PARASITIC CONTAMINANTS IN FOOD

Malinee T Anantaphruti

Department of Helminthology, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand

Abstract. There is a wide variety of food products that may be contaminated with one or more parasites and consequently enabling transmission to human beings. The prevalence of specific parasites in food supplies varies between countries and regions. Sources of food-borne products contaminated with parasites are pigs, cattle, fish, crabs, crayfish, snails, frogs, snakes and aquatic plants. One of the major factors influencing the prevalence of parasitic infections in the population is the habit, and traditional popularity of eating raw or inadequately cooked foods. The parasites that may be acquired by eating these foods are nematodes, trematodes, cestodes and protozoa. The major genera of parasites are *Trichinella, Gnathostoma, Angiostrongylus, Anisakis, Paragonimus, Clonorchis, Opisthorchis, Fasciola, Fasciolopsis, Echinostoma, Taenia, Spirometra* and *Toxoplasma.* These food-borne parasitic infections are public health problems worldwide. The contamination of food affects many including humans, livestock industry, agriculture, and food manufacturing and processing. Unsafe foods must be condemned and destroyed.

Today there is increasing travel hence there is the risk of humans' acquiring food-borne parasitic infections through eating native food often raw. Moreover, the consumption of imported livestock and foods, especially from endemic areas of food-borne parasitic zoonoses, can be the cause of infection. Awareness should be heightened wherever and whenever raw or inadequately cooked food are consumed.

INTRODUCTION

Food safety is important to enable humans to attain a better quality of life. Parasitic contamination of food causes serious disease to humans. The source of infection is raw or inadequately cooked food and processed food that harbors infective stages of parasites, or similarly contaminated drinking water. There is a wide variety of food that may be contaminated with one or more parasites. The prevalence of specific parasites in food and food supplies varies between countries and regions.

Over 40 million people of a total 750 million people at risk in the world are estimated to be infected with food-borne parasitic trematodes. These infections are highly prevalent in Southeast Asia and The Western Pacific (WHO, 1995). The infections of greatest health significance are fascioliasis, clonorchiasis, opisthorchiasis, paragonimiasis and other intestinal fluke infections. The sources of food are freshwater fish, shellfish and many kinds of aquatic plants that harbor metacercariae. Meat-borne parasitic nematodes and cestodes are prevalent in several regions of the world. The reported sources are livestock (pigs and cattle) as well as wildlife meat, freshwater and marine fish, snails and amphibians such as frogs and snakes. The parasites that may be acquired by eating these foods in their raw form are both helminths and protozoa. The important helminthic infections are trichinosis, gnathostomiasis, angiostrongyliasis, anisakiasis, taeniasis, sparganosis and toxoplasmosis. Since these parasitic infections are highly prevalent in the Asian region, this paper places its emphasis on the existence of helminths in foods in many Asian countries.

MEAT

There are several parasites, including protozoa, reported from livestock such as pork and beef. Pork, is able to harbor more than one species of parasite. The most important helminth found in wildlife is *Trichinella* spp.

Livestock meat: pork/beef

The important parasitic infections transmitted by eating pork and beef are taeniasis solium, taeniasis saginata, trichinosis, toxoplasmosis and sarcocystosis.

Taeniasis: Infection with the cestode, *Taenia solium* and *Taenia saginata* is reported worldwide and in Asia it is reported in China, Taiwan, Korea, India, Thailand, Indonesia and the Philippines. The prevalence of *Taenia saginata* infection is higher than *Taenia solium* infection in almost all the countries mentioned above.

In **China**, taeniasis is widespread throughout the country with a greater prevalence of infection with *T. saginata*, 2-70%, than *T. solium*, 1-15.2% (Gu, 1983 a,b; Jing, 1986). In a wedding party, infection with *T. solium* was reported in 6/45 attendants and 4 of the cases developed cysticercosis (Zhao *et al*, 1997). The source of the food was a pig that had been slaughtered locally without inspection.

In **Hong Kong**, the latest report was in 1969 with an infection of 1% prevalence (Huang *et al*, 1969). However, measly pork was collected from local abattoirs, especially from pigs imported from China (Ko, 1991).

In **Korea**, the estimated taeniasis infection rate is about 4% (Soh, 1991) while in mountainous areas of Taiwan, an infection rate of 10 to 20% is reported in aborigines (Chen, 1991). The latter is probably *T. saginata asiatica.*

In **India**, the overall prevalence of *Cysticercus cellulosae* in the muscles of pigs ranged from 2.0 to 28.0%. The cysts are most commonly found in the muscles of the thigh, tongue and neck, and less commonly in the liver, heart, lung, lymph nodes and brain (Bhatia, 1991). *Cysticercus bovis* in the muscles of cattle and buffalo is rare, with only a few animals found infected during the period 1976-1981 (Gaur, 1976; Sreemannarayana and Christopher, 1977; Kolte *et al*, 1981). The prevalence of *T. solium* infection in humans varies from 0.75 to 1.0% (Verma and Ahluwalia, 1981; Pathak *et al*, 1984) whereas 1.5% *T. saginata* infection was reported in 1988. (Ahmed *et al*, 1988).

In **Thailand**, cases of taeniasis solium are seldom found, compared with taeniasis saginata, which is more prevalent, especially in the north and northeast of Thailand (Khamboonruang, 1991a). The prevalence of taeniasis in Chiang Mai Province was found to be about 3% (Yamaguchi *et al*, 1982). In slaughterhouses, beef is frequently infected with *Cysticercus bovis* whereas *Cysticercus cellulosae* is sporadically found in pigs illegally slaughtered in rural communities in Thailand (Khamboonruang, 1991a).

In **Indonesia**, the prevalence of taeniasis is about 10% of the population in north Sumatra and Bali, and 20% in Irian Jaya (Kusharyono and Sukartinah, 1991). The Balinese serve *lawar*, a special dish prepared from half raw pork or beef mixed with coconut and vegetables, at traditional ceremonies (Suweta, 1991; Depary and Kosman, 1991). The prevalence of swine cysticercosis in Bali varied from 0.02-2.6% and bovine cysticercosis was 0.3-2.4% (Anon, 1988).

In the **Philippines**, the prevalence was less than 1% for taeniasis (Eduardo, 1991). However, in endemic foci in Leyte, a prevalence rate of over 10% for *T. saginata* infection was reported (Cabrera, 1973). Cysticercosis in swine is more common than either in cattle or water buffalo, 1.67, 0.02 and 0.03% respectively (Arambulo *et al*, 1976).

Trichinosis: The disease has been reported in China, Hong Kong and Thailand.

In **China**, epidemics of trichinosis have occurred. In Henan Province, 33.3% of 3,630 pigs examined were found infected with larvae of *Trichinella* sp (Wu, 1986). In **Hong Kong**, barbecue and "steam-boat seasons" in summer and winter are the source of trichinosis. This is not only because consumers are fond of the food but also because it is a means for escaping tiny, overcrowded, high-rise flats. Besides eating habits, socio-environment factors also contribute to this infection (Ko, 1991). About 3% of pigs slaughtered in Hong Kong, which had been imported from China, were infected with *Trichinella* larvae (Reviewed in Ko, 1991).

In **Thailand**, from 1967-1973, 355,820 pig diaphragms from various slaughterhouses in the northern provinces were examined by trichinoscope. It was found that 19 samples (0.005%) harbored *Trichinella* larvae. The number of larvae ranged from 2-800 per gram of sample. From 1973-1975, 7,598 diaphragms of pigs were collected from Chiang Mai municipal slaughterhouses and were examined by digestion method, only one sample harbored 41.7 *Trichinella* larvae per gram (Reviewed in Khamboonruang, 1991b).

In some countries, no human cases have been reported but infection in pigs has been reported, such as in India (Niphadkar *et al*, 1979).

Wildlife meat and others

Trichinosis is an important helminth acquired transmittion by eating raw wildlife meat; several species of vertebrates have been found to be infected with *Trichinella* sp.

In **Japan**, the first recorded outbreak of trichinosis was in 1974; 15 of a group of 20 hunters ate raw Japanese black bear meat (*Selenarctos thibetanus japonicus*) in Aomori Prefecture. The number of larvae (cysts) found per gram of bear meat was 5.1. The second outbreak occurred in 1979 among a tour group to Hokkaido who ate raw brown bear meat, *Ursus arctos yesoensis* at a local restaurant in Sapporo. By digestion method, 146 larvae per gram of meat were recovered. The third outbreak was in 1981, in Mie Prefecture. The patients ate raw black bear meat at a local restaurant and 60 out of 437 people who ate the bear meat were diagnosed with trichinosis. By compression method, 60.7 larvae per gram of meat were detected. In Mainland China, 86-166 trichina larvae per gram of bear meat has been reported (Yamaguchi, 1991).

Other species of animals were also reported. In China, Wu (1986) found 5.2% of 347 rats examined harbored the trichina larvae. In Sakon Nakhon

Province of Thailand, 421 dog diaphragms were examined by digestion method and 7 samples were found positive for larvae, with 5-9 larvae per one gram of meat (Srikitjakarn *et al*, 1981).

FISH

Fish is the most important source of human protein in many parts of the world. Freshwater as well as marine fish transmit serious parasitic diseases to man. The parasites include trematodes, nematodes and cestodes.

Freshwater fish

Clonorchiasis/opisthorchiasis/intestinal fluke infections: The liver fluke *Clonorchis sinensis*, is reported from China, Taiwan, Korea, while in Thailand, Lao PDR and Cambodia it is *Opisthorchis viverrini*.

In **China**, *C. sinensis* is widespread. An epidemiological survey conducted in Yangxin county, Hubei Province in 1993, by Kato-Katz method, reported an infection rate of 5.8%. Metacercarial infection of 3 species of fish ranged from 18-48%. Human infection in China occurs by consuming raw fish and or by eating food contaminated kitchen utensils (Chen *et al*, 1997). Pigs are important reservoirs, with infection rates of 11-35%. Fish in the Family Cyprinidae are an important source of infection (Li, 1991).

In **Hong Kong**, Duchastel in 1984 examined Hong Kong residents who applied to immigrate to Canada during 1979-1981 and found 13.4% positive by stool samples for *Clonorchis.*

In **Taiwan**, human infection reported in 1969 and 1979 was 20-50% (Cross 1969; Chen *et al*, 1979). Seventeen species of freshwater fish were found with metacercaria of *C. sinensis*. Among these, *Mugil cephalus* and *Ctenopharyngodon idellus* were the most highly contaminated, with more than 80% infection. The common and frequently consumed fish as sashimi are *C. idellus* and *Thirapia hybrid* (Chen, 1991). In an endemic area of clonorchiasis, "Sun Moon Lake", freshwater fish of the species *Hemiculter leucisculus* were examined in 1995; 2 out of 45 fish examined were positive with metacercaria of *C. sinensis*. However, 100% of the fish were positive for metacercaria in the muscle. The metacercariae found were of intestinal flukes; *Haplorchis taichui* 96%, *H. pumilio* 2% and *C. sinensis* 0.05% (Ooi *et al*, 1997).

In **Korea**, according to Seo *et al* (1981), the infection rate of clonorchiasis in people living along riversides was 8.0-40.2% with 21.5% being the overall infection rate. Approximately 36 species of freshwater fish were infected with the infective stage of this fluke. Among these, cyprinoid fish are in the majority. The infection rate in these fish ranged from 10 to 90%, with the highest rate in *Pseudorasbora parva* with a metacercarial density of 160/fish (Rim, 1997). In 1982-1983, the prevalence was still high, varying from 7-38% (Chai *et al*, 1982; Bae *et al*, 1983). The reservoir of this parasite includes domestic and wild animals (Min, 1982). The reported egg positive rates of dogs were 0.1-10.0%, cats 7.3% and house rats 0.3%. Among the trematodes infecting the intestinal tract of humans, *Metagonimus yokogawai* is the most common. The egg positive rate of residents along the streams in coastal areas was 10-20% (Chai *et al*, 1977; Seo *et al*, 1981). However, infection in 1987 was lower, with 6.6% prevalence (Ahn *et al*, 1987). Although infection of this parasite occurs by eating raw sweetfish *(Plecoglossus altivelis)*, the dace *(Tribolodon taczanowskii)* and the perch *(Lateolabrax japonicus)* (Chai and Lee, 1991), but the infection rate of metacercariae in these fish is unknown.

In **Thailand,** 7 million people are estimated to be infected with *Opisthorchis viverrini* (WHO, 1995). Six species of cyprinoid fish obtained from natural water resources in Khon Kaen Province were examined by digestion method. Four species of 2 families of trematodes infecting humans were isolated; in the Family Heterophyidae: *Haplorchis taichui, H. pumilio* and *Centrocestus formosanus*, and in the Family Opisthorchiidae: *Opisthorchis viverrini*. The intestinal species, *H. taichui*, was predominant; as many as 500 metacercariae were isolated from one *Hampala dispar* (Srisawangwong *et al*, 1997). About 63% of 6 species of fish in the same province harbored *Opisthorchis* metacercaria. The highest mean number of metacercariae per fish was 28 in *Cyclocheilichthys apogon* (Komalamisra and Setasuban, 1989). The popular dishes; *koi pla* and *pla som* are the major sources of human infection. *Koi pla* is made with chopped raw fish mixed with lemon juice, chili and some spices. *Pla som* is single overnight fermented flesh of fish mixed with boiled rice and some spices.

In the **Philippines**, *C. sinensis* was reported in 1947. Four species of Heterophyidae have been reported in humans: *H. taichui, H. yokogawai, Procerovum calderoni,* and *Stellanthchasmus pseudocirrata.* No study has been done concerning the species of fishes' intermediate host and contamination of the metacercariae of these trematodes in the fish (Eduardo, 1991).

In **Singapore**, all reported cases of clonorchiasis/opisthorchiasis were imported cases. Most infection was acquired during travelling in endemic countries

and sampling the contaminated delicacies of those countries.

Intestinal capillariasis: Intestinal capillariasis caused by *Capillaria philippinensis* is endemic in the Philippines and Thailand with several cases reported elsewhere. In experiments, several species of freshwater fish were able to transmit the infection. In the Philippines: Bagsit (*Hypseleotris bipartita*), Bagsan (*Ambassis miops*), Bacto (*Eleotris melanosoma*), Birut, Ipon (Fry) and Guppy (Cross and Basaca-Sevilla, 1991), in Thailand: Pla Nai (*Cyprinus carpio*), Pla Sew (*Rasbora borapetenis*), Pla Tapien Khao (*Puntius gonionotus*), Pla Krim (*Trichopis vittatus*), Pla Hautakua (*Aplocheilus panchax*), Pla Harngnokyoong (*Gambusia holbrooki*) (Bhaibulaya *et al*,1979). Capillaria-like larvae were recovered from 3 kinds of fish: Bagsit, Bagsan and Bacto from natural water of the Philippines. However, it was not possible to determine the species of the larvae. The Bagsit gravid female is preferably eaten raw in Western Luzon (Cross and Bhaibulaya, 1983).

Gnathostomiasis: Several species of *Gnathostoma* can produce the disease in humans. Among these, *G. spinigerum* is the most common cause of gnathostomiasis in several countries. Generally, freshwater fish is the source of infection. However, in **Japan**, 576 infective larvae of *G. hispidum* were recovered from the viscera of 4,461 loaches purchased in the city markets in Fukuoka City. The loaches were found to have been imported from Mainland China (Koga *et al,* 1985). Moreover, 7 *G. nipponicum* early third stage larvae were recovered from 3,098 native Japanese loaches: *Misgurnus anguillicaudatus* caught from Mie Prefecture (Ando *et al,* 1988).

In **Thailand**, 9 species of fish sold in a local market of Bangkok were found to be infected with *G. spinigerum* infective larvae with an infection rate of 1.2%. The highest infection rate, 40%, was found in the eel (*Fluta alba*) with the maximum number of larvae found per fish being 28 (Rojekittikhun *et al,* 1989). The infection rate of snake-head fish, *Channa striatus* sold in the market in Bangkok and Nakhon Nayok Province during 1987-1989 was 70% (Setasuban *et al*, 1991). However the prevalence decreased to 10% in Nakhon Nayok Province during the period October to December 2000 (Rojekittikhun, personal communication). In swamp eels purchased from markets in 11 provinces of central Thailand, gnathostome larvae were found in 7 provinces with prevalences between 10.0% in Lop Buri to 68.7% in Nakhon Nayok (Nuamtanong *et al*, 1998). An outbreak of *Gnathostoma* larvae migrans occurred among New Year's party attendants in Chachoengsao Province, central Thailand. They consumed *Hu sae*, a special Chinese dish prepared from raw flesh fish (Migasena *et al,* 1991).

In **Indonesia**, *Naniura* and *Lavara*, the special dishes made from raw fish and raw tuna, are popular among the inhabitants of North Sumatra, North and South Sulawesi. Fish have been found infected with *G. spinigerum* larvae were *Ophiocephalus striatus*, *Clarias batrachus* and *Cyprinus carpio*. Up to 1991, 4 cases of gnathostomiasis have been reported (Kushayono and Sukartinah, 1991).

In the **Philippines**, two human cases of gnathostomiasis due to *G. spinigerum* have been reported. Dogs, cats, the flying lemur and the palm civet serve as reservoirs of the parasites (Eduardo, 1991). There is no information on fish contamination in this country.

In **Hong Kong**, 1% of catfish, *Clarias fuscus*, purchased from local markets, harbored *G. spinigerum* larvae. The larvae were also found in *C. batrachus* and *Ophiocephalus* spp (Ko, 1991).

In **India**, 1.6% of dogs were infected with *G. spinigerum.* Three percent of *Ophiocephalus punctatus* contained infective larvae in the viscera and muscles of the fish (Baruah and Gogoi, 1988; Bhatia, 1991).

Marine fish/other aquatic food

Two groups of nematode larvae, in the family Anisakidae and in the Suborder Spirurina are found in marine products. The former produces gastric/ intestinal syndrome and the later larvae migrans. Moreover, the plerocercoid stage of the pseudo-phyllidian cestode is found in fish from the seawater of cold areas.

In **Japan**, several species of marine fish were reported to be sources of these nematode parasites. Thirty percent of trout examined at Yokohama fish market harbored plerocercoid of *Diphyllobothrium* sp (Oshima *et al,* 1983). Not only raw fish is a delicacy for the Japanese, but also squid. Of 162 squid examined, 25% harbored larvae in the Suborder Spirurina. However, 44 larvae of the same type were also found in 77 cods. These larvae produced cutaneous creeping eruptions in humans (Ando *et al,*1992; Ando and Chinzei, 1997).

In **China**, 83% of 33 species of marine fish, squid and cuttlefish from the Yellow Sea contained *Anisakis* larva (Sun, 1986).

In **Indonesia**, no human anisakiasis has been reported; however, *Anisakis* and *Terranova* larvae were

found in 3 species of fish caught from waters of Indonesia. Raw fish to be barbecued is served in Japanese and Korean restaurants and this is expected to increase the risk of human anisakiasis in Indonesia (Kusharyono and Sukartinah, 1991).

In the **Philippines**, less than 1% diphyllobothriid ova were found in stool surveys in various places (Cross and Basaca-Sevilla, 1984).

In **Kuwait**, between 1992-1995, 12.7% of 23 species of marine fish in local fish markets in Kuwait City were infected with third stage larvae: *Anisakis* 8.6%, *Terranova* 56.1% and *Contracaecum* 4.3% (Sey and Petter, 1997).

CRABS AND CRAYFISH

Crabs and crayfish are sources of lung fluke, *Paragonimus,* infection in humans and animals. In Asia, there are 6 species reported in humans *ie P. westermani*, *P. heterotremus*, *P. miyazakii*, *P. hueitungensis*, *P. philippinensis* and *P. skrjabini.*

In **China**, lung infection caused by *P. westermani* is a common infection in the northeast, whereas cutaneous infection with *P. skrjabini* is reported in the south and eastern parts of China. Crabs (*Eriocheir* and *Potamon*) and crayfish (*Cambaroides*) were the source of infection. In south China, raw wine-soaked "drunken" crabs and raw shrimp were special dishes; in southwest China, raw crab meat, raw crab sauce and crab jam; in northeast China, raw crayfish and crayfish curd (Xu, 1991). The crab infection rate was 0.3%. Canine and feline species were the reservoir hosts (Li, 1991).

In **Korea**, about 100 clinical cases of paragonimiasis were diagnosed annually. The infection rate in the crabs, *Eriocheir japonicus* and *E. sinensis* purchased in Seoul markets was 11.8%, with 2.1 metacercariae per crab. Infection in freshwater shrimp was low but existed, with 6 out of 4,382 *Macrobachium nipponensis* containing *P. westermani* metacercariae (Soh *et al,* 1966). The traditional food is *kejang,* raw crab immersed in soy sauce (Cho *et al,* 1997). Raw juice of the crushed crayfish (*Cambaroides similis*) is used as medicine for measles. This socio-cultural factor remains the cause of the continuous presence of infection (Soh, 1991).

In **Japan**, sporadic cases of paragonimiasis are still occasionally found in Miyazaki Prefecture. Between 1985-1990, a total of 13 cases was reported in residents of ancient endemic areas, the Oyodo River and the Hiroto River (Nawa, 1991).

In **India**, Singh *et al* (1986) reported paragonimiasis cases acquired by eating raw crab (*Potamon dehani*) containing *P. westermani* metacercariae.

In **Thailand**, there are 6 species of *Paragonimus* found in animals. The species reported in humans is *P. heterotremus* (Vanijanonta *et al,* 1981). A favorite ethnic dish is *pla poo* or *yam poo,* raw crabs of *Potamon* and *Parathelphusa* spp mixed with spices.

In the **Philippines**, 0.15% of 8,779 people examined were positive for *Paragonimus* eggs in sputum of residents in Sorsogon Province. The source of infection is *kinagang,* wrapping of crabs in banana leaves and quickly boiling them in coconut milk; the crabs are insufficiently cooked (Belizario *et al,* 1997).

In **Vietnam**, in a district located in the mountainous area near the Chinese border, the infection rate of paragonimiasis was 10-25% by sputum examination. Roasted crabs or crab juice was the source of infection (Vien *et al,* 1997).

SNAILS

Several kinds of snails are medically important and contain infective stage worms. The land snail is an important source for transmission of the rat lung nematode, *Angiostrongylus cantonensis* causing eosinophilic meningitis or eosinophilic meningoencephalitis in humans. Freshwater snails are the source of *Echinostoma*, an intestinal infections.

In **China**, 37% of *Achatina fulica* and 23% of *Vaginulus yuxisis* contained infective larvae of *A. cantonensis* (Liang, 1989).

In **Taiwan**, eosinophilic meningitis or meningoencephalitis is prevalent in the summer rainy season when snails are active in the field. Over 80% of the cases occurred in children aged under 15. Infection is not only caused by eating the raw snail but also by playing with the snail and coming into contact with the mucus or viscera of the snail which contains *A. cantonensis* third stage larvae (Reviewed in Hwang and Chen, 1991).

In **Thailand**, a survey of *Angiostrongylus* infections in snail intermediate hosts was performed in 5 provinces of northeastern Thailand. Approximately 0.9% of *Pila polita* and 36.4% of *A. fulica* harbored the infective larvae of *Angiostrongylus* sp (Pipitgool *et al,* 1997). The infection rate of the larvae in another edible land snail, *Hemiplecta distincta* collected from 14 provinces in the northeast, varied from 24% in Roi Et to 66% in Yasothon Province; a lower rate of

infection was found in central Thailand, with 7% in Saraburi and Lopburi (Panha, 1988).

In the **Philippines**, 10 human cases of angiostrongyliasis have been reported. Infection rate in the rat reservoir host ranged from 3-10%. Land snails and garden slugs were also found contaminated with the larvae (Cross, 1982).

In **India**, 2 human cases were reported. The source of the cases was confirmed, and as many as 200 larvae per gram of tissue of the slug, *Laevicaulus alta* were collected (Sharma *et al*, 1981).

FROG/SNAKE

Sparganosis: Over 300 human cases of sparganosis have been reported in China. The most important source is the frog, *Rana tigrina rugurosa*, with an infection rate of 61-91% (Li, 1991). Sparganum was reported to be widespread in tadpoles and frogs in the Philippines (Jueco, 1982), and 1-2% in frogs and snakes in Hong Kong in the 1970's, (Ng *et al*, 1988). Few human cases have been reported in the Philippines (Eduardo, 1991), India (Bhatia, 1991) and Hong Kong (Ng *et al*, 1988). Some cases are also reported from Taiwan.

Gnathostomiasis: Infective larvae of *G. spinigerum* were found in frogs and snakes in Thailand (Daengsvang, 1980), Hong Kong (Ko, 1991) and maybe other countries, too. In Japan, the snake, *Agkistrodon halys*, is the source of infection for *G. doloresi*. Imai *et al* (1988) reported that 100% of these snakes contained *G. doloresi* larvae.

Flukes: Twenty-six human cases of fluke infection due to *Fibricola seoulensis* have been reported from eating terrestrial snakes in Korea (Chung and Soh, 1991).

AQUATIC PLANTS

Freshwater aquatic plants containing metacercariae of flukes are the cause of fasciolopsiasis, an intestinal fluke infection, and fascioliasis, a liver fluke infection of humans. Several species of water plants are frequently eaten in their raw or fresh states. However, according to the literature, no study has been attempted on the percent contamination.

Fasciolopsiasis: The infection rate of *Fasciolopsis buski* infection in humans in China ranges from 4-57%. The sources of infection are the water caltrop *(Trapa natans)*, water chestnut, water bamboo and lotus root (Gao, 1983). The pig is the major reservoir host. In Thailand, human infection was found to be 38.5% in Ayutthaya Province, Central Thailand. The sources were caltrops (*Trapa bicornis*), lotus (*Nymphaea lotus*), watercress (*Neptunia aleracea*), morning glory (*Ipomoca aquatica*), and hyacinth (*Eichhornia speciosa*) (Manning *et al*, 1969).

Fascioliasis: Human infection with *Fasciola* is not common in this region. In China, up to 1991, 44 human cases have been reported. Seven cases have been reported in Korea (Im and Kim, 1988). However in ruminants, *Fasciola hepatica* is one of the most common parasites. Infection rates in certain areas of China were as high as 89% in 1983 and 67% in 1986 (Huang and Zhang, 1983; Huang, 1986). In countries of Southeast Asia, infection is mainly due to *Fasciola gigantica*. It is enzootic in ruminants. The prevalence in cattle and buffalo was 11.8% in Thailand (Sukhapesna *et al*, 1989). In some areas of the northeast, the infections are as high as 85% (Loehr *et al*, 1984). The prevalence in Bali, Indonesia ranged from 6.5 to 22% in cattle during the period 1983-1988; in Malaysia it was 42% in cattle and buffalo, 32% in goats and 7% in pigs (Loganathan and Aziz, 1983); in the Phillippines it was as high as 95% in some endemic areas (Eduardo, 1991). Nine human cases due to *Fasciola* sp have been reported in Thailand (Kachintorn *et al*, 1988), with only 2 cases in the Phillippines (Eduardo, 1991).

OTHERS

Cyclops from drinking water is the source of infection for *Spirometra* and *Dracunculus* larvae. *Dracunculus medinensis* or guinea worm infection in humans is widespread in India, especially in remote rural areas. Stray dogs are the principal reservoir hosts (Bhatia, 1991).

There are some human parasitic infections that are acquired through food or drinking water contaminated with parasite eggs. The helminths eggs from human or animal hosts are discharged in the host feces. The egg develops to the intermediate stage and when acquired, produces serious fatal disease in humans, such as cysticercosis and hydatidosis. Vegetables grown in soil irrigated by sewage water or the use of night soil as fertilizer may be the source of cysticercosis, and soil-transmitted helminthic infection *eg* ascariasis, trichuriasis. Moreover, vegetables may be contaminated with *Angiostrongylus* larvae if the infected mollusks are present, or with hookworm larvae.

Beetles and grubs with cystacanth larvae may be

infected with the acanthocephala, *Macracanthorhynchus hirudinaceus.*

CONCLUSIONS

Illness due to contaminated food is a widespread health problem and an important cause of reduced economic productivity. Food-borne parasitic infection is one example. There is an increasing risk to consumers of acquiring the infections in non-endemic areas because of growth of international trade and international travel and an increasing availability and interest in ethnic foods. These contribute to the risk of food-borne parasitic infection. Generally, food-borne parasitic diseases are associated with socio-cultural practices. Strict meat inspection and condemnation of the carcasses by the appropriate authorities can prevent the establishment of important parasitic zoonotic infections. However, in remote rural areas where animals are slaughtered locally and meat inspection is not available, people are at risk of obtaining unsafe food. To protect oneself from these infections, only properly cooked food should be eaten.

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