

*Parasites ramble on: Focus on food security*

## Feature Review

# Impacts of globalisation on foodborne parasites

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**Globalisation is a manmade phenomenon encompassing the spread and movement of everything, animate and inanimate, material and intangible, around the planet. The intentions of globalisation may be worthy – but may also have unintended consequences. Pathogens may also be spread, enabling their establishment in new niches and exposing new human and animal populations to infection. The plethora of foodborne parasites that could be distributed by globalisation has only recently been acknowledged and will provide challenges for clinicians, veterinarians, diagnosticians, and everyone concerned with food safety. Globalisation may also provide the resources to overcome some of these challenges. It will facilitate sharing of methods and approaches, and establishment of systems and databases that enable control of parasites entering the global food chain.**

**Globalisation: opportunities and threats**

Globalisation is the spread and exchange of people, animals, goods, resources, ideas, and other physical or cultural materials. This manmade phenomenon differs from natural dispersal or movement, although one may enhance, or reduce, the other. Often considered a modern phenomenon, the ontogeny of globalisation is the history of voyages, exploration, and discovery that brought people to different continents, resulting in global trading and exchange of ideas. Advances in transport and communications have intensified the rate of globalisation for every commodity imaginable as never before.

Globalisation advocates cite economic growth and development, global democracy, and shared humanity as

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**Glossary**

**Alariosis:** clinical infection with trematode parasites of the genus *Alaria*. The life cycle is complex, involving two intermediate hosts, a carnivorous definitive host (often a canid) and frequently paratenic hosts. *A. americana* has been transmitted to humans by ingestion of undercooked paratenic hosts and has resulted in both ocular and systemic infection, and can be fatal. Human infection with *A. alata* has not been detected, but the apparent lack of definitive host specificity, coupled with wild boar being a relatively common paratenic host, suggest a real zoonotic foodborne potential.

**Amoebiasis:** clinical infection with the protozoan *Entamoeba histolytica*, or any other pathogenic *Entamoeba*. Major waterborne outbreaks have been reported, but not foodborne outbreaks, although this non-zoonotic parasite is traditionally associated with food handlers and travellers' diarrhoea (with blood). Extraintestinal spread (particularly amoebic liver abscess) is a serious potential consequence of infection.

**Angiostrongylus cantonensis meningitis:** the nematode *A. cantonensis* (rat lungworm) is the most common cause of human eosinophilic meningitis. Human infection comes from ingestion of undercooked, infected intermediate hosts (snails, slugs) or their secretions, or paratenic hosts (crabs, freshwater shrimps).

**Ascariasis:** *Ascaris lumbricoides*, the usual cause of ascariasis, is the largest nematode parasitizing the human intestine, and is very common in areas where sanitation facilities are inadequate. Infection occurs by ingestion of the very robust *Ascaris* eggs. Migrating larvae in the life cycle may cause pulmonary symptoms. Adult worms tend to cause few overt symptoms, unless the worm burden is particularly high.

**Baylisascaris:** the nematode *Baylisascaris procyonis* usually completes its life cycle in raccoons; many birds and mammals can act as paratenic hosts. Infection of humans follows accidental ingestion of the embryonated eggs, and migration of larvae through the various tissues causes visceral larval migrans (VLM) and ocular larval migrans (OLM), similar to that seen with *Toxocara* spp. However, symptoms tend to be more severe due to the large size of the larvae, their wide wandering, and their longevity. Other species of potentially zoonotic *Baylisascaris*, include *B. columnaris* usually found in skunks.

**Chagas disease:** also known as American trypanosomiasis, this disease is often transmitted by infected blood-sucking triatomine bugs that defecate the flagellate protozoan *Trypanosoma cruzi*. The trypomastigotes enter into the bite wound or mucosal membranes; the parasite infects local cells and reaches more distant tissues with the blood stream. However, foodborne infection has been shown to be an increasingly common transmission route, usually from contamination of fruit juice with infected triatomine bugs or their faeces, or from secretions from other hosts such as opossums. There are two distinct disease phases, acute and chronic; it is a seriously disabling disease, with an intricate mechanism of pathogenesis, and foodborne transmission seems to result in greater severity, with deaths from heart failure not uncommon during the acute phase.

**Clonorchiasis:** clinical infection with the trematode *Clonorchis sinensis* (Oriental liver fluke) results from ingestion of the second intermediate host, freshwater fish, which have been infected by penetration of the free-swimming cercariae and are insufficiently cooked. Other fish-eating mammals can also act as reservoir hosts. Most symptoms are due to inflammation and intermittent obstruction of the biliary ducts. In chronic infections, cholangitis, cholelithiasis, pancreatitis, and cholangiocarcinoma can develop, which may be fatal.

**Cryptosporidiosis:** clinical infection with *Cryptosporidium* spp. [most commonly *C. parvum* (zoonotic) or *C. hominis* (largely non-zoonotic)] is manifested by acute, watery diarrhoea. Infection occurs from ingestion of the robust transmission stage, the oocyst. Although self-resolving in the immunocompetent host, the lack of an effective treatment means that infection may be prolonged and serious in immunocompromised patients.

**Cyclosporiasis:** clinical infection with the intestinal protozoan parasite, *Cyclospora cayentanensis*, which appears to be host-specific and anthroponotic. Symptoms are mainly gastrointestinal, particularly watery diarrhoea. The oocysts require a period (days to week) following excretion to sporulate and become infective, and this may be one reason why foodborne infection appears to be more common than waterborne infection.

**Cysticercosis:** the pork tapeworm (*Taenia solium*) is the main cause of human cysticercosis, in which oncospheres released from the ingested eggs invade the intestinal wall and migrate to striated muscles and other tissues and organs where they develop into cysticerci, the metacystode stage of the life cycle. Symptoms depend on the location and number of cysticerci; the most serious form of disease occurs when the cysticerci are located in the brain or central nervous system (CNS) resulting in neurocysticercosis.

**Diphyllobothriasis:** clinical disease caused by infection with tapeworms of the *Diphyllobothrium* genus, often *D. latum*, also known as the broad tapeworm. The life cycle of these tapeworms involves two intermediate hosts, and often a paratenic host, which are freshwater fish and the most common source of infection. Although adult tapeworms are very large (can be more than 10 m in length), many infections are asymptomatic. Clinical symptoms are abdominal, and heavy infections can cause intestinal blockage. As the parasite may cause dissociation of the vitamin B<sub>12</sub>-intrinsic factor complex within the gut lumen, vitamin B<sub>12</sub> deficiency with pernicious anaemia may occur.

**Echinococcosis:** human echinococcosis (also known as hydatidosis or hydatid disease) is caused by the larval stages of very small tapeworms (3–6 mm) of the genus *Echinococcus*. The most common forms of infection are cystic echinococcosis (CE) caused by *E. granulosus*, and alveolar echinococcosis (AE) caused by *E. multilocularis*. For both infections humans act as accidental intermediate hosts, ingesting eggs that are excreted in the faeces of the definitive hosts (canids). For *E. granulosus*, the usual intermediate hosts are sheep and other livestock, whereas small rodents are the usual intermediate hosts for *E. multilocularis*. The ingested eggs release the oncospheres, penetrate the intestinal wall, and are carried via blood to the liver, lungs, and other organs where they form cysts; these are unilocular for CE and multilocular for AE. Although asymptomatic for many years (5–15 years), the growing cysts cause symptoms associated with the organ in which they are located (most often the liver). Untreated, infection is often fatal in the case of AE due to the malignant behaviour of the parasitic cyst formation.

**Fascioliasis:** clinical disease caused by infection with liver flukes, trematodes in the genus *Fasciola*, most commonly *F. hepatica*, but also *F. gigantica* in some regions. Infections with *Fasciola* result from ingestion of metacercariae that have encysted, usually on aquatic vegetation, following release of the cercariae from the intermediate aquatic snail hosts. Herbivores such as sheep and cattle are more usual definitive hosts than humans. Migration of juvenile flukes through the liver causes the acute stage of disease, with abdominal symptoms and hepatomegaly the main signs. In the chronic phase, the adult flukes are located within the bile duct and cause biliary problems in heavy infections.

**Giardiasis:** clinical disease caused by the intestinal protozoan parasite *Giardia duodenalis*; although this parasite has proven zoonotic potential, the majority of human infections appear to be derived from other humans, either directly hand-to-mouth, or by contamination of suitable vehicles, such as water or food, with the robust cyst transmission stage. Symptoms are generally abdominal, with fatty, intermittent diarrhoea particularly predominant. Post-infectious sequelae seem to be increasingly recognised as potentially problematic.

**Gnathostomiasis:** clinical disease caused by infection with nematode larvae in the genus *Gnathostoma*. Humans are usually infected by ingestion of infected, undercooked second intermediate hosts (fish, amphibians, or reptiles) or paratenic hosts (amphibians, reptiles, birds) containing third-stage larvae. The migration of these larvae may result in symptoms, including intermittent painful swellings CLM (cutaneous larval migrans), as well as VLM (visceral) and OLM (ocular). The most serious manifestation is eosinophilic meningitis with myeloencephalitis.

**Linguatuliasis (visceral):** human linguatuliasis results from infection with the pentastomid arthropod *Linguatula serrata*, also known as tongue worm (although it is not a worm). Visceral linguatuliasis occurs when a person ingests the eggs sneezed or defecated out by the carnivore definitive host (often a dog). Infection is often asymptomatic, but hepatic symptoms may result and may be misdiagnosed as liver disease of another aetiology. It should be noted that nasopharyngeal linguatuliasis can also occur, in which the encysted larvae are consumed in undercooked meat and results in the establishment of the parasite in the nose, pharynx, or lungs, causing headaches, cough, and nasal discharge. In certain areas this latter manifestation, with humans acting as the definitive host, is very common and has resulted in local names such as Marrara syndrome or Halzoun.

**Neurocysticercosis:** this disease is a particularly severe manifestation of cysticercosis caused by *Taenia solium*, in which the cysticerci are located in the brain or spinal cord, and resultant symptoms include seizures and mental

disturbances. Neurocysticercosis can be fatal.

**Opisthorchiasis:** clinical disease caused by infection with trematodes in the *Opisthorchis* genus, particularly *O. viverrini* (Southeast Asian liver fluke) and *O. felineus* (cat liver fluke). With a life cycle very similar to that of *C. sinensis*, these parasites are transmitted to humans by ingestion of the second intermediate host, freshwater fish, which have been infected by penetration of the free-swimming cercariae and are insufficiently cooked. Other fish-eating mammals can also act as reservoir hosts. Although most infections are asymptomatic or symptoms are mild abdominal signs, in chronic infections, more severe symptoms may occur including cholangitis, cholelithiasis, and cholangiocarcinoma; over 60% of cases of cholangiocarcinoma in Thailand are associated with *O. viverrini* infection.

**Paragonimiasis:** various species of the trematode genus *Paragonimus* are infectious to humans and other mammals, including *P. westermani*, the Oriental lung fluke, in Southeast Asia and *P. kellicotti* in North America. Transmission to humans occurs by ingestion of the infected, undercooked second intermediate host, a crustacean such as a crab or crayfish. Symptoms associated with the acute phase of infection (invasion and migration) are largely abdominal. During the chronic phase of infection, pulmonary manifestations occur.

**Sarcocystosis:** two species of the genus of apicomplexan protozoa *Sarcocystis* use humans as definitive hosts, causing intestinal sarcocystosis (also known as sarcosporidiosis); these are *S. bovihominis* and *S. suihominis* for which cattle and pigs, respectively, act as intermediate hosts. Symptoms tend to be mild and generally nonspecific, with a predominance of abdominal signs. Humans may also become dead-end hosts for non-human *Sarcocystis* spp. after the accidental ingestion of oocysts, and for these infections (tissue sarcocystosis) symptoms are due to the sarcocysts in muscle and may include transitory oedema and myalgia.

**Sparganosis:** occurs when humans are infected, either as paratenic hosts (more commonly) or second intermediate hosts, by larval stages of tapeworms in the genus *Spirometra*. This is most commonly due to ingestion of flesh of an undercooked second intermediate or paratenic host (amphibians, reptiles, fish).

**Taeniosis:** occurs when humans are infected with adult tapeworms in the genus *Taenia*, including *T. saginata* (beef tapeworm) and *T. solium* (pork tapeworm), for which humans are the only definitive host. Symptoms of infection with these long (often around 3 m) cestodes tend to be mild abdominal discomfort. Probably the most important medical threat is the increased likelihood of acquiring cysticercosis associated with taeniosis due to the ingestion of eggs shed by the intestinal stage of *T. solium*.

**Toxoplasmosis:** *Toxoplasma gondii* is an apicomplexan protozoan that infects most species of warm-blooded animals. Humans are usually infected either by ingestion of tissue cysts (bradyzoites) in the undercooked flesh of intermediate hosts or ingestion of oocysts excreted by the feline definitive host or transplacentally. Infection in immunocompetent people is usually asymptomatic, or with mild symptoms only, although ocular infection with visual loss can occur. However, in immunosuppressed persons toxoplasmosis can be a serious, sometimes fatal, disease with a range of symptoms including encephalitis and necrotizing retinochoroiditis. An acute primary infection acquired by a mother during pregnancy may result in congenital toxoplasmosis, in which the symptoms include chorioretinitis, intracranial calcifications, and hydrocephalus, or abortion. Depending on various factors, including the stage in pregnancy that the mother became infected, the symptoms may be apparent at birth or learning and visual disabilities may develop later.

**Trichinellosis:** (also known as trichinosis) occurs when undercooked meat containing larvae in the *Trichinella* genus are ingested. In the domestic cycle, which is particularly associated with pork, *T. spiralis* is the species of concern, but other species (*T. nativa*, *T. murelli*, *T. nelsoni*, etc.) are also infectious to humans but tend to be associated with meat from other animal species, particularly wild animals. All infected animals, including humans, serve as both definitive hosts and potential intermediate hosts, and the symptoms of trichinellosis are associated with different stages of the life cycle, including intestinal symptoms (nausea, diarrhoea, etc.) associated with the intestinal invasion by adult worms, general nonspecific symptoms (fever, rashes) associated with larval migration, and finally symptoms associated with encystment in striated muscle cells, which is usually myalgia, but may include other symptoms associated with specific organs if these have been invaded (e.g., myocarditis). In the latter cases infection may be fatal.

positive effects. Critics list loss of cultural diversification, exploitation of smaller or weaker partners, rapid and extensive environmental deterioration, increasing poverty and alienation, and the spread of new diseases as negative impacts. Exponential growth of the human population and climate change will enhance the rate and amplitude of the negative aspects of globalisation.

Globalisation opens new markets and transforms food consumption patterns, resulting in rapid and massive

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