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Neglected Zoonotic Enteric Parasitic Diseases: Echinococcosis, Cysticercosis, Foodborne Trematodes, and Ttrichinellosis-Review

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Abstract

NEGLECTED Enteric Zoonotic Parasitic Diseases (EZPDS) are a critical public health challenge worldwide, particularly affecting low-and middle-income countries, including various regions across Africa, Asia, and Latin America. This literature review aimed to provide an extensive synthesis of the current understanding of four prominent EZPDs: echinococcosis (hydatidosis), cysticercosis, foodborne trematodes, and trichinellosis, emphasizing their prevalence, diagnosis, prevention, and control measures in diverse geographical contexts. Echinococcosis, caused by *Echinococcus granulosus* and *Echinococcus multilocularis*, leads to severe health complications, including hydatid cyst disease, particularly in regions with livestock farming and inadequate sanitation. Effective diagnosis relies on imaging techniques, serological tests, and molecular methods, though awareness and healthcare access vary significantly. Cysticercosis, resulting from the larval stage of *Taenia solium*, is a leading cause of neurocysticercosis, with substantial public health implications in areas with poor sanitation, including sub-Saharan Africa, and Southeast Asia. Foodborne trematodes, including *Fasciola hepatica* and *Clonorchis sinensis*, are prevalent in many parts of the world, especially in regions with traditional dietary practices that heighten exposure to contaminated food and water. *Trichinella* spp. causing trichinellosis, pose additional health risks through consumption of undercooked meat, leading to gastrointestinal and muscular complications in humans. In conclusion, this review highlights the necessity for improved diagnostic methods and underscores the urgent need for community awareness and education, comprehensive strategies that encompass effective and integrated control measures to combat these neglected diseases globally.

Keywords: Echinococcosis, Cysticercosis, Foodborne-Ttrematodes, Trichinellosis, Diagnosis, Control.

Introduction

Zoonotic diseases, or zoonoses, are infections that transmitted from animals to humans, often in environments where humans and animals live in close proximity; this is particularly common in the developing world, where people rely heavily on livestock and poultry for food, economic stability, and agricultural work. However, the same animals that provide these vital resources also pose significant disease risks [1]. One critical subset of zoonotic diseases is neglected zoonotic diseases (NZDs), which predominantly affect impoverished communities, especially in low and middle-income countries. These diseases not only threaten public health but also undermine the livelihoods of those who depend on animals for survival [2]. Neglected parasitic zoonoses (NPZs), a category within NZDs, include diseases such as echinococcosis, cysticercosis, and foodborne trematode infections and trichinellosis. These parasitic infections continue to place a significant burden on global health, especially among vulnerable populations that closely linked to livestock production [3]. NPZs are prevalent in regions where poverty, poor sanitation, and insufficient healthcare intersect, these diseases, often associated with livestock, significantly reduce both human and animal productivity, perpetuating cycles of poverty and illness [4].

The impact of these zoonoses extends beyond individual health. In many rural areas, livestock is essential for economic stability, providing food, income, and security [5]. When animals infected with zoonotic diseases, not only are their owners at risk of contracting these illnesses, but the productivity of the

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animals themselves declines [6]. This dual burden of illness on both humans and animals exacerbates poverty and reduces the ability of communities to recover from health crises [1]. Moreover, the global nature of zoonotic diseases is becoming more evident as populations grow, and human-animal interactions increase [7]. The rise in international trade, travel, and urbanization means that zoonotic diseases, once confined to remote regions, now have the potential to spread rapidly across borders [8]. The global burden of NPZs, further complicated by underreporting and misdiagnosis in many developing regions. Many NPZs are difficult to diagnose, especially in areas lacking sufficient medical and veterinary infrastructure [9]. The persistence of these diseases in poor and marginalized communities, where access to healthcare is limited, continues to undermine both public health efforts and economic development [10].

Integrated approaches that incorporate animal health interventions alongside human health strategies, such as the One Health model, offer the best opportunity to mitigate the burden of NZDs [11], particularly in regions like Egypt, where echinococcosis, cysticercosis, foodborne trematodes and trichinellosis remain endemic [12]. In summary, the growing prevalence of NPZs worldwide, which fueled by urbanization, poverty, and globalization, necessitates a renewed emphasis on treating these illnesses holistically [13]. The implementing of intersectional, integrated strategies, the global community can make strides in reducing the health and economic impacts of NPZs, improving both human and animal well-being in some of the world's most vulnerable populations [14]. Therefore, this review aims to summarize the status regarding prevalence, diagnosis, prevention and control of the neglected enteric zoonotic parasitic diseases with a particular emphasis on eccinococosis, cysticercosis, food borne trematodes and trichinellosis.

Echinococcosis

Echinococcosis is a parasitic zoonosis of great public health significance, which listed as one of the neglected tropical zoonotic diseases, caused by larval stages of cestodes of the genus *Echinococcus* (family Taeniidae) in intermediate hosts, such as ungulates and rodents, and can accidentally infect humans [15]. The economic losses in animal production as lowered meat, milk and wool production and health hazard along with treatment costs of cystic echinococcosis in man are enormous [16]. Hydatid cysts can spread in different organs of host such as liver, lung, heart, spleen and brain that may result in death [17]. Lung and hepatic hydatidosis injuries in animals cause c loss due to the condemnation of tissues [18].

Epidemiology and Prevalence

Out of the six species in the genus *Echinococcus*, four are of major public health concern: *Echinococcus granulosus* (causes cystic echinococcosis), *E. multilocularis* (alveolar echinococco sis), *E. vogeli* (polycystic echinococcosis) and *E. oligarthrus* (uni-cystic echinococcosis) [19]. Infected carnivores act as definitive hosts for the parasite where the larva matures to the adult tapeworm (3–6 mm long) in the intestine [20]. The intermediate hosts become infected by ingesting parasite eggs from contaminated food and water, and then develop into larval stages in the viscera. The eggs are adapted to survive in the environment for as long as a year in cool moist conditions but are susceptible to desiccation [21]. Humans accidentally infected by ingestion of eggs from contaminated food, water or soil, or after direct contact with animal hosts [22].

Transmission Cycles

The most widespread transmission cycle for *E granulosus* exists between dogs and sheep (Figure 1). The dogs can infected when they fed offal or scavenge infected sheep carcasses containing cysts, the infected dogs contaminate pasture with their faeces and sheep can re-infected as they graze on these pastures [23]. There exist many similar cycles in nature between dogs and horses, dogs and camels, etc., and in wildlife between wolves and moose/deer [24]. *E. multilocularis* mainly transmitted within the predator–prey relationship between foxes and small mammals, mostly rodents such as voles. Sometimes cattle, sheep and pigs can exposed to infection but develop small non- viable lesions of *E. multilocularis*, and therefore not considered to involve in transmission [25].

Diagnosis

In definitive hosts, diagnosis usually carried out by demonstration of adult worms in the intestine at postmortem or in the mucus after purgation, or finding the proglottids (tapeworm segments) in faeces [26]. In intermediate hosts, diagnosis depends on the postmortem detection of the cysts, particularly in the liver and lungs. Serological testing for cystic echinococcosis in cattle, sheep and pigs can carried out during epidemiological studies, but the sensitivity and specificity of these tests should be checked [27]. The primary diagnosis should confirmed by serological tests based on the detection of antibodies against *E. granulosus* antigens in serum [28]. Numerous methods, including the enzyme-linked immunosorbent assay (ELISA) and the enzyme-linked immune-electro-transfer blot (EITB) are used for this type of diagnosis in both humans and various animals [29]. Since ELISA is often less expensive, effective, has good sensitivity and specificity, it considered the preferable test for identifying many parasitic infections in domestic animals and people [30]. One of obstacles of this method is the difficulty of obtaining enough human *Echinococcus* spp. cysts from patients for antigen extraction and preparation. Therefore, most of the available serological assays depend on using antigens extracted from animal hydatid cysts to diagnose human CE [31]. For molecular diagnosis, eggs can sampled from soil (or faeces) for specific amplification of DNA to detect the presence of *Echinococcus* spp [32]. In humans, ultrasonography imaging is the technique of choice for the diagnosis of both cystic and alveolar echinococcosis [33]. This technique usually complemented or validated by computed tomography (CT) and/or magnetic resonance imaging (MRI) scans (fig. 2).

Prevention and control

The adequate control measures, infection rates can be very high in livestock and dogs, with associated significant incidence in humans. Control measures aim at interruption of the life cycle of the parasite [34]. Some of the important control measures for echinococcosis described by McManus *et al.,* [35], (Figure 3.) including: a) Preventing access of dogs to livestock carcasses or slaughter wastes from farms, households, abattoirs. b) Periodic deworming of dogs with praziquantel to kill the adult tapeworm. c) Detecting cysts during meat inspection. d) Vaccination of sheep or other livestock can be carried out to protect against development of the larval stage of *E. granulosus*. e) Public education campaigns should carried out; washing hands with soap and warm water after handling dogs and before handling, food is crucial for preventing the disease in humans.

<u>Taeniasis-Cysticercosis Complex</u>

Taeniasis/cysticercosis complex is a zoonotic infection in which humans are the obligate definitive hosts for the three cestode species: *Taenia saginata*, *Taenia solium* and *Taenia asiatica*; however, the intermediate hosts can vary with the parasitic species [36]. Cysticercosis is caused by the larval stage or metacestode (cysticerci) of *T. solium* in humans, where the tapeworm larvae can lodge in the muscles, skin, eyes and central nervous system, which may result in serious health effects [37].

Epidemiology and Prevalence

The World Health Organization (WHO), Food and Agriculture Organization (FAO) have classified the taeniasis/cysticercosis complex as a neglected zoonotic disease, and ranked *T. solium* as the most important food-borne parasite in terms of public health and related socioeconomic impact [38]. Human taeniasis is caused by ingestion of the metacestode larval stage, the cysticerci of *T. saginata* in beef (*Cysticercus bovis*) or *T. solium* (*Cysticercus cellulosae*), or *T. asiatica* in pork, resulting in sexual reproduction of the adult tapeworm in the human intestine [39]. Cysticercosis only acquired from the fecal–oral route by ingestion of *T. solium* eggs, and not through the ingestion of cysticerci in undercooked pork, which is associated with intestinal taeniasis [40].

Transmission Cycles

Humans can become infected with *T. saginata* or *T. solium* when they consume inadequately cooked contaminated beef (measly beef) or pork (measly pork), respectively contaminated with cysticerci. In the human intestine, the cysticercus develops over 2 months into an adult tapeworm, which can survive for years [41]. Humans can also host the infective stages of the *T. solium* (Figure 4), mainly by:

Ingestion of *T. solium* eggs in food and water contaminated by faeces from a person harboring adult worm.

Autoinfection, when ova carried from faeces to the mouth via the hands of infected persons.

Reverse peristalsis, bringing ova back to the stomach or duodenum where they hatch.

The accidental ingestions of *T. solium* eggs can cause cysticercosis, where the extra-intestinal development of larvae occurs in muscles, eyes and central nervous system of infected individuals**.**

Diagnosis

Human *Taenia* can diagnosed through: a) *<u>Microscopic examination</u>*: Tapeworm eggs detected in the stools after 2–3 months of infection or gravid proglottids based on internal structures [42]. b) *<u>Immuno-serological tests</u>*: ELISA for detection of copro-antigen of parasite [43]. c) *<u>Molecular tools</u>*: PCR-based assays, allows differentiation between *Taenia* species by the detection of species- specific DNA in human stool samples. [44]. D) *<u>Imaging studies</u>* for cysticercosis, with magnetic resonance imaging (MRI), computed axial tomography (CT) scans detect cysticerci in soft tissues such as brain (Figure 5**)** [45].

Animal cysticercosis, diagnosis based on postmortem surveys in pigs and cattle, using tongue or meat inspection, which remains the gold standard test**.** However, serological tests such as ELISA can carried out to determine the status of specific antibodies in sera or even meat juice [46].

Prevention and control

Control measures targeting humans as the final and intermediate host [47], include the following measures: a) Community health education, awareness and hygiene and food safety. b) Improved sanitary practices, such as restricting open defecation and safe disposal of human feces. c) Proper hygiene habits as washing hands with soap after using the toilet and before handling food. d) Wash and peel all raw vegetables and fruits before eating e) Chemoprophylaxis or treatment of individual cases f) Effective meat inspection at abattoirs. g) Proper cooking of meat at least 60 °C or freezing at −10 °C or less can destroy the parasite.

Foodborne Trematodes

Foodborne trematodes (FBTs) or parasitic flatworms are zoonotic diseases, which have a worldwide distribution and are believe to infect almost 75 million people [48]. The cluster of selected FBTs (Figure 6) include liver flukes (*Clonorchis sinensis*, *Opisthorchis viverrini*, *O. felineus*, *Fasciola hepatica* and *F. gigantica*), lung flukes (*Paragonimus westerman*) and intestinal flukes (*Metagonimus yokogawai, Heterophyes heterophyes.* and *Haplorchis taichui*) [49].

Epidemiology and Prevalence

FBTs characterized by complex lifecycle involving a primary intermediate snail host, and a secondary intermediate host. Humans (FH) becoming infected via the consumption of contaminated food [50]. The life cycles of the major food-borne trematodes are of species-specific characteristics (Figure 7), in brief, eggs produced by adult worms following sexual reproduction in the final host, which are humans or a range of domestic (or wild) animals. Eggs released via feces (most food-borne trematodes) or sputum (*Paragonimus* spp.) [51].

Transmission Cycles

Once an egg has hatched, a swimming "sac-like" larva is released, the so-called miracidium. The miracidium, penetrates the molluscan intermediate host. Humans and animal hosts infected when eating raw, pickled, or insufficiently cooked aquatic products harboring metacercariae or drinking contaminated water [52]. Several animal hosts play a role in the transmission of food-borne trematodiases, for example, myriad definitive hosts reported for *F. hepatica*, such as sheep, cattle, pig, and donkeys [53]. Illustrations of epidemiological characteristics of foodborne trematodiases shown in table (1).

Diagnosis

The three main approaches that are currently available are, direct parasitological diagnosis (detection of parasite eggs in stool, sputum, or other bio-fluids) [54]. Also immune-diagnosis such as intradermal tests, IHA, IFAT, and ELISA [55]. Moreover, molecular biology approaches to detect egg trematode DNA in stool samples or metacercariae in the second intermediate host, [56].

Prevention and control

Hygiene levels need to be improved, clean water needs to provided and adequate sanitation facilities must installed and properly use [57]. In several countries where fluke infections are endemic, toilets built in close proximity to fish ponds so that feces, also food-borne trematode egg-contaminated ones, directed into pond water, hence, there is a need to eliminate these water toilets and construct more adequate sanitation facilities [58]. Herby, food control is necessary to protect customers. Whereas, guidelines by the Food and Drug Administration (FDA) recommend freezing at −20°C or below for 7 days to retailers who provide fish intended for raw consumption [59].

Trichinellosis

Trichinellosis (also called trichinosis) is a zoonotic disease that is responsible for huge economic losses in the piggery sector. The disease caused by nematodes of *Trichinella* spp., which considered as one of the most widespread parasites infecting humans and animals [60]. The important *Trichinella* species causing public health-related issues is *Trichinella spiralis*, this species has a wide global distribution and is considered the most important etiological agent causing disease in humans. Pork scraps from *T. spiralis*-infected pigs are the main source of infection for synanthropic animals [61].

Epidemiology and Prevalence

The parasite is a tissue-dwelling nematode that can acquired by the ingestion of raw or inadequately cooked meat products containing encapsulated larvae. The larvae are release after gastric digestion and mature into adult worms that can penetrate the mucosa of the host's intestine. After fertilization, the female sheds new larvae, which disseminate throughout the host to find their definitive location, i.e. the striated muscle, where they encyst. [62]. In humans, calcification of the cyst may begin within 6 months to a year, a process that eventually followed by death of the encysted larvae [63]. The transmission life cycles of *Trichinella* spp clarified in figure (8).

Diagnosis in Animals

Direct methods: Postmortem meat inspection for the detection of *Trichinella* larvae in muscle samples of pigs and other animals intended for human consumption is important. On microscopic examination, the encysted parasites easily observed, and if there are degenerative changes or necrotic muscle fibbers, an inflammatory reaction with many eosinophils may be present around them [64].

Serology: is suitable for the surveillance and epidemiological investigations of infection in domestic animals and wildlife. Animals can tested for the presence of anti-Trichinella antibodies in the serum or meat juice [65].

Molecular techniques: including polymerase chain reaction, is a sensitive and rapid diagnostic approach that can identify even a low number of larvae infections. These tools are also important to characterize the isolates to the species or genotype during epidemiological studies [66].

Diagnosis in Humans

The early clinical diagnosis of trichinellosis in humans is difficult because of the lack of any specific or pathognomonic signs. So, the diagnosis should base on three main criteria [67], as following: a) *Clinical findings*: Recognition of the signs and symptoms of trichinellosis. b) *Laboratory findings*: The clinical picture such as biochemical, molecular and serological means. Eosinophilia and elevation in muscle enzymes, antibody detection and larval detection in a muscle biopsy. c) *Epidemiological investigation*: This involves the identification of the source and detection of the outbreak origin.

Prevention and control

Control of Trichinella Infection in Pigs

Commercial and backyard pig production needs to have stringent barriers to exposure to wild animals, rodents and uncooked meat scraps [68]. Proper awareness of the modes of transmission of *Trichinella* to domestic pigs can be helpful to pig farmers and producers to allow management systems that can prevent or reduce the risk of exposure to the parasite [69]. Farm hygiene, including proper disposal of dead animals, proper hygienic feeding of animals, and rearing of piglets with controlled housing conditions in endemic regions to reduce contact with wild life and rodents [70].

Control of Trichinellosis in Humans

The consumption of contaminated meat and meat products remains the important route of trichinellosis in humans [61]. Meat from animals that might contain *Trichinella* larvae but cannot be tested by an appropriate laboratory method should be treated by a procedure that has been proven to inactivate *Trichinella* before distribution for human consumption [71]. Common methods that have been shown to reliably inactivate *Trichinella* larvae in meat [72].

Conclusion

Due to environmental, socioeconomic, and healthcare-related variables, the prevalence of neglected enteric zoonotic parasite infections poses a significant burden on public health systems globally. Foodborne trematodes, trichinellosis, echinococcosis, and cysticercosis all have a substantial impact on human health in many nations, including Egypt, where they increase morbidity, mortality, and economic loss in impacted areas. The inadequacy of current diagnostic tools frequently results in treatment delays and increased disease transmission. Furthermore, prevention and control initiatives are frequently dispersed and poorly carried out, requiring a more coordinated strategy involving veterinarians, healthcare authorities, and communities worldwide. An integrated approach centered on improving diagnostic capacities, increasing public awareness, and putting into practice efficient preventative and control measures suited to both local and global contexts needed to address these issues. Integrated approaches needed to incorporate animal health interventions alongside human health strategies, such as the One Health model, offer the best opportunity to mitigate the burden of neglected zoonotic diseases.

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Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical of approval

Not applicable in this study.

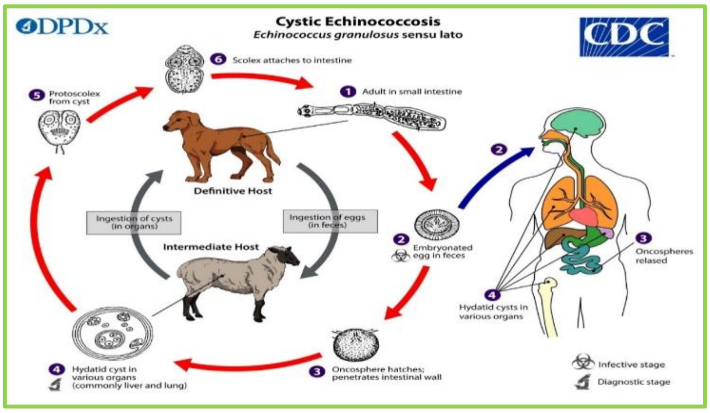

Fig. 1. Transmission cycles for *E. granulosus* exists between dogs and sheep (Cited from: https://www.cdc.gov/dpdx/echinococcosis/index.html)

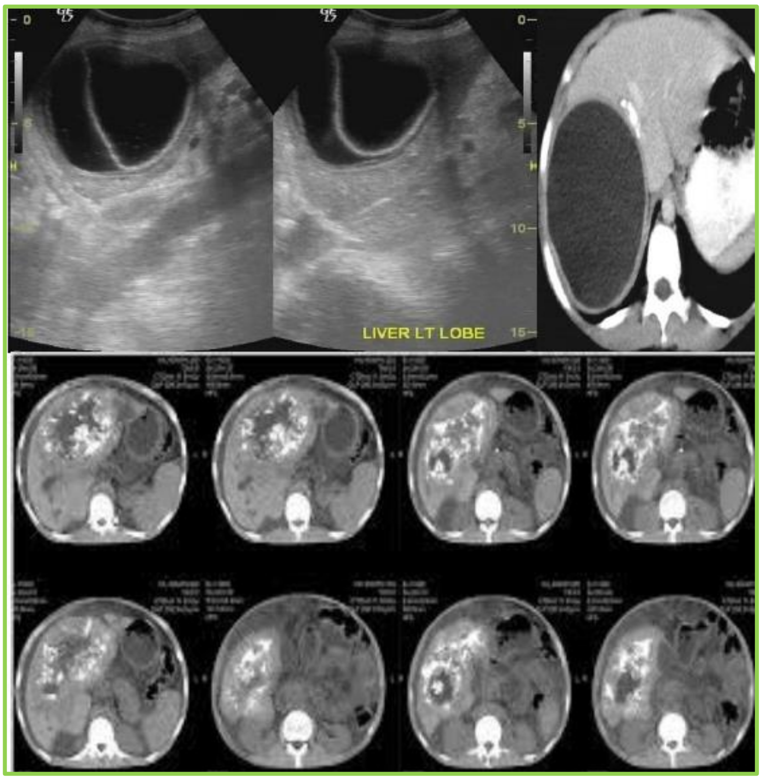

Fig. 2. Hepatic hydatid cyst by ultrasound, CT and MRI Imaging (Yu *et al.*, [33])

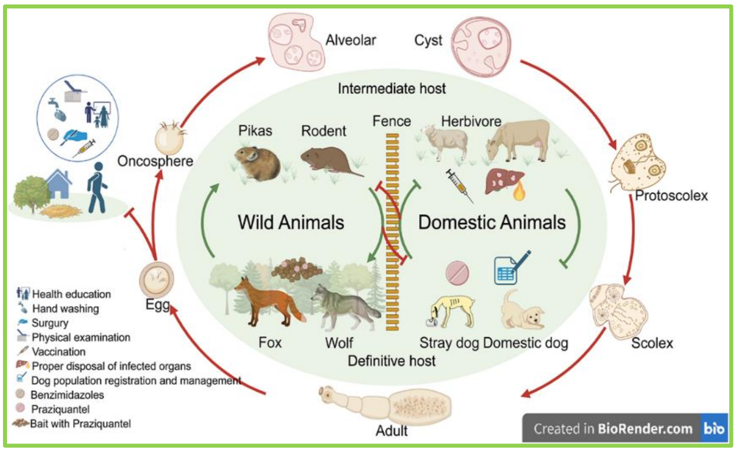

Fig. 3. Prevention and control of echinococcosis (McManus *et al.*, [35])

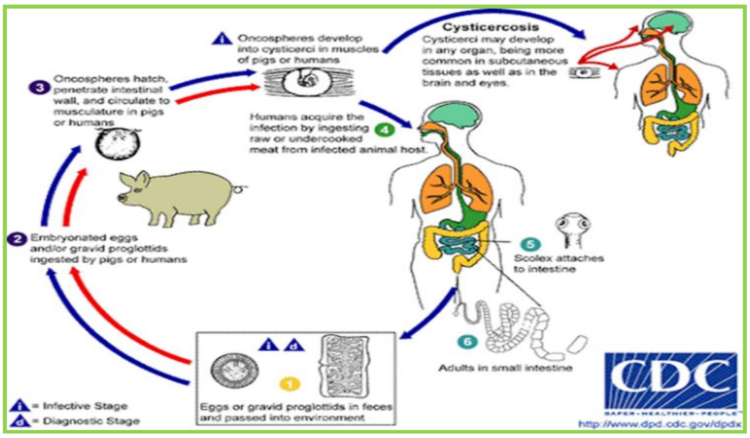

Fig. 4. Transmission cycle of taeniasis/cysticercosis (https://www.cdc.gov/dpdx/cysticercosis/index.html#:~taeniasis)

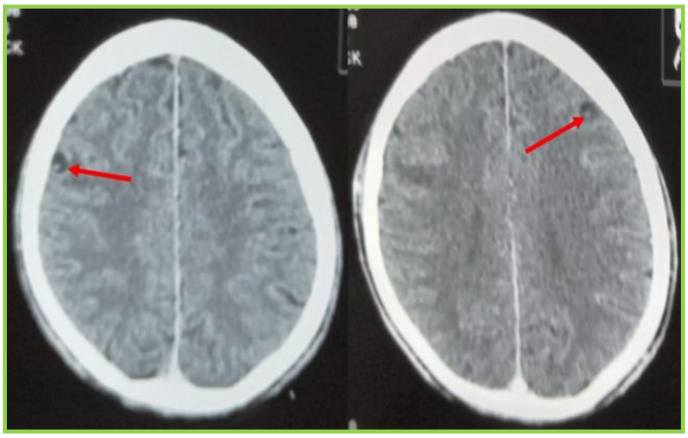

Fig. 5. Contrast enhanced axial computed tomography (CT) scan images of the brain showing cysts with eccentric scolices in the frontal lobes (Guzman and Garcia, [45])

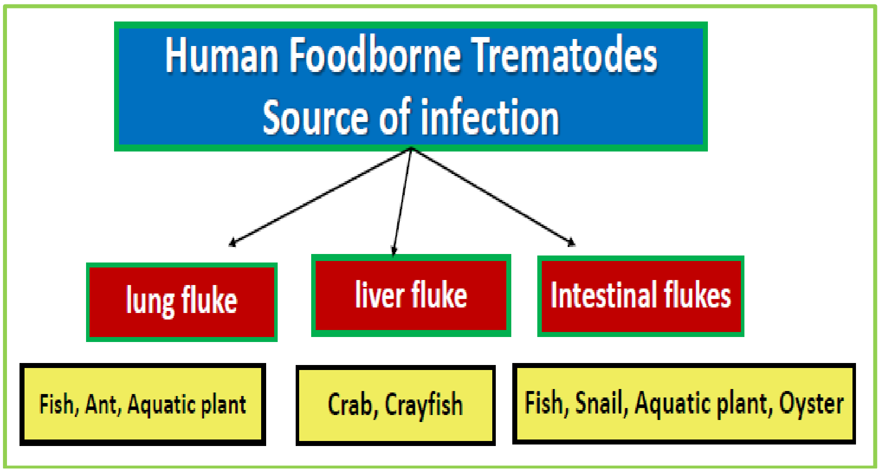

Fig. 6. Foodborne trematode source of infection (Chai and Jung, [49])

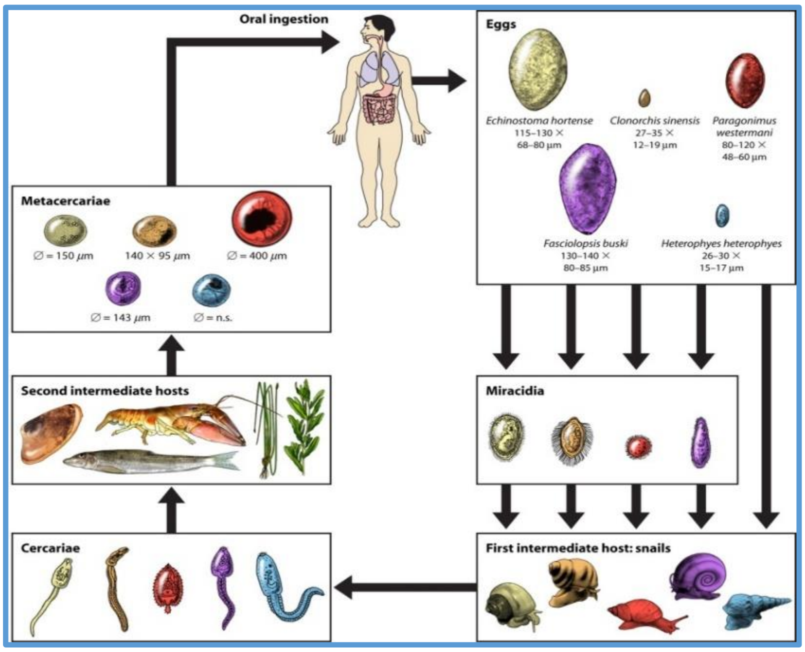

Fig. 7. Life cycles of food-borne trematodes (Keiser and Utzinger [51])

TABLE 1. Epidemiological characteristics of foodborne trematodes

Infectious agent	Disease	Source of infection	Natural final hosts
Clonorchis sinensis	Clonorchiasis	Freshwater fish	Dogs and other fish-eating carnivores
Opisthorchis viverrini *Opisthorchis felineus*	Opisthorchiasi	Freshwater fish	Cats and other fish-eating carnivores
Fasciola hepatica *Fasciola gigantica*	Fascioliasis	Vegetables	Sheep, cattle and other herbivores
Paragonimus spp	Paragonimiasis	Freshwater crustaceans (crabs and crayfish)	Cats, dogs and other crustacean-eating carnivores

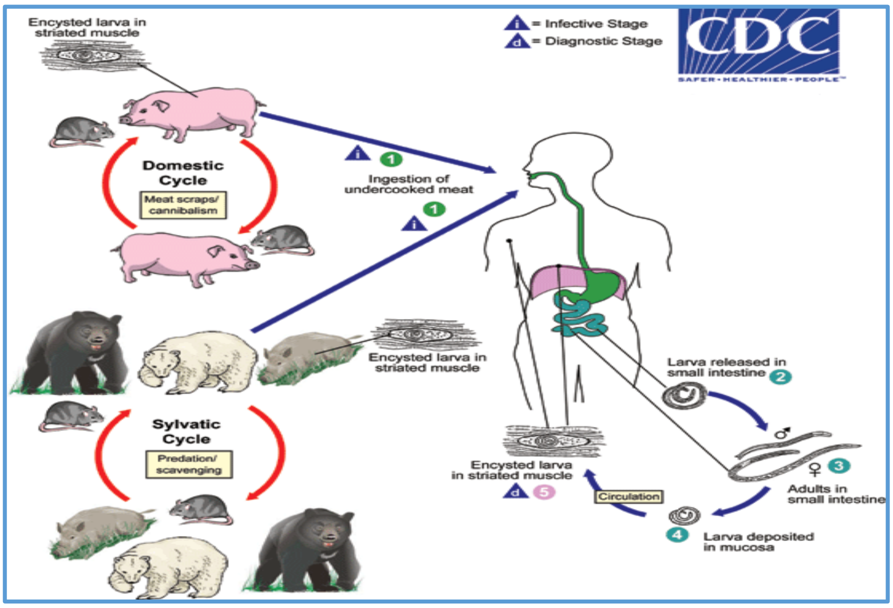

Fig. 8. Life cycles of *Trichinella* (Cited from: https://www.cdc.gov/dpdx/trichinellosis/index.html)

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الأمراض الطفيلية المعوية الحيوانية المنشأ المهملة: داء المشوكات القزمية، داء الكيسات المذنبة، الديدان المفلطحة المنقولة بالغذاء، وداء الشعريات

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الملخص

تمثل الأمراض الطفيلية المعوية الحيوانية المهملة تحديًا بالغ الأهمية للصحة العامة في جميع أنحاء العالم، وتؤثر بشكل خاص على البلدان ذات الدخل المنخفض والمتوسط، بما في ذلك مصر ومناطق مختلفة في جميع أنحاء أفريقيا وآسيا وأمريكا اللاتينية. ويتناول هذا البحث المرجعي إلى دراسة توليفة موسعة من الفهم الحالي لأربعة من الأمراض الطفيلية المعوية المشتركة بين الانسان والحيوان والمهملة مثل: داء المشوكات القزمية (الكيسات المائية) وداء الكيسات المذنبة، والديدان المفلطحة المنقولة بالغذاء، وداء الشعريات (التريكينيلا)، مع التركيز على تشخيصها والوقاية منها وتدابير السيطرة عليها في اماكن جغرافية متنوعة. ويؤدي داء المشوكات القزمية، الذي تسببه طفيل ال *Echinococcus granulosus* و*E. multilocularis*، إلى مضاعفات صحية خطيرة، بما في ذلك مرض الكيس المائي، وخاصة في المناطق التي تعاني من تربية الماشية وعدم كفاءة الصرف الصحي، مثل المناطق الريفية بمصر وأجزاء من آسيا الوسطى. يعتمد التشخيص الفعال على تقنيات التصوير بالأشعة والاختبارات المصلية والطرق الجزيئية، وعلى الرغم من اختلاف الوعي والوصول إلى الرعاية الصحية بشكل كبير. فإن داء الكيسات المذنبة (Cysticercosis) الناتج عن مرحلة اليرقات من دودة الشريطية هو السبب الرئيسي لمشاكل صحية كبيرة في المناطق ذات الصرف الصحي السيئ، بما في ذلك مصر، وأفريقيا جنوب الصحراء الكبرى، وجنوب شرق آسيا. وتنتشر الديدان المفلطحة المنقولة بالغذاء (FoodborneTrematodes)، بما في ذلك الفاسشيولا والكلونورشيس ، في العديد من أنحاء العالم، وخاصة في المناطق ذات العادات الغذائية التقليدية التي تزيد من تعرض الأطعمة والمياه للتلوث. كما تشكل أنواع الديدان الخيطية (الشعريات) المسببة لداء التريكينيلا (Trichinellosis) مخاطر صحية إضافية من خلال استهلاك اللحوم غير المطبوخة جيدًا، مما يؤدي إلى مضاعفات في الجهاز الهضمي والعضلات لدى البشر. وفي الختام، سلط هذا البحث المرجعي الضوء على ضرورة تحسين أساليب التشخيص وتؤكد على الحاجة الملحة إلى التوعية المجتمعية والتثقيف، والاستراتيجيات الشاملة التي تشمل تدابير مكافحة فعالة ومتكاملة لمكافحة هذه الأمراض المهملة في مصر والعالم.

الكلمات الدالة: داء المشوكات القزمية، داء الكيسات المذنبة، الديدان المفلطحة المنقولة بالغذاء، داء الشعريات، التشخيص، المكافحة.