



Epidemiological and clinical characteristic of *Hymenolepis diminuta* infection – review of current literature

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ABSTRACT

Hymenolepis diminuta (rat tapeworm) is widespread worldwide, though in comparison to *H. nana* it is less frequent in humans (accidental host). The definite hosts, as well as the natural reservoir of *H. diminuta*, are small rodents. Literature on the subject reports that the predisposition to infestation with this tapeworm mainly concerns small children and adults from a poor socioeconomic background. The epidemiological data presented

in this article provide the latest scientific information on the prevalence of this parasite, the course of hymenolepiasis, as well as the treatment method. Owing to the low prevalence of hymenolepiasis in humans, the diagnosis, analysis and description of the course of the disease in humans provides new and crucial information on *H. diminuta* infection.

Keywords: hymenolepiasis; tapeworm; epidemiology.

INTRODUCTION

The rat tapeworm *Hymenolepis diminuta* (Cestoda) is a common intestinal parasite of small rodents, such as mice and rats. It is common in temperate and tropical climate zones. Even though it is a rat parasite, there are reported cases of infections in people as accidental hosts [1, 2, 3, 4, 5, 6]. Owing to the simple lifecycle of *Hymenolepis diminuta*, it is used as a model parasite in studies on the parasite-host system. Experimental studies on the effect of *H. diminuta* infestation on a host's organism mostly use the rat model. The mouse model is not as applicable due to the overly increased activity of the immune system in primary and secondary infections [7, 8]. It is proven that the tapeworm is not excreted from the body of a rat infected with a small number of parasites (10–20). Therefore, *H. diminuta* may live as long as its host (to 14 years) [6, 9, 10, 11, 12, 13].

STRUCTURE AND LIFECYCLE OF *H. DIMINUTA* RUDOLPHI, 1819

The structure of *H. diminuta* comprises: the scolex (head), the neck, which is where new segments of tapeworm are present, and proglottids (segments) forming the strobila. The strobila of an adult tapeworm can be as long as 20–60 cm and have the thickness of 3–5 mm. The length of *H. diminuta* is determined by the extent of infection (the so-called crowding effect). There are reports of 90 cm long specimens. The parasite has 800–1000 proglottids of 3.5 mm in width and 0.76 in length – Figure 1 [8, 14, 15, 16].

Since the tapeworm has both male and female reproductive organs, each segment contains a complete set of internal organs. The terminal segments (uterine segments) are the

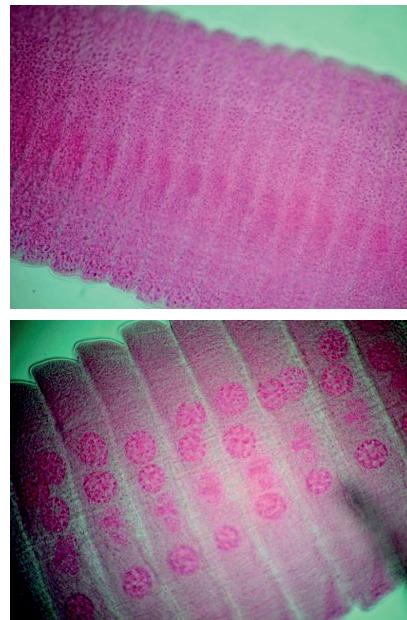


FIGURE 1. Proglottids of rat tapeworm (*Hymenolepis diminuta*): A – at 10 x magnification (original photography); B – filled at 10 x magnification (original photography)

place of maturation of individual organs at a given time interval, with male organs maturing as first producing spermatozoa, followed by maturation of the female organs – ovaries. The scolex does not have hooks, but is equipped with 4 suckers allowing attachment to the host's intestinal wall – Figure 2 [17, 18].

Similarly to other tapeworms, *H. diminuta* does not have a circulatory system, nor a digestive system, and absorption of small intestine matter rich in nutrients (the host's digestive milk) occurs through the whole body surface through the



FIGURE 2. Scolex and neck of rat tapeworm (*Hymenolepis diminuta*) at 10 x magnification (original photography)

cuticle. The cuticle has a vital role in the process of excreting metabolic products, it secretes substances covering the body of the parasite to protect it from the action of digestive enzymes produced by the host. Below the cuticle is a dermato-muscular epithelium – tegument. The muscular system of this parasite is very complex. Underneath the epithelial tissue, the locomotor system is built from myocytes which form a circular layer (located externally), the longitudinal layer (located deeper) and myofibrils. Myocytes are characterised by the presence of cellular organelles including a nucleus, rough endoplasmic reticulum, ribosomes, the Golgi apparatus, mitochondria as well as lipids and glycogen. Myofibrils consist of actin and myosin, responsible for contractility and movement production. Below the layer of muscles are myoblasts and parenchymal cells. Additionally, there are calcareous corpuscles between the parenchyma cells. The nervous system of *H. diminuta* consists of 2 main nerve trunks extending laterally. The transverse plexus (the central, cerebral ganglion) is located in the head, and the subcutaneous nervous system plexuses extend along the body below the tegument epithelium. The trunks branch in segments, allowing the tapeworm to react to tactile stimulation [3, 17, 18, 19, 20, 21, 22].

The eggs of the parasite are ovoid or slightly oval and 60–85 µm in diameter, with a thick striated external sheath and a thin internal sheath. Additionally, the oncosphere of the egg does not contain polar filaments of the external sheath, but instead contains 6 characteristics centrally located hooks – Figure 3 [2, 17, 23].

The lifecycle of *H. diminuta* involves 2 hosts: the intermediate hosts include beetles (*Tenebrio* and *Tribolium*), fleas (*Ctenocephalides*, *Xenopsylla*, and *Pulex*), cockroaches and caterpillars, and the definite host – mainly small rodents, most of all rats and mice. Following the arthropods ingesting the tapeworm eggs, the oncospheres penetrate into the host's intestinal wall. The cysticercoid maturation process lasts approx. 10–14 days. Following this, infestation of the definite host occurs following ingestion of the infected intermediate host and the release of mature cysticercoids. In the stomach and intestine of the definite host, the parasite reacts to the chemical signals and penetrates into the intestinal lumen. Then, it attaches to the intestinal mucosa and reaches maturity, about 18–24 days, producing more than 250,000 eggs every day. However, few of them

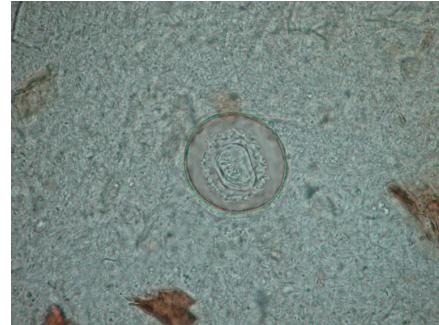


FIGURE 3. Egg of rat tapeworm (*Hymenolepis diminuta*): A – with 4 visible hooks at 40 x magnification (original photography); B – with 6 visible hooks at 40 x magnification (original photography)

reach full reproductive maturity. Releasing proglottids filled with eggs occurs with defecation by the infected definite host. In the case of people, infestation may take place due to accidental ingestion of food contaminated with insects or their faeces [2, 17, 23, 24, 25, 26].

EPIDEMIOLOGY

According to literature on the subject, the predisposition to be infected with intestinal parasite mainly concerns in small children and adults from poor socioeconomic backgrounds. Additional factors increasing the risk of intestinal parasite transmission include variable dietary habits and culinary tastes, and consumption of unwashed food or food of unknown origin. Other factors affecting the occurrence of parasitoses in people are socioeconomic conditions, low personal hygiene, migrations and social status. The difference between reported frequencies of infections between developing and developed countries is distinguishable, being higher most of all in countries with poor living conditions, e.g. lack of sewage system or poor access to drinking water or medicine [27, 28, 29, 30, 31, 32, 33, 34, 35].

Hymenolepis particularly affects children, though each age group have seen cases reported. Both in developing and developed countries, the greater likelihood of tapeworm transmission in small children is probably due to yet undeveloped hygiene habits and geophagy, while in developing countries, the risk of parasitosis is higher due to poverty, undernourishment, illiteracy, high population density and low socioeconomic status [28, 30, 32, 34, 36, 37, 38].

Epidemiological data indicate a constant rise in *H. diminuta* infections. So far, there have been approx. 500 cases reported worldwide, with the severity of the infection related to the population status in a given country. Infections have been reported in all continents. The reports of worldwide studies of various populations have shown the level of occurrence of *H. diminuta* in faecal samples is about 0.001–5.5%. There have been reports of infections in people, in Indonesia, Thailand, the USA, the Democratic Republic of São Tomé and Príncipe, Italy, Spain, Turkey, Jamaica, Iran, Malaysia, as well as in Poland – Table 1 [39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57].

The first cases of hymenolepiasis in people were reported as early as in 1935 in Thailand and in 1965 in the USA. The latter is the case of a 6-year-old boy from New York (USA), with a confirmed presence of cockroaches and rodents in his home [40, 58]. There have been other cases reported in the USA in the previous century concerning children of both sexes, with the confirmed presence of *H. diminuta* eggs in faeces (1975, 1985 and 1990) [42, 45, 46]. Almost 100 years ago in India, a cohort study of 8,000 faecal samples revealed 20 cases of hymenolepiasis in people [59]. The 4 most recent cases of hymenolepiasis were reported in a 12-year-old girl in 2008, an 18-year-old youth in 2013, a 10-year-old girl in 2014, and an 11-year-old boy in 2016 [49, 52, 53, 55]. India is marked with a gradually increasing number of infections with rat tapeworm, most likely due to insects being an ingredient of everyday food for millions of people. Entomophagy is common in south-eastern Asia and Mexico. More than 2,000 insect species are considered edible and constitute a source of not only protein but also vitamins and iron [60]. In the last 10 years, the presence of *H. diminuta* eggs in faecal samples has been identified worldwide: a 2-year-old girl in 2011 and a 43-year-old man in 2013 from Selangor (Malaysia), a 20-month-old boy from Turkey in 2015, and in 15-month-old boy from Iran in 2017 [36, 51, 56, 57]. The epidemiological data from Iran also show an increasing trend of reported cases of hymenolepiasis: in 1986 in a 10-year-old boy, in 1972 5 cases including 4 children aged 6–11, and in 2008 in a 16-month-old girl [39, 61, 62]. In Poland, hymenolepiasis in people is reported sporadically. In the period 1994–2019, there were 6 cases reported: in 1994, 1997, 2001, 2002, 2009 and 2014. The first 5 cases were reported in the annual reports of the Provincial Sanitary and Epidemiological Stations and epidemiological inquiries of the Department of Parasitology of the National Institute of Public Health – National Institute of Hygiene in Warsaw. The most recently reported case was that of a 3-year-old boy in 2014 in Starachowice [53, 63, 64, 65, 66, 67].

CLINICAL MANIFESTATION AND THE COURSE OF HYMENOLEPIASIS

Since the scolex of *H. diminuta* lacks hooks which could mechanically damage the epithelial tissue of the gastrointestinal tract, the parasite is classified as non-invasive. However, numerous studies show that the metabolites secreted by the parasite

may result in disorders of the digestive system of the host (rat) causing excessive production of saliva, inhibition of gastric juice secretion and an increase in the activity of trypsin in duodenal fluid. Furthermore, it was found that the adaptive mechanisms developed by *H. diminuta* deactivate the digestive processes in the host and, at the same time, limit the elimination of the parasite, as well as affect the immunological mechanisms and the activity of antioxidative enzymes, resulting in inflammation [68].

The symptoms of hymenolepiasis in people caused by *H. diminuta* are non-specific and at times are wrongly diagnosed as other illnesses. Rat tapeworm infections are often asymptomatic. In such cases, the disease shows a self-limiting course, and the incubation period amounts to 7 days. However, literature on the subject reports cases of symptomatic hymenolepiasis manifested in indigestion, nausea, abdominal pain, diarrhoea, fever and irritability. At times the occurrence of the following was reported: irritation, itching around the anus, enteritis, anorexia and allergic reactions – Table 1 [38, 40, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57].

DIAGNOSTICS

Modern parasitological diagnostics use a variety of diagnostic methods. As for diagnosing intestinal parasites, a golden standard has yet to be established. Consequently, there is an extremely wide range of methodological approaches. Nonetheless, parasitological diagnostics of *H. diminuta* mainly consists of microscopic inspection of samples. The most frequently used biological material used for the identification of rat tapeworm is faeces. It is vital that the material is sampled before the initiation of treatment or a relatively long time after ceasing (1–3 weeks). The use of antibiotics, laxatives, antidiarrheal and antiparasitic medicine, antacids and contrast media may hinder identification of disperse forms or prevent identification of the parasite in faeces. It is important to collect samples from 3 sources (preferably 3) and deliver to the laboratory in special stool sample containers (provided with a scoop). In order to obtain the most reliable result, 3 samples are routinely taken and examined. In case of evidence of the fragments of *H. diminuta* (proglottids), it is recommended that they be delivered to the laboratory in containers with a small amount of water. Most often, identification of tapeworm consists of determining the presence of eggs in a direct faecal smear exam with a saline solution or stained with Lugol's solution – Figure 4 [36, 39, 56, 69, 70].

TREATMENT AND PREVENTION

Literature on the subject provides few reports concerning the therapeutic procedures of treating hymenolepiasis, therefore clinicians have struggled to establish standards of treatment. Consequently, each reported case is an invaluable source of information and contributes to developing an effective mode

TABLE 1. List of clinical cases of *H. diminuta* infections worldwide

Symptoms of hymenolepidosis	Diagnostics/Indication	Interventions	Age	Gender	Region	Year	Study
Respiratory tract infections, for several months' anorexia, abdominal pain, listlessness and failure to gain weight, fever	<i>H. diminuta</i> eggs were detected in the direct stool preparation	piperazine citrate 500 mg 2ce daily for 7 days, quinacrine hydrochloride 100 mg daily for 5 days, dithiazine iodide 50 mg 3 times a day for 7 days and chloroquine phosphate 250 mg daily for 5 days	6-year-old	male	New York, USA	1962	Edelman et al. 1965 [40]
–	<i>H. diminuta</i> eggs were detected in the direct stool preparation	–	6–15-year-old	males/females	New Guinea	1971	McMillan et al. 1971 [41]
9/10 were asymptomatic, 1 inpatient case	<i>H. diminuta</i> eggs were detected in the direct stool preparation	niclosamide, praziquantel	20 month–55-year-old	males/females	Thailand	1935–1985	Wiwanikit 2004 [38]
Developed enteritis with periumbilical abdominal pain, vomiting, headache, diaphoresis and black stools	<i>H. diminuta</i> eggs were detected in the direct stool preparation	niclosamide 1 g the 1st day, 0.5 g per day for 6 days	9-year-old	female	USA	1975	Cohen and Mackey 1977 [42]
Small laceration at the anterior orifice of the anus	stool examination at the formal ether concentration method showed the presence of <i>H. diminuta</i> eggs	niclosamide (a 1 dose) 1 g and 2 h later bisacodyl (a 1 dose) – 5 g	21-month-old	female	Sabah, Malaysia	1979	Kan et al. 1981 [43]
Apparently healthy	the tests were made according to the modified Ritchie technique on fecal specimens preserved with 10% formal solution. <i>H. diminuta</i> eggs were detected in the direct stool preparation	–	0–3 4–12 >12-year-old	males/females	Democratic Republic of São Tomé and Príncipe	1983	Pampiglione et al. 1987 [44]
Fever, more than 10 watery stools per day, abdominal pain, and anorexia of 6 days duration	<i>H. diminuta</i> eggs and <i>Giardia lamblia</i> cysts were reported by the parasitology laboratory	furazolidone, 1 teaspoon p.o., QID (5 mg/kg/day) for 7 days to treat the giardiasis, niclosamide, 1 g p.o. to treat the <i>hymenolepis</i> infection	3.5-year-old	–	New York, USA	1985	Levi et al. 1987 [45]
Asymptomatic	<i>H. diminuta</i> strobili were detected in the direct stool preparation	niclosamide (500 mg, 1 dose)	17-month-old	male	North Carolina, USA	1990	Hamrick et al. 1990 [46]
Abdominal pain and anal pruritus, enuresis and restlessness, drowsiness and hypotony	Graham test verified the absence of <i>Enterobius vermicularis</i> eggs. Parasitological examination of concentrated stools revealed spherical eggs, they were identified as <i>H. diminuta</i> eggs	treatment with a 1 dose (10 mg/kg of body weight) of praziquantel was ineffective, but the parasite was eradicated after 3 treatment cycles with the same drug at dosages of 25 mg/kg/day for 5 days	5-year-old	female	Guadalajara, Spain	1997	Tena et al. 1998 [47]
Emission of tapeworm proglottids in his stool, the patient had episodes of itching and nocturnal restlessness	macroscopic and microscopic tapeworm examinations were suggestive of <i>H. diminuta</i> proglottids. Parasitological examination of concentrated stool samples revealed spherical eggs	niclosamide (1 g for the 1st day, 500 mg/day for the following 6 days)	2-year-old	male	Rome, Italy	2003	Marangi et al. 2003 [48]

Symptoms of hymenolepidosis	Diagnostics/Indication	Interventions	Age	Gender	Region	Year	Study
Abdominal pain, irritability and pruritis	<i>H. diminuta</i> eggs were detected in the direct stool preparation	–	12-year-old	female	Devgarh, India	2008	Watwe and Dardi 2008 [49]
Recurrent fever with abdominal pain, diffuse cutaneous itching, transient thoracic rash, and arthromyalgias, occasional emission of suspected taeneworm proglottids in stool	parasitological stool examinations were performed. <i>H. diminuta</i> eggs were found in the patient's stool	7-day cycle of oral niclosamide	2-year-old	male	Paterno, Italy	2007	Patamia et al. 2010 [50]
Abdominal discomfort and itchiness over the abdomen especially at night, occasional emission of suspected taeneworm proglottids in stool	microscopic examination demonstrated numerous spherical eggs <i>H. diminuta</i>	1 dose of praziquantel (20 mg/kg of body weight)	2-year-old	female	Selangor, Malaysia	2011	Rohela et al. 2012 [51]
Intermittent generalized maculopapular pruritic rash with vague left iliac fossa pain	<i>H. diminuta</i> eggs were detected in the direct stool preparation	2 doses of praziquantel 20 mg/kg on day 0 and 7	18-year-old	male	Odisha, India	2013	Karuna and Khadanga 2013 [52]
Slow weight gain	<i>H. diminuta</i> eggs found in the patient's stool	1st: 1 dose of albendazole (400 mg); 2nd: 1 dose of praziquantel 150 mg	3-year-old	male	Starachowice, Poland	2014	Kolodziej et al. 2014 [53]
Vomiting 3–4 times a day along with mud-like diarrhea continuing for a week	<i>H. diminuta</i> eggs were detected in the direct stool preparation	niclosamide (1 dose 500 mg and 250 mg on the following 5 days)	20-month-old	male	Turkey	2015	Kilincel et al. 2015 [36]
Abdominal pain, anal pruritus and nocturnal restlessness since the last 2–3 weeks	<i>H. diminuta</i> eggs were detected in the direct stool preparation	praziquantel (10 mg/kg body weight) for 7 days	10-year-old	female	Kendrapada district of Odisha, India	2014	Tiwari et al. 2014 [54]
Pain in the abdomen	<i>H. diminuta</i> eggs were detected in the direct stool preparation	–	11-year-old	male	North India	2016	Mane and Sangwan 2016 [55]
Abdominal colicky pain	endoscopy revealed worms in the lumen of the small intestine – identified as <i>H. diminuta</i>	1 dose of praziquantel (25 mg/kg)	43-year-old	male	Selangor, Malaysia	2013	Ahmad et al. 2017 [56]
Pain in the abdomen	<i>H. diminuta</i> eggs were detected in the direct stool preparation	1 dose of praziquantel	15-month-old	male	Guilan, Iran	2017	Sharifdini 2019 [57]



FIGURE 4. Egg of rat tapeworm (*Hymenolepis diminuta*) in a stool sample: A – at 40 x magnitude (original photography); B – at 20 x magnitude (original photography)

of treatment. The most frequently used drug of choice in the case of *H. diminuta* infection, both in children as well as adults, is praziquantel and niclosamide (Tab. 1). In most cases, a single dose has proven to be effective. The duration of treatment, however, seems to vary. Literature on the subject indicates the use of other substances and medicines in the treatment of rat tapeworm infection, e.g. piperazine citrate, quinacrine hydrochloride, dithiazanine iodide, chloroquine phosphate, bisacodyl and albendazole [36, 38, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 71].

Human infestation with rat tapeworm can be prevented by means of protecting the food against contamination by rodents and arthropods. Additionally, protective actions should be taken to raise the awareness of threats resulting from ingesting contaminated food and promote appropriate hygiene habits in children.

SUMMARY

Owing to the low worldwide prevalence of *H. diminuta*, each reported case of infection provides valuable research information with respect to the mechanisms in the parasite-host system. The analysis and description of the disease course provides insight into the treatment and prevention of *H. diminuta* infections. Undoubtedly, epidemiological data concerning hymenolepiasis reflects the worldwide transmission of the parasite and can indicate preventive actions. Knowledge of parasitic infections and resulting health threats, observing hygiene standards and improving sanitary conditions certainly contributes to lowering the prevalence of parasitic diseases.

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