoking of fish do not destroy the larvae. Inactivation of the larvae to be executed by freezing fish. The temperature of -20^{0}C destroys the larvae for 60 hours. Them destroys elevated temperature of 50^{0}C to 52^{0}C for 40 seconds (del Pozo *et al.,* [17], Baltić and Teodorović [11], Kulišić [3], Ljubojevic *et al.,* [18]).

2.2.1.2 Ascaris lumbricoides

Ascaris lumbricoides is roundworm that in humans causes a disease called ascariasis. Adults worm parasites in the small intestine of humans (Figure 4). The females are long up to 40 cm and in the small intestine of people lay up to 200,000 eggs a day. During defecation of man, eggs ripen in the environment. In favorable environmental conditions eggs embryonated and in them is developed infective larvae. Eggs can be easily transmitted to other people through unwashed hands, objects or food. The eggs are very resistant to desiccation. Larva inside the egg can remain vital more than two years. The man is infected when enters food with embryonated eggs. From eggs in the duodenum exits larva. The released larva penetrates the intestinal mucosa, then though of blood stream is coming in liver and lung. From blood vessels of lung can enter in the alveoli, bronchi, trachea, from where they come in the pharynx. From the pharynx are swallowed and so come again in the digestive tract. In the small intestine, from the larvae develops adult worm. The worms can be found in the feces, pharynx, mouth and nose.

Invasion of a large number of larvae leads to pneumonia, fever and difficulty breathing, damage of blood vessels, blood clots. During migration, the larvae can penetrate not only the lungs, also in other organs,

which can lead to the appearance of abscesses and inflammation of the pancreas. Digestive disorders occur due to the presence of adult forms in the small intestine. Adult worms in children can lead to complete blockage of the intestine. Adult worms in the small intestine can reach the throat and cause suffocation. Adult forms may reach the bile duct and cause its blockage. Due to damage to the mucous membrane of the small intestine because of penetration of larvae and mechanical pressure of adult worms, occurs local bleeding and inflammation of the abdominal muscles. May occur allergic reactions of the metabolic products of the parasite, as well as substances which are released upon decomposition of dead parasites, which manifest as asthma and difficulty sleeping. Particular danger of infection the people represents eating of unwashed and uncooked vegetables and fruit which is grown on contaminated land. It is also important regularly to control food handlers on the presence eggs of parasites in faeces (Marinculić *et al.,* [19], Schüle *et al.,* [20].

Figure 4. *Ascaris lumbricoides* - adult worm (Source: pediatriaoriente.med.uchile.cl/parasitologia/fotosP/images/ascaris.jpg [31])

2.2.1.3 Enterobius vermicularis

This cylindrical worm parasitizes in the large intestine of man and cause disease enterobiosis. Females are 8 - 13 mm and males up to 5 mm in length. Sexually mature worms are usually at the turn of small in the large intestine, but also in other parts of the intestines. After adhesion to the mucous membrane of the intestine, worms feed by microorganisms and epithelial cells of the intestine. Females lay eggs in the area around the anus, in which rapidly developing infective larvae. Females usually at night exit from the body, so can be found in the area around the anus and in the feces. In doing so, cause inflammation, itching and redness of the skin. In the area around the anus can be found and eggs. Strong invasions manifest with insomnia, loss of body weight, hyperactivity, gnashing of teeth, abdominal pain and vomiting, which is particularly manifested in children. This disease is considered one of the most common in the world. In the United States this disease infected about 40 million people. Pregnant females can break through the hose to reach into the abdominal cavity and create granulomas in uterus and oviduct. They can also reach up to the urinary bladder and appendix. Since the infection comes through contaminated food and water, unclean hands of an infected person, in order to prevent the occurrence of this disease should take strict control of hygienic conditions of food and personal hygiene (Uçar *et al.,* [23], Jardine *et al.,* [24]).

2.2.2 Class *Enoplea*

2.2.2.1 Trichuris trichiura

This cylindrical worm parasitizes in the large intestine of man and causing disease trihuriasis. Females are longer than the males and lay about 5,000 eggs a day. Eggs are form of lemon with caps at both poles. The eggs in the faeces exit into the environment and embryonated relatively slowly in moist and warm soil. The man is invaded when swallowed embryonated eggs through food, water or dirty hands. The eggs in the small intestine release larvae that enter the intestinal mucosa and then migrate to the colon. In the large intestine develops adult form that penetrates its slim front part of the mucous membrane and feeds by the mucosal epithelial cells. Chronic invasion manifests by emergence tinge of blood in the faeces, pain in the abdomen and nausea. Due to bleeding caused by larvae that penetrate the mucous membranes, as well as blood-feeding adult worms, occurs anemia. At the site of penetration of larvae leads to secondary bacterial infections. The disease is mainly transmitted through uncooked vegetables and fruits that are grown in soil contaminated by eggs. Therefore, in order to prevent the occurrence of this parasitosis must be strictly take care of hygiene measures during the production of fruit, vegetables and personal hygiene by staff handling with food (Vavricka *et al.,* [21], Crowe *et al.,* [22]).

2.2.2.2 Trichinella spiralis

This cylindrical worm causes trichinelosis of people and animals. It can invade almost all mammals as well as birds and reptiles. Trichinelosis is a major health problem and it is believed that there are about 10 million infected people in the world. To the disease leads feeding with raw or undercooked meat that comes from animals infected by trichinellosis (pigs, horses, bears, wild game). Special hazards represent meat products if they are produced from contaminated meat. The most common clinical signs are manifested in humans are general weakness, fever with temperature 39 - 40 ^{0}C for 8 - 10 days, diarrhea, abdominal pain, muscle pain, headache, facial edema and eosinophilia. The larvae in migration lead to tissue damage, especially the heart and brain. Cardiovascular disorders are manifested in

the form of tachycardia and in chronic patients come to death. Changes on the nervous system are manifested with headache and meningitis (Ribich *et al.,* [25], Dorny *et al.,* [26], Bruschi and Murrell [27]).

Males *T. spiralis* are 1 - 1.5 mm in length, and females 2.5 - 3.5 mm. Invasive larvae of the first degree is a long 1 mm (Figure 5). After the entering of contaminated meat into the digestive tract, in the mucus of the small intestine free larvae ripen in adult parasites. After fertilization in the small intestine, females lay live larvae which by bloodstream migrate through the body and encapsulate it in the striated muscle tissue. Encapsulated larvae become infective for 15 days. As measures to prevention the disease is most important to carry out the inspection meat of animals (domestic and wild pigs, bears) on the presence of larvae *T. spiralis* (Šibalić and Cvetković, [8]).

Figure 5. Larvae *Trichinellae spiralis* (Source: https://commons.wikimedia.org/wiki/File:Trichinella_larv1_DPDx.JPG [32])

3. Conclusions

- Helminthes that contaminate food cause different diseases in humans and animals, many of which are zoonoses. Infected animals and humans eliminate eggs and larvae of helminthes most often through feces.

- Significant measures to prevent the occurrence helminthoses transmitted through food and water are adequate implementation of hygiene measures during production, processing, preparation and consumption of food, appropriate thermal treatment of food, personal hygiene measures and hygiene environment, bio-thermally treatment of manure and others.

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