EPIDEMIOLOGY OF MARINE FISH-BORNE PARASITIC ZOONOSES

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Abstract. Most parasites of marine animals are of little public health concern; however, some helminths are capable of infecting humans. Marine zoonotic infections in humans result from consumption of contaminated edible tissues or products of seafood or, to a lesser extent, from physical contact with contaminated seafood. Worldwide, over 50 species of helminth parasites from fishes, crabs, crayfishes, snails, and bivalves are known to produce human infections. Most helminth zoonoses are rare and invoke only slight to moderate injury; however, some are more prevalent and pose serious potential health hazards. Worldwide, the majority of seafood zoonoses occur along coastal regions where seafood products are commonly consumed. Continuing improvements in transportation, technology, and food handling, however, allow fresh seafood to be shipped throughout the world; thus, the potential for acquisition of parasitic infections from marine products is not limited to coastal populations. Although the number of documented cases continue to increase, the overall risk of human infection is slight. The increasing exploitation of the marine environment by humans, changing dietary habits incorporating "natural" seafood dishes (eg, sushi and sashimi), and tendency to reduce cooking times when preparing seafood products, all increase the chances of becoming infected with these parasites.

INTRODUCTION

Food safety, regardless of the specific food product, should be of paramount concern to everyone. Parasitic diseases represent one potential health risk from foods. Aquatic food products are not without risk from parasitic zoonoses. Researchers, for example, have implicated over 50 species of helminth parasites as producing zoonotic infections resulting from eating raw or undercooked aquatic foods (eg, fishes, crabs, crayfishes, snails, and bivalves) (Sprent, 1969; Williams and Jones, 1976). Because of the variety of seafood items, lack of inspection, and difficulty with control of production, a diversity of unique health concerns are manifested. (For a general overview of zoonoses transmitted by aquatic animals, see Williams and Jones, 1976; Beaver *et al*, 1984; Higashi, 1985; Schantz, 1989; Deardorff and Overstreet, 1990).

Examples of common raw seafood dishes known to transmit parasitic zoonoses are Japanese sushi (raw seafood surrounded with rice and nori wrap), Japanese sashimi (thinly sliced raw fishes), Japanese salad (raw fish, fresh lettuce, and soya sauce), Hawaiian lomi lomi salmon (chopped salmon, bell peppers, and tomatoes), tako poki (Japanese and Hawaiian cephalopod dish), palu (meat from a fish head and visceral organs that have been allowed to ripen in a closed container), Dutch green herring, Scandinavian gravlax, Latin American ceviche (fillets marinated in lime juice), Philippine bagoong (uncooked fish viscera, often in a deteriorated state), and Pacific Island poisson cru (fish fillets marinated in coconut juice). Humans who eat contaminated products may become infected; however, two reported human cases occurred by contact with contaminated seafood.

Many marine-associated parasitic diseases occur only in specific areas of the world. Diseases may be restricted to these areas because of a variety of determinants such as the availability of specific intermediate and definitive hosts necessary to complete a parasite's life cycle. An example of a seafood-transmitted disease that became established in the US because of the presence of suitable parasitic hosts is diphyllobothriasis. This disease continues to infect US citizens today.

In addition to the availability of suitable intermediate and definitive hosts, improved sanitation, refined food handling techniques, changes in dietary habits in some societies, and personal and social behavior patterns play a significant role in transmission or discontinuation of parasite diseases. These determinants are self explanatory. Location also has influenced transmission. In coastal areas, seafood is fresh, abundant, and comprises the majority of the protein intake for these inhabitants. The vast majority of seafood-related zoonoses, therefore, occur in localities adjacent to the coasts because exposure to the various parasites are greatest for these populations.

Health authorities in the past principally focused on the safety of their own fisheries and seafood products. Problems associated with the marine products imported from other countries were of little concern. This "ivory tower" approach to seafood safety is no longer prudent. Parasites, after all, do not honor national boarders. Humans traveling as tourists or immigrants represent a potential vehicle for the introduction of a disease into a country. *Diphyllobothrium latum* was introduced into the US by immigrants from Europe. Establishment of this parasite occurred because proper conditions and suitable intermediate and definitive hosts existed in the lake regions of the central USA. The British Isles, Argentina, Australia, Venezuela, and the Federal Republic of Madagascar also have reports of diphyllobothriasis occurring from travelers.

Today, improved modes of transportation, advanced technology, and refined food handling allow fresh seafood to be shipped throughout the world. In 1987, for example, 65% of the seafood consumed in the US was imported from 141 countries. Canada supplies approximately 20% of the US demand for seafood, Europe about 12%, and Thailand 8%. Reports of shipments into the US of imported seafood contaminated with viable parasites demonstrated to be infectious to humans are known. Clearly, the potential for acquisition of parasitic infections from marine products is no longer limited to areas where a parasite's life cycle occurs or along coastal regions. Marine foods, on a global scale, must be considered by government regulatory agencies to ensure a safe seafood supply.

The connection between marine mammals and zoonoses has become increasingly more apparent. Since the establishment of the Marine Mammal Protection Act in 1972, the numbers of some marine mammals rapidly have increased worldwide. An increased mammal population influences parasitic worm burdens in fishes. Further, if a parasite is capable of infecting a marine mammal, there is a good chance that it also may infect humans. Some marine mammal parasites known to infect humans are *Diphyllobothrium* spp., *Diplogonoporus* spp., *Anisakis* spp., *Pseudoterranova decipiens, Acanthocephalus rauschi*, and *Corynosoma strumosum*. Because the life cycle of these parasites begins and ends in marine mammals, it is logical that fishes would have a greater opportunity to become infected and possess increased numbers of worms in areas where marine mammals were abundant. Several surveys conducted for ascaridoid nematodes around the world confirmed this association.

Canadian fishermen have expressed concern about the population explosion of harbor and gray seals along the northeastern coastline of North America and a corresponding increased prevalence and intensity of the third-stage juvenile of *P. decipiens* in the Atlantic cod, *Gadus morhua*, caught in Canadian waters. The increase in prevalence and intensity of juvenile *P. decipiens* (commonly called the "cod worm") has been documented in commercially important fishes. Canadian researchers report approximately two worms per kilo of cod. The increase has cost Canada's cod industry and consumers substantial sums of money (eg, removal of worms from fillets by candling, lost sales because of the negative aesthetic impact to consumers). The industry estimates that about 50 million dollars per year is spent to reduce the numbers of cod worms in commercially important fish fillets. The cod worm also has been found in other ground fish. Undeniably, the presence or absence of large marine mammal populations serves as a barometer to predict the presence or absence of some worms of potential human health significance in fishes.

The importance of marine food-borne zoonoses, in terms of the numbers of people affected, morbidity, mortality and socio-economic impact, place these diseases near the bottom of the list

of global public health concerns. Clearly, the majority of seafood-transmitted parasite illnesses are not severe compared with other types of parasitic zoonoses and some represent an incidental parasitosis that may be considered acceptable in public health terms.

All potential problems, however, are not known. The number of new cases, as well as additional unrecognized parasitic diseases, should continue to increase as mankind exploits the marine environment for food. Protozoans of marine animals, even though none have been demonstrated to infect humans, may represent a potential area of risk. While additional research to confirm whether marine protozoans are capable of infecting humans is needed, it appears that immunocompromised individuals, whether due to heredity, immunosuppressive drugs associated with transplantation, or AIDS, possess an appreciably increased risk of infection with marine protozoans.

Once the epidemiology of marine zoonoses is understood, prevention and control of the diseases can be adequately addressed. For most known marine zoonoses, temperature extremes are extremely effective in the prevention of parasitic infections. The heat from thorough cooking kills marine parasites. When thorough cooking is not desired, freezing is effective in devitalizing the worms. The time and temperatures necessary to kill parasites varies with the species of fish and thickness of fillet. Some countries such as the Netherlands and the United States, and those in the European Economic Community currently have freezing regulations or recommendations in effect. No freezing restrictions are in effect in Japan. The enormous diversity of fishes and invertebrates known to harbor potentially infective juveniles makes control difficult (Oshima, 1972). According to Deardorff and Overstreet (1990), Japanese cooks reportedly freeze Pacific salmonids before serving raw dishes to kill potentially invasive helminths. Even with this precaution, approximately 1,000 episodes of anisakiasis alone are reported every year from Japan.

While thorough cooking or adequate freezing of seafood are good preventive measures against anisakiasis and other seafood-transmitted parasitic zoonoses, these practices will not always be followed and are difficult to enforce. Prevention and control of these diseases are probably best accomplished by educating the public to the health risks of eating raw seafood. Consumer should know the risks and evaluate the potential consequences themselves. Acceptance of risks should be voluntary as with other foods. Consumers, for example, are more than likely aware that raw beef (ie, steak tartare) may be the vector for the beef tapeworm or be the cause of toxoplasmosis and that raw pork may transmit the pork tapeworm or be the cause of trichinosis. When they choose to eat these foods, they have considered and voluntarily accepted the risks. As with beef and pork, the vast majority of seafood products are safe to eat; however, the importance of consumer awareness concerning the possible hazards of eating raw seafood cannot be over emphasized.

In addition to responsible and accurate reporting, educational efforts must be continuous for two reasons. First, constant reminders of potential dangers are necessary to reenforce proper seafood handling practices. We are creatures of habit; some habits may represent risks to our health. History shows us that ingrained habits such as smoking and drinking alcohol, which are linked to serious human disease, are difficult habits to break. Continuous reminders appear necessary. Second, as we continue to exploit the marine environment in our search for food, new parasites, no doubt, will be encountered. The vast majority of these worms will be of interest to a few parasite taxonomists; however, a small number of newly encountered marine parasites, those that are capable of infecting humans, also will be found. Our knowledge of seafood-transmitted zoonoses, therefore, will continue to change. Its dynamic nature a reflection of the types of seafood we choose to eat and variations in preparation techniques. Concerning seafood transmitted diseases, potentially pathogenic parasites will continue to exist unknown to humans until we happen to intrude into their niche and we will intrude. Public health authorities must be prepared.

Although marine fish-borne zoonoses are, and always will be, an area of public health concern, there remains a paucity of research and researchers in this area. Additional marine parasitologists with expertise in a wide variety of fields (eg,

taxonomy, ecology, immunology, evolution, molecular biology) are required to ascertain the unbelievably intricate and unpredictable epidemiological relationships between humans and the parasites of marine animals. The field of marine parasitology promises to be as vast as the oceans.

Today, our seafood industry has a worldwide market, tremendous diversity of sources, and enormous varieties of the food items. Trends toward increased consumption of more and fresher marine seafood and the inevitable introduction of new species and products from around the world will require expanded monitoring proficiency to ensure a safe seafood supply. A uniform, global, seafood inspection system looms on the horizon.

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