Infections Associated with Exotic Cuisine: The Dangers of Delicacies

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ABSTRACT “Exotic” food dishes are an expression of regional culture, religion, and ethnicity worldwide. With the increase in international travel to remote areas of the world, globalization of the food supply, and changes in food habits, more people are consuming dishes once considered exotic. Such behavioral changes require awareness by consumers and clinicians about the risks of food-borne infections. This chapter addresses pathogens associated with consumption of raw or undercooked seafood including anisakidosis, Diphyllobothrium latum infection, flukes, and other infectious and toxin-mediated diseases. We discuss the geographic distribution of the pathogens, symptomatology, and basic principles of treatment. Food products derived from turtles, snakes, and other reptiles are reviewed, and we address the risk of gnathostomiasis, sparganosis, trichinellosis, and other pathogens. In discussing infections associated with undercooked beef, pork, and bush meat, we address dysentery, amebiasis, toxoplasmosis, Taenia infections, and risks of novel viral infections, among others. We also review infectious risks from poultry, dairy, and other food items, focusing on those organisms encountered less frequently by clinicians in developed countries. The wide range of infectious organisms related to exotic cuisine underscores the importance of educating the adventurous traveler and warrants continued vigilance on the part of the clinician.

INTRODUCTION

“If it has four legs and it’s not a table, eat it.”
—Cantonese saying

“Exotic” food dishes reflect the diversity of human culture. From raw turtle eggs and raw snake meat in Asia, crocodile meat in Australia, and raw duck blood soup in Vietnam, examples abound of food considered exotic to those from other areas of the world. With the increase in international travel to remote areas of the world, globalization of the food supply, and changes in food habits, more people are consuming dishes once considered exotic. Many such individuals are immunosuppressed or susceptible to infection based on underlying medical conditions (e.g., HIV) or age and expose themselves to potentially risky food for the purposes of cultural exploration and adventure. Despite improvements in hygiene, water purification, and food sanitation in some locales, many parts of the world continue to be plagued by deficiencies in these areas.

While there are numerous infections related to cuisine, this chapter is intentionally not exhaustive. We have focused on those infections associated with exotic cuisine and those seen less commonly in developed countries. The aim of this chapter is to inform travelers and physicians in Western countries about food types associated with infections and to briefly discuss the geography of where such infections are found, the symptoms, and the treatment.
RAW SEAFOOD

“Most seafoods... should be simply threatened with heat and then celebrated with joy.”

Jeff Smith, The Frugal Gourmet

In many cultures, raw seafood is popular, and dishes that were once regional specialties are now found more widely. Raw, undercooked, salted, or pickled herring, anchovies, and oysters in Europe; sea urchins in the Mediterranean and Far East; and ceviche (raw seafood marinated in lemon or lime juice and spices) in parts of South America and the Caribbean are common. In Korea, raw crab meat is spiced with soy sauce (kejang), raw grass carp is eaten in China, and uncooked or fermented fish (lab pla, koi pla, pla som, and pla ra) is found in Thailand and Laos. Ikizakana, a Japanese sashimi dish, is served immediately after killing the fish, and it may be still twitching. Consumption of raw or undercooked seafood is the source of a variety of infectious diseases (Table 1).

Nematodes
Anisakidosis
Anisakidosis, also known as codworm, whale worm, herring worm, and sealworm, results from infection with the larval stage of several nematodes, usually Anisakis simplex or Pseudoterranova decipiens. The adult parasites are typically found in the stomachs of large sea mammals, and humans are infected as dead-end hosts. The larvae develop first in small crustaceans and then in fish and squid (intermediate hosts) until they are eaten by the definitive host (seals, sea lions, and walruses for P. decipiens and dolphins, porpoises, and whales for A. simplex) (Fig. 1).

Humans become infected after consumption of raw, undercooked, or inadequately pickled, salted, or smoked marine fish or squid. The majority of reported cases worldwide have occurred in Japan, but cases have been described in coastal areas of Europe (especially the Netherlands, Germany, France, and Spain), South America, and other areas. Larvae have been found in more than 200 species of fish including cod, sole, flounder, fluke, salmon, mackerel, herring, sea eel, yellow-tail, and squid. Other than sushi, high-risk dishes include salted and smoked herring in the Netherlands, Scandinavian gravlax, Hawaiian lomi-lomi (raw salmon), South American ceviche, Spanish pickled anchovies (boquerones en vinagre), and raw sardines. Infection can be eliminated by freezing and reduced by visual examination of fish, extraction of visible parasites, and elimination of heavily parasitized fish. In countries where

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recommended freezing practices have been implemented and enforced, consumption of sushi and sashimi in restaurants should be safe, but the risk might be higher in areas with poor enforcement.

The four major clinical syndromes of symptomatic anisakidosis include gastric, intestinal, extra-intestinal or ectopic, and allergic disease. Gastric anisakidosis manifests with the abrupt onset of severe epigastric or esophageal pain, nausea, vomiting, low-grade fever, and occasionally rash. Infection with *P. decipiens* tends to be milder than disease due to *Anisakis* species. Infected people can experience the “tingling throat syndrome” or cough from a worm crawling in the upper esophagus. For those with gastric infection, the acute symptoms resolve within a few days, but infected people may report persistent vague abdominal pain, nausea, and vomiting for weeks to months. Untreated gastric disease may lead to chronic, ulcer-like symptoms. Early endoscopic removal is the preferred treatment, and examination of the larva provides a definitive diagnosis. If endoscopy is delayed, the worm may degenerate, be eliminated, or pass through the mucosa (resulting in ectopic disease) and no longer be visualized. Eosinophilia can be seen in gastric infection—particularly if the worm remains in place.

Intestinal anisakiasis is characterized by abdominal pain that starts 5 to 7 days after ingestion of the larvae. Infected individuals may develop ascites and/or peritoneal signs. Intestinal infection and the subsequent inflammatory response predominantly occur in the terminal ileum. Rare complications include small bowel obstruction, ileal stenosis, intussusception, intestinal perforation, and pneumoperitoneum. Ectopic, extra-gastrointestinal, or intra-peritoneal anisakiasis—less common complications—result from larval penetration of the stomach or intestine. This can lead to migration in the peritoneal cavity, the pleural cavity, and elsewhere. Surgical removal of the larvae is occasionally required for management of intestinal or ectopic infections and is diagnostic. Serologic evaluation can be useful in intestinal and ectopic cases. Limited evidence suggests that albendazole (400 to 800 mg daily for 6 to 21 days) is an effective therapy.

Anisakidosis is also associated with a strong allergic response. In reports primarily emerging from Spain, frequent fish consumption (particularly anchovies) and occupational exposure (e.g., fish processing) are associated with increased risk of an allergic response to *A. simplex*. Generally less than 6 hours after ingestion of infected fish, allergic symptoms develop ranging from urticaria and angioedema to anaphylaxis. High levels of anti-*A. simplex* IgE are often present, but some assays are cross-reactive with other parasites and nonrelated animals. Because of the limitations of the existing assays, testing for allergic anisakidosis may require a constellation of tests.

**Gnathostomiasis**

Gnathostomiasis is an emerging travel-related illness that is likely underreported. Humans are infected primarily with the nematode *Gnathostoma spinigerum*, but cases have been reported from others among the 12 *Gnathostoma* species. Adult worms in the gastric wall of the definitive host (felines, canines, boars, and other vertebrates) pass eggs in the animal feces. Embryonated in water, eggs are ingested by a small crustacean (*Cyclops*) and develop into larvae. Humans become infected after consumption of raw or undercooked freshwater fish (including snakehead, carp, catfish, and tilapia), shellfish, frogs, snakes, and poultry. The larvae complete their life cycle in the definitive hosts but not in humans.

Gnathostomiasis is found most commonly in Southeast Asia, especially Thailand, but cases are also reported from Japan, Mexico (and other parts of Latin America), and other areas of the world. Larvae have been found in the United States from live swamp eels imported from gnathostomiasis-endemic countries.
Nonspecific symptoms of malaise, nausea, vomiting, cough, myalgias, and occasionally fever follow soon after infection, but the hallmark of clinical gnathostomiasis is recurrent migratory erythema or pruritic subcutaneous nodules due to larval migration. Symptoms may vary slightly depending on the species, with some causing a serpiginous eruption similar to cutaneous larva migrans from dog or cat hookworm infection. Larval migration into deeper tissue can result in fatal visceral, ocular, or central nervous system (CNS) disease (including meningoencephalitis, cranial nerve palsy, and myelitis). Subarachnoid hemorrhage and painful radiculopathy accompany CNS infection and help distinguish it from angiostrongyliasis as a cause of eosinophilic meningitis. Peripheral eosinophilia and elevated IgE levels are commonly seen when the skin lesions are present. For cutaneous gnathostomiasis, both albendazole (400 mg daily or twice daily for 21 days) and ivermectin (0.2 mg/kg once or daily for 2 days) have been shown to be effective in small studies, but relapses occur and retreatment may be necessary. For CNS infection, a combination of treatment with albendazole and corticosteroids can be used, although it is not clear at this time that the addition of corticosteroids is beneficial.

**Eustrongylides**

The nematode *Eustrongylides*, a parasite of aquatic birds, can infect fish as well as amphibians and reptiles (paratenic hosts). Human infection has been reported from consumption of raw freshwater fish. Mimicking appendicitis, infected individuals develop severe right lower quadrant pain and peritoneal signs or intestinal perforation. Surgery reveals small pink-red worms in the peritoneum. Of three patients who swallowed live minnows in Maryland and developed *Eustrongylides* infection, two underwent laparotomy, and *Eustrongylides* larvae were found to have perforated their ceca.

**Capillaria philippensis**

Humans become infected with the nematode *C. philippensis* after ingestion of raw or undercooked freshwater or brackish-water fish. Fish-eating birds appear to be the natural final host. In the human intestine, adult female worms produce fertilized eggs and larvae. Importantly, the latter can cause autoinfection resulting in sustained human infection for years. *Capillaria* is endemic in areas of the Philippines and Thailand, and sporadic cases have been reported in Japan, Korea, Taiwan, Indonesia, India, Iran, and Egypt. Infected patients experience diarrhea and abdominal pain, and if the infection goes untreated, they may develop weight loss, weakness, malaise, anorexia, edema, and even death. Diagnosis is made by stool examination, and treatment with albendazole for 10 days is thought to be effective.

**Cestodes**

*Diphyllobothrium latum*

*D. latum* is the largest human cestode (tapeworm), measuring up to 30 feet in length. Of the 50 other *Diphyllobothrium* species, approximately 13 also reportedly infect humans (including *Diphyllobothrium dendriticum*, *Diphyllobothrium nihonkaiense*, and *Diphyllobothrium klebanovskii*, among others), albeit less frequently. Infected humans and other fish-eating mammalian hosts (cats, dogs, foxes, bears, wolves, and pigs, among others) pass immature eggs in feces. The life cycle passes through freshwater crustaceans and then small freshwater fish (the second intermediate host), in which the larvae migrate into the fish flesh and develop into a sparganum, which is infective for humans. Humans are usually infected by consuming raw or undercooked larger fish (e.g., trout, salmon, pike, perch) that have ingested the second intermediate hosts. The sparganum develops into an adult tapeworm that attaches to the intestinal mucosa and discharges eggs.

Endemic areas include Europe (particularly Scandinavia), Asia, Russia, and parts of North and South America, including outbreaks in the United States from fresh salmon. *D. latum* infection is typically associated with gefilte fish, a traditional dish of chopped fish, crumbs, eggs, and seasonings among Jewish people, which is often tasted to assess the seasoning prior to boiling. Other dishes associated with *D. latum* infection include raw, salted, or marinated fillets in Baltic countries, South American ceviche, Japanese sushi, Northern Italian carpaccio (thin slices of raw fish), and tartare maison of raw salmon. The importation of infected fish can result in cases outside the usual areas. Most infections are asymptomatic, but nonspecific symptoms include abdominal discomfort, diarrhea, and weight loss. Pernicious megaloblastic anemia (and resultant neuropathy) can result from the tapeworm absorbing vitamin B₁₂ in the proximal small intestine. Very heavy infections and proglottid migration can cause intestinal obstruction, cholecystitis and cholangitis. Diagnosis is made by examination of the stool for proglottids and the oval eggs, which have a characteristic operculum. A single dose of praziquantel (25 mg/kg) is curative.
Infections Associated with Exotic Cuisine

Flukes
Liver flukes
The liver flukes *Clonorchis sinensis*, *Opisthorchis viverrini*, *Opisthorchis felineus*, and *Metorchis conjunctus* cause hepatobiliary disease. The life cycle involves snail intermediate hosts and then freshwater fish, although carnivorous animals can also serve as reservoir hosts. Human infection occurs by ingestion of infective undercooked, salted, pickled, or smoked freshwater fish. After the metacercariae excyst in the duodenum and ascend the biliary tract, the adult flukes take up residence in the biliary ducts. *C. sinensis* is endemic in East and Southeast Asia (South Korea, China, Taiwan, northern Vietnam, and the far eastern part of Russia), and *O. viverrini*, in Southeast Asia (particularly Thailand, Laos, southern Vietnam, and Cambodia). *O. felineus* extends to central and western Eurasia, and *M. conjunctus* is found in Canada and the United States. All are also seen in nonendemic areas in immigrants or those consuming imported fish. Fish susceptibility varies widely by parasite species with more than 100 species of freshwater fish, especially the *Cyprinidae*, and three species of freshwater shrimp serving as intermediate hosts. Examples of traditional dishes associated with liver fluke infections include slices of raw fish with red pepper sauce (Korea), congee (rice gruel with raw fish) in southern China and Hong Kong, *koi pla* (raw fish with garlic, lemon juice, fish sauce, chili, rice, and vegetables), and similar dishes including *pla ra*, *pla som*, *pla lap*, *som fak*, and *pla kaw* in northeastern Thailand and Laos.

Low-level infections can by asymptomatic. Higher-grade infections can result in intermittent biliary obstruction with symptoms of fever, right upper quadrant or epigastric abdominal pain, nausea, and diarrhea; chronic infections can cause cholangitis, cholelithiasis, pancreatitis, cirrhosis, and ultimately cholangiocarcinoma. Lab testing indicates eosinophilia during acute infection. The diagnosis is made upon detection of ova in feces, but multiple stool samples may be required. PCR-based testing is being available. Abdominal ultrasonography may demonstrate biliary dilatation, sludge, stones, and other findings. Treatment with praziquantel (25 mg/kg three times a day for 2 days) is highly effective.

Lung fluke
*Paragonimus westermani*, the lung fluke, is the most common *Paragonimus* species to cause human infection, but infection with other species occurs (*Paragonimus scrjabini*, *Paragonimus heterotremus*, *Paragonimus uterobilateralis*, and *Paragonimus mexicanus*, among others). Human infection results from ingestion of infective larvae in freshwater crabs. Larvae penetrate the peritoneal cavity and move across the diaphragm into the pleural cavity and lung parenchyma, where they mature and form cysts. While approximately 20% of infections are asymptomatic, clinical manifestations of larval migration include fever, chest pain, and cough (productive of rust-colored, blood-streaked sputum). Complications include pleural effusions, empyema, and pneumothoraces; eosinophilia is characteristic in the acute and subacute phases of infection. Chest radiographs may demonstrate infiltrative, nodular, and cavitating lesions. Ectopic manifestations include cutaneous disease (painless, mobile subcutaneous swellings) and cerebral disease (eosinophilic meningoencephalomyelitis, seizures, visual impairment, and hemiplegia). The diagnosis is made by detection of ova in sputum, stool, or gastric aspirates; serological tests are also available. Treatment consists of praziquantel at a dosage of 75 mg/kg per day for 3 days.

Other flukes
The family *Heterophyidae* consists of minute intestinal flukes that infect birds and mammals. Humans can be infected by a large number of species, including *Metagonimus yokogawai* and *Heterophyes heterophyes*. The parasites are distributed widely in Asia, and infection results from consumption of raw or undercooked freshwater fish including *ayu*, or sweetfish (*Plecoglossus altivelis*), in Japan and Korea. Human infections with *M. yokogawai* have also been recorded from Siberia, Europe, China, and Taiwan. *H. heterophyes* is found predominantly in the Middle East and around the Nile Delta in Egypt secondary to the local custom of consuming salted or insufficiently baked fish. Depending on the species, infection can also occur by ingesting snails, frogs, snakes, and even aquatic plants.

People with low-level infection can be asymptomatic or have nonspecific symptoms (fatigue, mild epigastric pain, diarrhea, and anorexia), but heavy infection can result in more severe weight loss and malabsorption. Several heterophyid species, including *Stellantchasmus falcatus*, *Haplorchis* species, and *Procerovum* species, can cause significant cardiac and CNS disease. Distinguishing species by stool microscopy is almost impossible, but purged adult worms can be identified after treatment (praziquantel, 10 to 50 mg/kg, depending on the parasite species).

About 15 of the more than 200 species of *Echinostomatidae* trematodes infect humans, most notably *Echinostoma botnense* and *Echinocotyle japonicas*. Infections have been reported from Asia and the western...
Paciﬁc but may also occur in Africa. Gastric and duodenal ulcerations can occur. Another intestinal ﬂuke, *Nano phyetts salmincola*, has been reported to cause disease in people who have eaten raw salmon, Paciﬁc steelhead trout, or steelhead roe, most commonly in far eastern Russia and the Paciﬁc Northwest region of the United States.

Toxins

It is well known that the puffer ﬁsh (*Fugu* or *Takifugu*), even when dried, has high concentrations of tetrodotoxin that causes paresthesias (usually perioral). More severe manifestations include respiratory failure and paralysis that often necessitate short-term respirator support. Scombrotoxemia is an allergic-type reaction due to high levels of histamines and other biogenic amines that accumulate in tuna, mackerel, and other fish. Affected individuals develop rapid-onset facial ﬂushing, diarrhea, and other histamine-mediated symptoms. Symptoms usually resolve within several hours.

Bacteria and Viruses

Epidemic infection with *Vibrio cholerae* is associated with the ingestion of raw marine and freshwater ﬁsh and other seafood, including outbreaks from a cold seafood salad on an airplane, raw ﬁsh in Thailand, Colombian crab smuggled into New Jersey, and episodic cases in travelers returning from South and Central America. The dehydration associated with cholera diarrhea can lead to death in as little as 6 hours, and the key to treatment is rehydration. Notably, travelers taking medication for acid reﬂux are at increased risk of *Vibrio* infection because such agents have been shown to decrease the infectious dose of *V. cholerae* 10,000-fold. Citrus juices, which are added to many foodstuffs (e.g., ceviche), have a protective effect, decreasing the risk of *V. cholerae* infection by 69 to 80% in two different settings and resulting in a 5-log-unit inactivation of *Salmonella, Listeria*, and *Escherichia coli* O157:H7 in laboratory studies. Notably, other bacterial and viral pathogens can be transmitted via raw or undercooked seafood, including norovirus and hepatitis A.

**REPTILES**

“Young tortoises make excellent soup”

Charles Darwin, 1854

Reptiles (including crocodiles, alligators, turtles, iguanas, and snakes) are farmed for human consumption in many parts of the world including sub-Saharan Africa, Central and South America, Asia, Australia, England, and North America. In parts of Central and South America, iguanas have been a traditional food source for 7,000 years. Soft-shelled terrapins are farmed in many Asian countries (including China, Taiwan, and Japan), where raw or broiled turtle and terrapin meat, eggs, blood, and soup are considered delicacies. Although the skin is highly prized, crocodile and alligator dorsal ﬁllets and tails are often harvested for consumption, particularly in Australia, Southeast Asia, and the southern United States. Snake meat which is considered an aphrodisiac in Korea, is widely consumed in the Far East; dried snake meat and powders are used for medicinal purposes in some Mexican American communities. Consumption of reptile products are a source of several notable infections detailed below (Table 2).

**Sparganosis**

Sparganosis is a disease in which the plerocercoid larvae of a canine and feline tapeworm of the genus *Spirometra* are found in humans instead of the usual hosts. Typical routes of acquisition of sparganosis are the direct application of raw snake, frog, bird, or ﬁsh ﬂesh (or poultices) to the skin and ingestion of snake meat and

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**TABLE 2** Infections associated with exotic reptile dishes

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<td><em>Vibrio, Salmonella</em> spp.</td>
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<td><em>Spirometra</em> spp.</td>
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<td>Migratory subcutaneous nodules</td>
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<td><em>Trichinella</em></td>
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<td>Turtle, lizard</td>
<td>Nausea, vomiting, diarrhea, facial and periorbital edema; followed by muscle pain, multiorgan illness</td>
</tr>
<tr>
<td><em>Gnathostoma spingerum</em></td>
<td>Asia, Latin America, Africa</td>
<td>Snake</td>
<td>Migratory nodules, central nervous system disease</td>
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<tr>
<td><em>Pentastomids</em></td>
<td>Africa</td>
<td>Snake, crocodile, reptile eggs</td>
<td>Ocular, visceral disease</td>
</tr>
<tr>
<td><em>Chelonitoxism</em> (lyngbyatoxins, other toxins)</td>
<td>Indo-Pacific region</td>
<td>Sea turtle</td>
<td>Gastrointestinal, multiorgan system, neurologic disease</td>
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potentially other reptiles. Infection through consumption of contaminated water has also been reported. Infections occur most commonly in Asia, particularly in Korea, China, Japan, Taiwan, Vietnam, and Thailand. The plerocercoids develop in tissues causing slow-growing, migratory, subcutaneous nodules often of the abdominal wall or chest that occasionally migrate to the CNS, with potentially fatal consequences. Complete excision of the larvae is diagnostic and therapeutic; praziquantel has been used for pleural disease.

Other Parasitic Infections
Trichinella infection has been associated with both lizard and raw turtle meat consumption, including an outbreak at a restaurant in Taiwan associated with the consumption of raw turtle meat, liver, blood, and eggs. Infections have also been documented in other reptiles. Anisakid larvae have also been found in crocodiles (paratenic hosts) and could theoretically serve as a source of infection for humans, although such infections have not been documented. Pentastomids, also known as tongue worms, are worm-like arthropoda 1 to 10 cm long that live in the rhino-pharynx and sinus cavities of snakes, crocodiles, and many mammals. Infection from raw or undercooked snake, crocodile, or reptile eggs has been reported in Africa; it is often asymptomatic but can cause ocular and visceral disease.

Bacteria
Reptiles, including turtles, snakes and iguanas, are known reservoirs for bacteria including *Salmonella*. *Salmonella* species have been found in fresh and frozen crocodile meat, and infections have been documented following consumption of raw soft-shelled terrapin blood, viscera, and meat in Japan; sea turtle in Australia; and rattlesnake in the United States. *Vibrio* species have been found in terrapins, and an outbreak was documented following consumption of raw sea turtle eggs in Costa Rica.

Toxins
Chelonitoxism can result from ingestion of sea turtle flesh. The exact toxins are not confirmed, but it is suggested that sea turtles consume cyanobacteria on sea grass and rocks that develop into *lyngbyatoxins* and other toxins. The toxins do not affect sea turtle health, but humans that ingest contaminated meat may develop nausea, vomiting, epigastric pain, diarrhea, and malaise. Severe cases can cause multiorgan system failure and neurologic dysfunction, but less severe symptoms usually resolve within one week.

SNAILS AND SLUGS
“The thought of eating snails conjures up all kinds of weird mental pictures. This state of mind doesn’t last for long upon seeing how snails are prepared in Burgundy. We then realize how corrupt our mental picture of this delicacy was.”

Leon Kafka, 1951, *Paris News Post*

Land snails, consumed at least since Roman times, are a well-known delicacy in France, where “escargot” are often served with parsley butter and garlic. Elsewhere in Europe, they enter a wide variety of dishes including escargots gratin, mushroom and escargot soup, or as a sauce in pasta. Slugs are less commonly consumed intentionally, except on a dare.

Angiostrongylus
Angiostrongyliasis, caused by the larval stage of the nematode *Angiostrongylus cantonensis*, is the most common infectious cause of eosinophilic meningitis worldwide. Individual cases and outbreaks of infection with this nematode have been reported in endemic areas of Southeast Asia and the Pacific Rim (e.g., China, Taiwan, Thailand, and the Pacific Islands) and in travelers returning from endemic areas. Humans become infected predominantly by ingesting third-stage larvae in intermediate hosts (slugs and snails), food items contaminated with larvae (e.g., salad or juice containing snails, slugs, or larvae), or potentially from transport hosts (e.g., freshwater crustaceans). After penetrating the gastrointestinal tract, the larvae spread hematogenously to the CNS. Following an average incubation period of 1 to 3 weeks, symptomatic people often develop headache, meningeal symptoms, and sensory abnormalities. Less commonly, infection results in severe neuropathic and motor symptoms, coma, and death. Analysis of cerebrospinal fluid samples usually shows increased eosinophil counts. Treatment is primarily supportive; systemic corticosteroids (potentially in conjunction with antihelmintics) may be beneficial.

UNDERCOOKED AND RAW BEEF AND PORK

“Some hae meat and canna eat, And some wad eat that want it; But we hae meat, and we can eat, And sae the Lord be thankit.”

Robert Burns

Beef tartare and other variations of raw beef in combination with spices and other ingredients remain a global
delicacy. The traditional European and American recipe taught in many culinary institutes is raw beef mixed with “something flavorful (mustard, Worcestershire sauce, Tabasco sauce), something crunchy (capers, cornichons, shallots), something colorful (chives, parsley, scallion)” (Vogue, November 3, 2014). The raw beef amalgamation is also native to many cultures worldwide. In the Middle East, it’s served with bulgar wheat, olive oil, and spices as *kibbeh nayyeh*, while further east in Korea, *yukhoe* is raw beef mixed with soy sauce, garlic, sesame oil, and other ingredients. Pork meat is rarely served raw but may be encountered in *nam mu sod*, a Thai recipe that combines ground pork with lemon juice, chilies, and garlic. Although raw meat carries the highest risk of infections, most cases of food-borne infection with meats are actually associated with undercooked or improperly prepared recipes. Beef and pork products that are contaminated with pathogens can cause bacterial or amoebic dysentery (Table 3). Parasites such as *Taenia saginata* can additionally be encountered with undercooked and contaminated beef. Zoonotic parasites associated with pork consumption have long been part of human history and continue to be of significance. The “three Ts,” *Taenia solium*, *Toxoplasma gondii*, and *Trichnella spiralis*, are commonly associated infections related to this dietary choice.

### Bacteria

#### Shigella

Travelers, particularly those with adventurous appetites, have long had to contend with dysentery. The major pathogens of dysentery can be transmitted via most contaminated foods, including meats and cheeses, as well as water. Dysentery is defined as frequent small bowel movements with blood and mucus, accompanied with pain on defecation. The invasion of the colonic mucosa by bacteria, commonly *Shigella* species or *E. coli*, or the parasite *Entamoeba histolytica*, causes inflammation and cytotoxic effects. Other pathogens of dysentery such as *Yersinia*, *Salmonella*, and *Vibrio* species are discussed elsewhere in this chapter.

*Shigella* species (*Shigella dysenteriae*, *Shigella flexneri*, *Shigella sonnei*, and *Shigella boydii*) and enteroinvasive

#### TABLE 3 Infections associated with exotic raw or undercooked meat dishes

<table>
<thead>
<tr>
<th>Organism</th>
<th>Geographic distribution</th>
<th>Commonly associated food items</th>
<th>Classic symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacteria</strong>&lt;br&gt; <em>Shigella</em> spp.</td>
<td><em>Shigella flexneri</em> and <em>Shigella sonnei</em>: worldwide; <em>Shigella boydii</em>: Indian subcontinent</td>
<td>Meats, cheeses, contaminated water</td>
<td>Acute bloody diarrhea, high fever, abdominal pain, malaise, headaches</td>
</tr>
<tr>
<td><strong>Enteroinvasive Escherichia coli (EIEC)</strong></td>
<td>Worldwide</td>
<td>Hamburger meat, unpasteurized milk, contaminated water, foods contaminated with human feces</td>
<td>Abdominal cramps, diarrhea, vomiting, fever, chills, malaise</td>
</tr>
<tr>
<td><strong>Enterohemorrhagic E. coli (EHEC) O157:H7</strong></td>
<td>Worldwide</td>
<td>Undercooked meats, cheeses, alfalfa sprouts, lettuce, unpasteurized fruit juices, contaminated water</td>
<td>Acute hemorrhagic diarrhea, abdominal cramps, rarely hemolytic uremic syndrome</td>
</tr>
<tr>
<td><strong>Salmonella typhi, Salmonella paratyphi and nontyphoidal strains</strong></td>
<td>Worldwide, heaviest burden in developing countries</td>
<td>Contaminated foods (including meats, eggs, poultry), water</td>
<td>Diarrhea, high fever; with typhoid fever: intestinal bleeding, systemic illness, metastatic abscesses, particularly in immunocompromised</td>
</tr>
<tr>
<td><strong>Parasites (protozoa)</strong>&lt;br&gt; <em>Entamoeba histolytica</em></td>
<td>Worldwide</td>
<td>Contaminated water, soil, foods</td>
<td>Bloody diarrhea, weight loss, fatigue, abdominal pain, amebic liver abscesses</td>
</tr>
<tr>
<td><strong>Cestodes (tapeworms)</strong>&lt;br&gt; <em>Taenia saginata</em></td>
<td>Africa, Southeast Asia, Latin America, parts of Eastern Europe</td>
<td>Infested beef products</td>
<td>Abdominal pain, diarrhea, weight loss, nausea, headaches, intestinal obstruction</td>
</tr>
<tr>
<td><strong>Taenia solium</strong></td>
<td>Asia, Latin America, West Africa, among immigrants from endemic areas residing in North America and Europe</td>
<td>Infested pork products, fecal-oral transmission from colonized human hosts</td>
<td>Early infection often asymptomatic; neurocysticercosis can present with seizures, hydrocephalus, and other symptoms depending on cyst location</td>
</tr>
<tr>
<td><strong>Nematodes (roundworms)</strong>&lt;br&gt; <em>Trichnella spiralis</em></td>
<td>Worldwide</td>
<td>Undercooked, or infested meat products, generally pork, wild game</td>
<td>Nausea, vomiting, diarrhea, facial and periocular edema, followed by muscle pain, multiorgan illness</td>
</tr>
</tbody>
</table>
invasive *E. coli* (EIEC) are thought to form a single pathovar, derived from multiple origins of *E. coli*. EIEC even causes a shigellosis-like syndrome. Each of the *Shigella* species exhibits unique epidemiological and pathological features. *S. flexneri* and *S. sonnei* are prevalent in both developing and developed countries, *S. boydii* is restricted to the Indian subcontinent, and *S. dysenteriae* is an epidemic strain in Africa. The pathogenesis in shigellosis is mediated by the Shiga toxin, a potent enterotoxin, cytotoxin, and neurotoxin, that leads to cytokine-mediated inflammation and necrosis of the colon. The colitis and mucosal ulceration result in acute dysentery with high fever, abdominal pain, malaise, and headaches. *Shigella* has no natural reservoir and can be transmitted human-to-human or via contaminated foods, and the infectious dose can be as low as 200 CFU per milliliter. The incubation period ranges between 6 hours and 9 days, generally presenting within 72 hours.

Despite the invasive nature of acute infection, disseminated infection or bacteremia is rare. Children, particularly those under 5 years of age, are more likely to suffer from severe disease that could include seizures. Reactive arthritis and conjunctivitis may develop after infection. Diagnosis is made by culture of stool. For children and immunocompromised and ill adults, early antibiotic treatment is often recommended with a 5-day course of ceftriaxone, azithromycin, or ciprofloxacin (with the choice dependent on illness severity and the susceptibility pattern of the isolate). Oral rehydration solution is also recommended. A retrospective series of literature published between 1966 and 1997 calculated the annual number of *Shigella* episodes to be as high as 164.7 million worldwide, with 69% of all episodes and 61% of all deaths attributable to shigellosis involving children under 5 years of age. Currently there are no approved vaccines.

**E. coli**

Certain EIEC strains produce a syndrome similar to acute shigellosis. Although rare in the United States, one strain of EIEC was associated with an outbreak resulting from consumption of contaminated French Camembert cheese. Enterohemorrhagic *E. coli* (EHEC), also known as Shiga toxin–producing *E. coli*, can occasionally be found in the intestinal flora of cattle. It has been associated with multiple outbreaks involving undercooked burgers in the United States but has also been implicated in outbreaks from alfalfa sprouts, unpasteurized fruit juices, dry-cured salami, lettuce, game meat, cheese curd, and other food items. EHEC strains cause about 75 to 90% of the cases of hemolytic uremic syndrome (HUS) in North America, although HUS only develops as a complication in 8% of EHEC infections. The incubation period is around 2 to 3 days, and stool culture on MacConkey’s culture medium usually makes the diagnosis. Antibiotic therapy is not effective for infections caused by EHEC or EIEC, and in the case of some EHEC strains may increase the pathogen’s phage-mediated production of Shiga-like toxins and the development of HUS.

**Parasites**

**Amebiasis**

Amebic dysentery is the second-largest cause of deaths from parasitic infections worldwide after malaria, with an estimated annual toll of 40,000 to 100,000 deaths. In addition to infection from contaminated meat and vegetables washed in contaminated water, waterborne outbreaks occur in areas with poor sanitation, as *Entamoeba* cysts persist despite chlorination. A large outbreak at the 1933 World Fair in Chicago, caused by faulty plumbing at a local hotel that introduced the pathogen into the water supply, caused 1,704 cases of illness and 98 deaths. Amebic dysentery accounted for almost 10% of the worldwide waterborne outbreaks from protozoa between 2004 and 2010.

After ingestion, the *E. histolytica* cysts undergo digestion of the outer capsule in the small bowel, and the resulting trophozoites invade colonic tissue, causing shallow flask-shaped ulcers. Infection can lead to colonization in 90% of cases, as trophozoites form new cysts that are excreted in feces. Patients generally report one to several weeks’ history of crampy abdominal pain, watery or bloody diarrhea, and weight loss. Tissue invasion is mediated through contact-dependent cytolysis of intestinal mucosa as well as host immune system evasion. The amebae can seed the liver, brain, lung, and pericardium, particularly in the setting of host immune suppression, malnutrition, or pregnancy. Stool antigen testing is diagnostic; serologic testing can be useful but takes 5 to 7 days to become positive and may remain positive for years. Computed tomography (CT) imaging is helpful in the diagnosis of amebic liver abscesses. Treatment includes the use of tinidazole or metronidazole, followed by a luminal agent, generally paromomycin, to eradicate cysts.

**Taenia saginata**

The many permutations of raw beef, served in questionable establishments or prepared with “measly”
(cyst-infested) meat, are sure recipes for infection with *T. saginata*, the beef tapeworm. *T. saginata* is endemic in Europe, West Africa, South Asia, Japan, and the Philippines and less common in Australia and the Americas. Humans are the definitive host and can house adult tapeworms $\sim$10 meters in length and pass thousands of eggs in feces. In areas with poor sanitation practices, cattle become infected upon consuming contaminated vegetation and develop cysticerci within striated muscle. Consumption of undercooked or uncooked infected beef can lead to human infection. In most cases, these infections are asymptomatic or can present with abdominal pain and malaise. Patients may note proglottids in stool, and their presence aids in the diagnosis. Of note, *T. saginata* eggs are indistinguishable from those of *T. solium*. The treatment is generally praziquantel.

**Taenia solium**

The World Health Organization (WHO) considers *T. solium*, a “tool-ready” disease, which we have the capacity to eradicate. In spite of this, cysticercosis remains a neglected disease, and neurocysticercosis is a leading cause of acquired epilepsy in endemic areas, accounting for up to 50% of the cases in some areas. Although human cases of cysticercosis were identified as early as the 15th century, it wasn’t until 1855, when a German pathologist, Kuchenmeister, identified that the parasite was linked directly to human disease. In an experiment that today would not pass muster with an institutional review board, he fed *T. solium* cysts to a soon-to-be executed prisoner and 2 days later recovered the young worms on autopsy. Spread of the parasite outside endemic areas was demonstrated through discovery of neurocysticercosis in British soldiers who had spent a tour of duty in India.

Both humans and pigs are hosts and play a role in the life cycle of the *T. solium* cestode. Human cysticercosis occurs through ingestion of eggs shed by a human tapeworm carrier, often through contamination of food. The ingested embryonated eggs hatch as oncospheres in the human intestine, invade the intestinal wall, and migrate to striated muscles as well as distant organs such as the brain, liver, heart, and eye (Fig. 2). The subsequent cysticerci can cause serious complications, particularly in the case of CNS involvement (neurocysticercosis). Pigs can also ingest eggs or gravid proglottids shed by a human carrier, and this infection results in formation of cysticerci in their striated muscles. The life cycle is completed when humans ingest undercooked pork infested with cysts, which subsequently invaginate, invade the intestinal wall, and develop into an adult tapeworm that will release eggs and proglottids. A cluster of cysticercosis cases in an Orthodox Jewish community in New York City elucidates the role of human carriers. Although the affected individuals neither ate pork nor had direct contact with pigs, they developed cysticercosis. The infection originated from domestic workers in the affected households who had come from endemic areas where they had consumed pork products.

The infection of most human tissue with the cysts can be asymptomatic and hence, most symptomatic cases present as neurocysticercosis, where the host inflammatory response or mass effect can cause seizures. Extraparenchymal disease, noted in one third of patients presenting to U.S. medical centers, can cause more serious sequelae including headaches, effects of hydrocephalus, basilar arachnoiditis, cerebrospinal fluid outflow obstruction, and cerebrovascular events. Computed tomography or magnetic resonance imaging are useful in diagnosing neurocysticercosis, particularly when the scolex is visualized. Depending on the assay used and the number of cysts present, serologic testing is quite sensitive but can be falsely positive in those with previous infection or exposure to other cestodes. Stool studies can be examined for eggs and proglottids, and collecting three stool samples over different days can increase sensitivity. Treatment of neurocysticercosis requires individualization based on the location, character, and number of cysts, with approaches including albendazole with or without praziquantel, antiepileptic medications, corticosteroids, and in some cases, neurosurgical intervention.

**Toxoplasma gondii**

*Toxoplasma gondii* is an intracellular protozoan that is present ubiquitously throughout the world. It undergoes its sexual cycle in cats, which release oocysts into the environment for 1 to 2 weeks after acute infection. After consumption by humans or other animals, oocysts become tachyzoites, which localize to neural and muscle tissue, becoming tissue cysts or bradyzoites. Humans become infected when they eat the meat of animals with infected tissue cyst or consume food or water contaminated by cat feces, via blood transfusion or organ donation, or congenitally.

The seroprevalence of *T. gondii* in the human population varies worldwide depending on the region, ranging from 6.7% in Korea, 12.3% in China, 23.9% in Nigeria, 46% in Tanzania, 47% in rural France, and as high as 98% in some regions of Brazil. Approximately 9% of the U.S. population is seropositive, with contaminated pork and lamb products being the major
source of infection. A study from 1968 showed that pork products were much more likely to be contaminated than lamb in grocery stores, 32% versus 4%. The prevalence of *T. gondii* in pigs has declined significantly in developed countries due to changes in production practices, with one prevalence study from 2005 examining retail meat showing only 7 of 2,094 pork samples and none of 2,094 beef or 2,094 chicken samples contaminated. However, the increase in consumer demand for free-range and organic small farm–raised meat sources may pose a higher risk for exposure to this pathogen.

Acute infection with toxoplasmosis is generally asymptomatic in immunocompetent patients. Symptoms occur in 10 to 20% of immunocompetent adults, with most cases presenting as lymphadenopathy and mild constitutional symptoms such as fever, malaise, and rash. Exposure may lead to asymptomatic chronic infection with persistence of cysts in host tissue. Neonatal infection from pregnant mothers can result in chorioretinitis, neurologic disease (seizures, intracranial calcification, hearing loss), or generalized disease (fever, hepatosplenomegaly, jaundice, pneumonitis). The severity of congenital infection is worse when the mother...
becomes infected during the first or second trimester. Recurrence of neonatal ocular symptoms may occur with age. Immunocompetent adults also (albeit rarely) can develop bilateral chorioretinitis, generally in the fifth or sixth decade of life, presenting with blurred vision, eye pain, photophobia, and scotoma. Late presentation of congenital disease (in patients in their 30s or 40s) is usually more severe than acutely acquired chorioretinitis.

In immunosuppressed hosts, toxoplasmosis is usually the result of reactivation or latent chronic infection with disruption of tissue cysts and local and hematogenous spread to lymph nodes and distant organs. Patients may be severely ill with pneumonitis, encephalitis, and myocarditis. Patients with AIDS can develop focal CNS lesions and neurological abnormalities.

Histological demonstration of cysts in tissue or *T. gondii* DNA in body fluids via PCR can help with diagnosis. While specificity is very good, the sensitivity of PCR assays varies widely. Serologic testing can aid in diagnosis, but interpretation can be complicated by the persistence of IgM for years and false positive results due to autoimmune or rheumatologic disease. Avidity testing can be useful in determining whether infections are acute or chronic. Self-limited and mild acute infections in immune-competent patients are often not treated unless symptoms persist. In AIDS patients with CNS disease, a prolonged course of treatment with pyrimethamine combined with sulfadiazine is generally indicated.

**Trichinella spiralis**

*Trichinella spiralis*, the most common of the *Trichinella* species to cause human disease, is often noted as one of the reasons why Jewish and Muslim traditions banned the consumption of pork. Trichinellosis is associated with ingestion of undercooked pork from domestic pigs, and the incidence of infection has decreased in developed areas of the world as the practice of feeding pigs infested meat or rodents has drastically declined. Worldwide, rates are still higher in areas where such practices persist. In Eastern Europe, due to war, economic depression, and poor access to veterinary care due to a breakdown in government services, some areas reported a seroprevalence of up to 50% among domestic swine in the 1990s. In Thailand, communal feasts marking Thai New Year are heralded by an annual increase in trichinellois cases.

Larvae from infested meat enter the columnar epithelium of the small intestine and develop into adult male and female worms. After 1 week, females release larvae that penetrate the small intestine wall and spread via lymphatic and eventually blood circulation. The *T. spiralis* larvae penetrate striated muscles where they can form collagenous cysts and potentially remain viable for months to years or progress to the infective stage acutely. Infections can be asymptomatic, but a high inoculum can lead to systemic illness marked by watery diarrhea, abdominal pain, nausea, and vomiting followed by a parenteral phase marked by periportal edema, malaise, weakness, and muscle pain. Symptoms peak 2 to 4 weeks after ingestion of meat. The incubation period can range from 1 to 2 days for the enteral phase and up to 2 to 8 weeks for the parenteral phase. The later phase is marked by eosinophilia due to larval migration causing direct tissue damage and an immune-mediated reaction. Myositis, endocarditis, and thromboembolic diseases may occur in severe cases.

Diagnosis is based on patient history combined with characteristic clinical presentation, confirmed by identification of *Trichinella* larvae in muscle biopsy or by antibody. The differential diagnosis is great in the early phase of the infection, and trichinellosis diagnosis can be challenging in nonoutbreak settings. Albendazole or mebendazole can be used for treatment, sometimes in conjunction with steroids.

### WILD GAME

“Mr Leopold Bloom ate with relish the inner organs of beasts and fowls. . . . Most of all he liked grilled mutton kidneys which gave to his palate a fine tang of faintly scented urine.”

James Joyce, *Ulysses*

Both toxoplasmosis and trichinellosis can result from consumption of wild game. *T. gondii* has been isolated in game animals such as black bears, white-tailed deer, and raccoons with high frequency. The role of game animals in cases of trichinellosis has increased as domestic meat sources have become secure in the United States. In the Inuit populations, cases result from ingestion of raw walrus and polar bear, although this may represent a different *Trichinella* species.

### Filoviruses

Unfortunately, increasing population and economic stressors on poor communities worldwide, combined with deforestation, have drastically raised the chances of zoonotic infections among humans. Increased encroachment into natural reservoirs by humans in search of food sources creates greater opportunities for contact between humans and previously rare pathogens. Depending on the location of travel, illness following game consumption should evoke concern for a range of
other infections. In equatorial Africa most outbreaks of filoviruses such as Marburg or Ebola virus are thought to start with human contact with an animal reservoir, presumed to be fruit bats or infected game animals such as nonhuman primates. The outbreaks are then fueled through human-to-human contact. The index case in the 2014–2015 West African Ebola zaire epidemic was thought to be an 18-month-old child in Guinea who had contracted the disease through consumption or handling of bush meat.

Filovirus transmission primarily occurs through contact with body fluids of sick humans or animals. The severity of infection with filoviruses depends on the strain involved, and mortality ranges from 50 to 90%. Patients present after an incubation period of 2 to 21 days, and most cases present within 10 days. Symptoms commonly include fever, myalgia, arthralgia, nausea and vomiting, and diarrhea. Late hemorrhagic features, such as mucosal bleeding, internal bleeding, and dysentery, present with varying degrees of severity depending on the timing of presentation and the strain of the virus. Diagnosis in acute illness is made via PCR; antigen-based rapid assays are being developed. Treatment is supportive.

**Human and Simian T Lymphotropic Viruses**

Other viruses found in Central African countries are potentially associated with bush meat. Simian T lymphotropic viruses 3 and 4 (STLV 3 and 4) are thought to be emerging risks that could cause human disease. Human T lymphotropic viruses (HTLV) 1 and 2 are known to bear significant correlation with their simian counterparts, STLV 1 and 2, suggesting zoonotic origins through human and nonhuman primate contact. HTLV-3 was discovered in 2004 in two Cameroonian individuals, and analyses comparing the virus to STLV-3 suggest recent and multiple “spill-over” events from nonhuman primates into humans. Butchering nonhuman primate game may be the likely route of transmission for STLV-3. HTLV-4 has also been isolated in a human in Cameroon, but its simian equivalent has not been found in local nonhuman primate species. Further epidemiological and clinical studies are required to determine if HTLV-3 and HTLV-4 cause disease similar to other HTLVs and are transmissible among humans.

**Simian Foamy Virus**

Simian foamy virus may also represent an emerging pathogen with the potential to cause human disease. The first foamy virus was found in a Kenyan patient with nasopharyngeal carcinoma. Since then, sporadic cases have been reported, including a series of cases among laboratory and monkey-house workers in 1995. Direct contact with blood and body fluids of the sick nonhuman primates was potentially associated with infection, but the jury remains out on whether simian foamy virus infection leads to clinical sequelae.

**POULTRY AND EGGS**

“The German birds didn’t taste as good as their French cousins, nor did the frozen Dutch chickens we bought in the local supermarkets. The American poultry industry had made it possible to grow a fine-looking fryer in record time and sell it at a reasonable price, but no one mentioned that the result usually tasted like the stuffing inside of a teddy bear.”

Julia Child, *My Life in France*

Chicken is sometimes considered a timid dinner choice, but when served without proper disinfection or undercooked it has the potential to carry significant risk for infection. If you are traveling through the Philippines, you may encounter the *balut* egg as street food. Sold as a late night snack, balut is a developing duck embryo that is boiled and eaten in its shell. Its culinary appeal is said to be in a balance of tastes and textures. It also carries cultural symbolism and is purported to have aphrodisiac properties. The same dish with slightly different preparation can be found throughout other South-Asian countries such as Vietnam and Laos. In China, the adventurous traveler may encounter the *century egg* or *hundred-year egg*, a chicken, duck, or quail egg preserved with strong alkaline solutions for weeks to months prior to ingestion.

**Influenza**

Pathogenic avian influenza strains circulating among wild aquatic birds and domestic poultry have at times adapted to mammalian species, posing a significant risk to the human population. The highly pathogenic influenza A H5N1 strain has killed millions of poultry in countries throughout Asia, Europe, and Africa and caused hundreds of human infections. Were it to be transmitted easily between humans, a pandemic would likely result. Avian influenza viruses are shed in the feces and respiratory secretions of ill birds. Once the infection has entered a poultry flock, it spreads quickly due to the close proximity of birds.

Humans acquire the adapted viruses through close contact with birds and in rare cases eating raw tissue from infected birds. Influenza A virus subtype H7N9 is a novel avian influenza first identified in humans in 2013 and is linked to live bird markets. Infection can range
from mild to severe respiratory syndrome, with associated fever, cough, and gastrointestinal symptoms.

**Salmonella**
The major infectious concern of partaking in culinary offerings of eggs is enteritis from *Salmonella* species, particularly if consumed in areas where egg pasteurization is not strictly enforced or if the egg is not thoroughly cooked. Salmonella enteritis from nontyphoidal species is generally 7 to 10 days of self-limiting diarrheal illness, which can be accompanied by fever and abdominal cramping. Dehydration may necessitate hospitalization. After resolution of symptoms, the carriage of nontyphoidal *Salmonella* in the stool can last 4 to 5 weeks.

**DAIRY PRODUCTS**

“Dessert without cheese is like a beauty with only one eye.”

Jean Anthelme Brillat-Savarin

Even for the truly adventurous gastronomist, *casu marzu*, a Sardinian sheep milk cheese containing live maggots, may cause hesitation. Larvae of cheese fly, *Piophila casei*, are used to cause advanced fermentation, and the cheese is eaten while the worms are still alive. *Casu marzu* is associated with some risk of enteric myasis, but pathogens usually associated with unpasteurized milk and cheese claim a much larger pool of cases annually. Among others, these pathogens include *Campylobacter jejuni*, *Salmonella* species, *Yersinia enterocolitica*, Shiga toxin–producing *E. coli* such as *E. coli* O157:H7, *Brucella* species, *Listeria monocytegenes*, *Mycoplasma bovis*, *Mycoplasma tuberculosis*, and *Staphylococcus aureus* toxin-mediated disease.

**PLANT MATERIAL**

“Facts must be faced. Vegetables simply don’t taste as good as most other things do.”

Peg Bracken, *The Compleat I Hate to Cook Book*

**Fasciola**

While consumption of plant material is less exotic in itself, a few more exotic plant-related infections bear mentioning. In addition to transmission of *Giardia* species, *Cryptosporidium* species, and *Cyclospora cayetanensis*, plant material can also result in infection with less common pathogens. Human infection with *Fasciola hepatica* (and *Fasciola gigantica*) results usually from ingestion of freshwater aquatic plants, such as watercress, that are contaminated with metacercariae. After ingestion, the metacercariae excyst in the duodenum and migrate through the intestinal wall and ultimately into the biliary ducts, where they develop into adults and reside and discharge eggs. Eggs become embryonated in water and release miracidia, which invade snail intermediate hosts and develop into cercariae; once released, these cercariae encyst on aquatic vegetation, becoming infective metacercariae. More rarely, infection can occur from ingesting raw or undercooked bovine liver contaminated with juvenile worms (such as in bovine liver sashimi in Japanese yakitori bars). Cases of fasciolia infection are found in Europe, the Middle East, Asia, and other regions where humans consume raw watercress (or raw bovine liver). Consumption of alfalfa juice as an herbal medicine in Peru has also been identified as a risk factor for *F. hepatica* infection. Acute infection may cause abdominal pain, vomiting, diarrhea, and fever accompanied by urticaria, eosinophilia, and hepatomegaly. Chronic infection symptoms may be less obvious except for intermittent biliary obstruction and inflammation. Ectopic infection can occur. A single dose of triclabendazole (10 to 20 mg/kg) is the treatment of choice.

**Other Infections**

*Ascaris lumbricoides*, the large human roundworm, contaminates raw unwashed fruit and vegetables, as does *T. gondii*. Although *Trypanosoma cruzi*, the agent responsible for Chagas disease, is primarily vector-borne, it has also been transmitted through sugar cane juice, fruit juices, and other food contaminated with infected triatomine or their feces in Brazil and other South American countries. Human papilloma virus infection has been associated with consumption of *gutka* (a betel, areca, lime, and tobacco concoction) in Pakistan. Leafy greens can also be contaminated by *Angiostrongylus* larvae.

**CONCLUSION**

Paulo Coelho once said, “If you think adventure is dangerous, try routine; it’s lethal.” Good food, in all its variety, provides richness to the tapestry of our travel memories. With the explosion of travel shows on television highlighting foods from different parts of the world, the World Food Travel Association estimates that food tourism had grown to a $150 billion annual industry in 2013. The increased ability to travel, and to experience exotic foods both at home and abroad, requires an additional level of awareness about inherent risks from food-borne infection. These opportunities to experience
the nonroutine underpin the importance of enhanced surveillance of the food industry, systemic evaluation of imported and served foods, education of the food consumer, and continued vigilance on the part of the clinician.

**PRACTICAL TIPS**

**For Consumers**
- Consider the risks before you consume “exotic” cuisine. There are often less risky ways to experience the culture.
- When possible, avoid consuming raw or undercooked seafood unless you are certain it has been previously frozen to FDA standards.
- Although the citrus juice in ceviche is partially protective against some ingested pathogens, the protection is not complete.
- Avoid eating raw or undercooked meat, reptile, or poultry products as well as unpasteurized dairy products.

**For Clinicians**
- Educate travelers (or those who consume imported food products) about the potential risks associated with selected foods.
- Obtain a full food history from returning travelers, including information about products used for medicinal or aphrodisiac purposes.
- Consider the geographic distribution of infectious diseases when determining potential infections associated with consuming exotic cuisine.

**RECOMMENDED READINGS**


