Parasitic diseases are of considerable public health significance in Canada, particularly in rural and remote areas. Food- and waterborne parasites contribute significantly to the overall number of parasitic infections reported in Canada. While data on the incidence of some of these diseases are available, knowledge of the true burden of infection by the causative agents in Canadians is somewhat limited. A number of centers of expertise in Canada study various aspects of parasitology, but few formal societies or networks of parasitologists currently exist in Canada, and previously none focused specifically on food or environmental transmission. The recently established Food and Environmental Parasitology Network (FEPN) brings together Canadian researchers, regulators and public health officials with an active involvement in issues related to these increasingly important fields. The major objectives of the Network include identifying research gaps, facilitating discussion and collaborative research, developing standardized methods, generating data for risk assessments, policies, and guidelines, and providing expert advice and testing in support of outbreak investigations and surveillance studies. Issues considered by the FEPN include contaminated foods and infected food animals, potable and non-potable water, Northern and Aboriginal issues, zoonotic transmission, and epidemiology.

INTRODUCTION

Parasitic diseases are of considerable public health significance in Canada, particularly in rural and remote areas. Many parasitic infections acquired in Canada are transmitted directly through the fecal-oral route (i.e., person-to-person or zoonotic transmission). Some of these same parasites are, however, also transmitted indirectly through the consumption of fecally-contaminated water or fresh produce, and their transmission is affected by a variety of environmental and societal factors. In addition, a few parasites of concern in Canada are associated with the consumption of raw or poorly cooked fish, meats, or other foods. Although a number of different surveillance systems are in place in Canada to monitor the burden of illness resulting from these parasitic infections, data of
this type are somewhat limited and often not associated with a specific route of transmission. A number of centers of expertise that exist in Canada study various aspects of parasitology, but very few formal societies or networks of parasitologists exist, and previously, none focused specifically on food or environmental transmission.

The recently established Food and Environmental Parasitology Network (FEPN) brings together Canadian researchers, regulators and public health officials with an active involvement in issues related to these increasingly important fields. This article discusses the objectives, scope and current status of the Food and Environmental Parasitology Network and its relationship to other existing parasitological affiliations in Canada. It also highlights the parasites of greatest public health concern in Canada, including their geographic ranges, mechanisms of transmission, susceptibility factors, and, wherever possible, their prevalence or incidence in humans. The surveillance systems in place for parasitic diseases in Canada are also discussed.

SURVEILLANCE OF PARASITIC DISEASES IN CANADA

Parasites play a significant role in human health, particularly in developing countries and tropical regions around the world. In urban regions of Canada, the intensity and diversity of parasitic infections are dramatically lower, but parasites are still of considerable public health significance, especially in rural and remote areas. The epidemiology of some parasitic infections in Canada has been reviewed (14); however, knowledge of the true burden of parasitic infections in Canadians is limited, and the incidences are often extrapolated from surveillance data. Data on non-reportable parasitic diseases are further limited to case reports and physician/hospital records.

Currently, giardiasis, cryptosporidiosis, cyclosporiasis, and malaria in humans are all nationally notifiable diseases in Canada, and with the exception of cyclosporiasis, the numbers of reported cases per year, up to 2004, are available by province from the Public Health Agency of Canada (PHAC) at http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/c_dis_e.html (accessed September 17, 2013). Trichinellosis and amoebiasis were removed from the nationally notifiable diseases list in Canada in 2000, but the numbers of cases prior to that date are still available. More recent surveillance reports on enteric diseases, including giardiasis, cryptosporidiosis, cyclosporiasis, and amoebiasis, are available through the National Enteric Surveillance Program (NESP) at: http://www.nml-lnm.gc.ca/NESP-PNSME/index-eng.htm (accessed September 17, 2013). The NESP 2006 Annual Summary indicates that of 5,468 stool samples positive for parasites in 2006, *Giardia* was detected in 72.5%, *Cryptosporidium* in 13.3%, *Entamoeba* in 11.5%, and *Cyclospora* in 2.7%. Under-reporting and information bias are prominent, however, because passive surveillance systems require that individuals seek medical attention, physicians have a high index of suspicion and request laboratory diagnostics, patients collect and submit samples, and the diagnostic tests chosen are pathogen-appropriate, with suitable sensitivity and specificity. As a result, illnesses with mild symptoms, or asymptomatic infections, are generally not captured by passive surveillance systems. In addition, people living in rural and remote areas may have little access to health care, further affecting the number of potentially infected individuals that could be included in a reporting system.

In the case of vulnerable groups such as immigrants and Aboriginal and Inuit populations, both social and physical barriers may limit access to health care, further contributing to a lack of data for these groups. Members of some indigenous communities are more frequently exposed to zoonotic parasitic diseases through traditional livelihoods such as hunting and trapping, as well as through consumption of country foods (5, 16). Inuit populations, in particular, may acquire parasitic diseases through consumption of uncooked, fermented, dried or smoked meat and fish, which comprise an important part of their traditional diet (15).

In a review of hospitalizations due to acute gastrointestinal illness in Canada between 1995 and 2004, 0.3% of cases, translating into 2,783 hospitalizations, were attributable to parasitic infections (giardiasis, cryptosporidiosis or amoebiasis) (11). A complementary study reported 108 echinococcosis and 14 trichinellosis hospitalizations in Canada from 2001 to 2005, with the highest rates being found in the Northern regions (13). Although hospitalizations are another measure of illness, this approach generally captures only the most severe infections.

TRANSMISSION OF PARASITIC INFECTIONS IN CANADA

Some of the more exotic parasitic infections in Canada are diagnosed in immigrants and in those who have travelled to endemic regions abroad (14). These include vector-borne diseases such as malaria, Chagas disease, leishmaniasis, and filariasis, or diseases resulting from larval penetration through the skin such as hookworm, strongyloidiasis and schistosomiasis. Infections with enteric parasites such as *Ascaris, Entamoeba, Giardia*, and *Cryptosporidium* are also common globally, and may be acquired by international travellers who do not heed the recommended precautions regarding food, drink, and hygiene.

Many parasitic infections, however, are acquired within Canada and are transmitted directly through the fecal-oral route. The fecal-oral route is associated with poor personal hygiene or sexual contact in the case of person-to-person transmission (e.g., *G. duodenalis, Cryptosporidium spp.*), or contact with animals or their feces in the case of zoonotic
transmission (e.g., Cryptosporidium spp., Toxoplasma gondii, Echinococcus spp., Toxocara spp., Baylisascaris procyonis).

Many of these parasites may also be transmitted indirectly through water or food in Canada and may be associated with factors such as sewage-contaminated drinking water, agricultural runoff, contaminated irrigation or food-processing water, application of human and animal wastes to crop lands, and poor personal hygiene in food handlers. Waterborne and foodborne parasites contribute significantly to the overall number of parasitic infections reported. In fact, the majority of human parasitic infections in Canada are caused by a select group of waterborne and foodborne pathogens including G. duodenalis, Cryptosporidium spp., Toxoplasma gondii, Cyclospora cayetanensis, Entamoeba spp., and Trichinella spp. Some parasites, such as G. duodenalis and Cryptosporidium spp., are relatively common in raw surface waters in Canada, and a number of waterborne outbreaks and cases related to these parasites have been documented (29). For example, in the spring of 2001, an estimated 5,800 to 7,100 people living in the city of North Battleford, and the town of Battleford, Saskatchewan, developed diarrheal illness during an outbreak of cryptosporidiosis associated with contaminated drinking water (28). Outbreaks of cryptosporidiosis associated with recreational water in pools and aquatic parks have also been reported in Canada (22). Further, a rare waterborne outbreak of toxoplasmosis, identified in Victoria, British Columbia, in 1995, was attributed to contamination of a drinking water reservoir after heavy rainfall washed down feces of domestic or feral cats, or cougars (3). Cercarial dermatitis, or swimmer’s itch, is caused by waterborne trematode parasites transmitted to humans by means of skin penetration by the free-swimming larval stage. Its increasing prevalence in Canada and elsewhere has been associated with climate change (21).

Table 1 lists the food and environmentally-acquired parasitic infections of concern in Canada, their geographic distributions worldwide and within Canada, exposed and susceptible populations, sources of infection, and numbers of cases or prevalence/incidence reported.

In Canada, there is a growing demand and availability of imported foods such as produce, fish, and meats, and a trend toward increased consumption of raw foods (25). There is, therefore, an increased potential for infection associated with the consumption of foods that are imported from endemic regions, especially fresh fruits and vegetables. In particular, numerous outbreaks of illness due to infection with C. cayetanensis have been reported in recent years, most of which have been associated with imported produce from Central and South America (8). However, foods produced in Canada have also been associated with parasitic illnesses. Infections with parasites such as Trichinella spp., T. gondii, and Taenia spp., for example, may be acquired from meats originating in Canada, at least when the meat is consumed raw or lightly cooked. While commercial swine in Canada are Trichinella-free (12), many cases and outbreaks of infection have been reported in Aboriginal and Inuit communities, and in hunters and tourists, in association with the consumption of raw or poorly cooked meat from wildlife. The only zoonotic parasites in meat animals that are immediately reportable to national animal health authorities are Cysticercus bovis (Taenia saginata) and Trichinella spp., while Echinococcus spp. and T. gondii are annually notifiable and tracked only at the level of animal diagnostic laboratories. In addition, larvae of the fishborne parasites Anisakis spp., Pseudoterranova spp., Diphyllobothrium spp., and Metorchis conjunctus are present in the flesh of a variety of fishes in Canadian waters, and human infections have been reported (14).

A variety of other societal and environmental factors also have a considerable impact on the transmission of food and environmental parasites in Canada (25). Among those already mentioned, the increasingly global food trade and international travel are particularly important. Evolving culinary preferences, rapid and marked changes in human social ecology (migrant workers, immigration, travel to developing countries), agricultural intensification, and food production practices are giving rise to new and emerging foodborne, waterborne and environmental parasitic illnesses. Another important factor is the increasing number of susceptible individuals, many of whom are in institutional settings such as daycare facilities and retirement homes, where outbreaks may occur. Further, immunosuppressed individuals within the population may be particularly susceptible to prolonged and severe illnesses. Finally, there are environmental factors, such as climate change, that may contribute to the altered survival and transmission of parasites and may have an effect on host and parasite ranges, resulting in the emergence or reduction of diseases in humans and animals (7, 16, 17). Changing weather patterns may be of particular concern in Northern and indigenous communities as they may affect hunting and fishing practices, possibly resulting in altered exposure to zoonotic parasites such as Trichinella spp., T. gondii, and Diphyllobothrium spp.

PARASITOLOGICAL AFFILIATIONS IN CANADA

The field of parasitology has a long history in Canada, with an abundance of distinguished researchers and many important discoveries and findings (1, 9, 10, 26). Parasitologists in Canada work on many aspects of parasite biology and ecology, as well as the impact of parasites on human and animal health. While there are academic institutions and government departments in Canada that house centers of expertise in various aspects of parasitology (26, 27), few formal societies or networks of parasitologists currently exist in Canada.
### TABLE 1. Food- and environmentally-acquired parasitic infections of concern in Canada

<table>
<thead>
<tr>
<th>Parasite group</th>
<th>Species</th>
<th>Geographic distribution</th>
<th>High-risk groups for acquisition or severe illness in Canada</th>
<th>Sources of infection</th>
<th>Cases or prevalence / incidence reported in Canada (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protozoans</td>
<td><em>Cryptosporidium</em> spp.</td>
<td>Worldwide</td>
<td>Immunocompromised persons; children; elderly; travellers</td>
<td>Person-to-person; food; drinking water; recreational water; zoonotic</td>
<td>802 (2008)*</td>
</tr>
<tr>
<td></td>
<td><em>Cyclospora cayetanensis</em></td>
<td>Worldwide; endemic in Haiti, Peru, Guatemala, Nepal</td>
<td>Immunocompromised persons; travellers</td>
<td>Fresh imported produce; water</td>
<td>151 (2008)*</td>
</tr>
<tr>
<td></td>
<td><em>Toxoplasma gondii</em></td>
<td>Worldwide</td>
<td>Immunocompromised persons; pregnant women; consumers of raw meat; Inuit</td>
<td>Raw meat; fresh produce; soil contact; cat litter; drinking water; consumption of raw or dried seal or caribou meat</td>
<td>up to 53%*</td>
</tr>
<tr>
<td></td>
<td><em>Giardia duodenalis</em></td>
<td>Worldwide</td>
<td>Immunocompromised persons; children; travellers</td>
<td>Person-to-person; food; drinking water; zoonotic</td>
<td>4,230 (2008)*</td>
</tr>
<tr>
<td></td>
<td><em>Entamoeba histolytica</em></td>
<td>Worldwide; particularly tropical regions</td>
<td>Immunocompromised persons; travellers; male homosexuals</td>
<td>Person-to-person; food; drinking water</td>
<td>566 (2009)*</td>
</tr>
<tr>
<td>Trematodes</td>
<td><em>Fasciola</em> spp.</td>
<td>Worldwide</td>
<td>Immunocompromised persons; consumers of raw watercress</td>
<td>Raw watercress</td>
<td>rare</td>
</tr>
<tr>
<td></td>
<td><em>Metorchis conjunctus</em></td>
<td>Southern Canada</td>
<td>Consumers of raw freshwater fish (e.g., white sucker)</td>
<td>Raw freshwater fishes</td>
<td>19 (1993)*</td>
</tr>
<tr>
<td>Cercarial dermatitis (schistosomes of the genera <em>Trichobilharzia</em>, <em>Schistosomatium</em>, <em>Gigantobilharzia</em>, <em>Australobilharzia</em>)</td>
<td>Worldwide; Great Lakes-St. Lawrence Basin in North America</td>
<td>Swimmers in shallow lake waters inhabited by snails</td>
<td>Skin penetration by free-swimming cercariae emerging from infected snails in shallow lake waters</td>
<td>74 (1988)*</td>
<td></td>
</tr>
<tr>
<td>Cestodes</td>
<td><em>Echinococcus granulosus</em></td>
<td>Worldwide; northern and western Canada</td>
<td>Northern residents; Inuit and Aboriginal people</td>
<td>Ingestion of eggs in the feces of dogs, wolves and coyotes</td>
<td>0.72 hospitalizations per million per year*</td>
</tr>
<tr>
<td></td>
<td><em>Echinococcus multilocularis</em></td>
<td>Northern Hemisphere; north central Canada</td>
<td>Consumers of fecal contaminated produce or water; people in contact with dog feces in endemic areas (Canadian North and the prairie provinces)</td>
<td>Ingestion of eggs in the feces of foxes, coyotes, dogs and cats</td>
<td>rare*; only 1 autochthonous case reported</td>
</tr>
</tbody>
</table>
### TABLE 1. Food- and environmentally-acquired parasitic infections of concern in Canada (cont.)

<table>
<thead>
<tr>
<th>Parasite group</th>
<th>Species</th>
<th>Geographic distribution</th>
<th>High-risk groups for acquisition or severe illness in Canada</th>
<th>Sources of infection</th>
<th>Cases or prevalence / incidence reported in Canada (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nematodes</td>
<td>Diphyllobothrium spp. (including D. dendriticum, D. latum, D. ursi, D. nihonkaiense)</td>
<td>Northern Hemisphere; northern Canada</td>
<td>Consumers of raw freshwater and anadromous fish</td>
<td>Raw freshwater and anadromous fishes</td>
<td>up to 80% in some Inuit communities; rarely reported in southern Canada</td>
</tr>
<tr>
<td>Nematodes</td>
<td>Trichinella spiralis (T1)</td>
<td>Worldwide; currently non-existent in Canada</td>
<td>Consumers of raw meat</td>
<td>Undercooked pork and wild boar meat from other countries are the primary risk</td>
<td>43 (1999)</td>
</tr>
<tr>
<td>Nematodes</td>
<td>Trichinella nativa (T2)</td>
<td>Holarctic; including most of Canada</td>
<td>Inuit and Aboriginal people; hunters; other consumers of wildlife meat</td>
<td>Raw meat from wild carnivores, particularly walruses and bears</td>
<td>95 (1982-2009)</td>
</tr>
<tr>
<td>Nematodes</td>
<td>Trichinella pseudospiralis (T4)</td>
<td>Worldwide</td>
<td>Inuit and Aboriginal people; hunters; other consumers of wildlife meat</td>
<td>Raw meat from wild carnivores and birds</td>
<td>no reported cases</td>
</tr>
<tr>
<td>Nematodes</td>
<td>Trichinella murrelli (T5)</td>
<td>North America</td>
<td>Inuit and Aboriginal people; hunters; other consumers of wildlife meat</td>
<td>Raw meat from wild carnivores</td>
<td>no reported cases</td>
</tr>
<tr>
<td>Nematodes</td>
<td>Trichinella genotype T6</td>
<td>Holarctic; including most of Canada</td>
<td>Inuit and Aboriginal people; hunters; other consumers of wildlife meat</td>
<td>Raw meat from wild carnivores</td>
<td>no reported cases</td>
</tr>
<tr>
<td>Nematodes</td>
<td>Toxocara spp.</td>
<td>Worldwide; southern Canada</td>
<td>Rural residents; consumers of contaminated soil, produce or water; children</td>
<td>Ingestion of eggs in the feces of dogs (T. canis) or cats (T. cati)</td>
<td>9–14%</td>
</tr>
<tr>
<td>Nematodes</td>
<td>Baylisascaris procyonis</td>
<td>Worldwide; southern Canada, especially Ontario</td>
<td>Consumers of contaminated soil, produce or water; children</td>
<td>Ingestion of eggs in the feces of raccoons and dogs</td>
<td>2 (2006–2009)</td>
</tr>
</tbody>
</table>

*National Notifiable Diseases Database, Public Health Agency of Canada.

* C. cayetanensis is not considered endemic in Canada, but numerous outbreaks (Ontario, Quebec, British Columbia) in recent years have been associated with the consumption of fresh imported produce.

* Based on Toxoplasma seroprevalence in Montreal, Quebec (14).

* Cases reported include both E. histolytica and E. dispar (National Enteric Surveillance Program, 2009 Annual Summary).

* From an outbreak of acute infection near Montreal, Quebec (23).

* Cases of swimmer’s itch traceable to 28 water bodies in Quebec (20).

* Hospitalizations due to echinococcosis in Canada (13).

* Prevalence rates of D. dentriticum in humans in the Arctic (14).

Table 1 continued on next page
The Parasitology Section (now known as the Parasitism, Immunity and Environment Section) of the Canadian Society of Zoologists (CSZ) was established in 1974 and previously represented the only national organization of parasitologists in the country (http://www.csz-scz.ca/sectionPIE.html) (accessed September 17, 2013) (1). Its members study various aspects of parasitology, from traditional taxonomy to host-parasite interactions, ecology, and molecular characterization.

The Centre for Host-Parasite Interactions (http://www.mcgill.ca/chpi/members/) (accessed September 17, 2013) is based at the Institute of Parasitology, McGill University, in Sainte-Anne-de-Bellevue, Quebec. Its members study how parasites and hosts interact in order to obtain basic knowledge for the design of better vaccines or drugs to control parasitic diseases, and to develop new methods to improve diagnoses.

The Public Health Agency of Canada’s Arctic Zoonoses Sub-Issue Group (AZSIG) was formed in 2008 as a working group of the Public Health Network’s National Non-Enteric Zoonotic Diseases (NNEZD) Issue Group. Members represent federal departments, provincial and territorial public health and animal health organizations across the country and in the North, as well as academic partners. The AZSIG workplan includes development of a white paper that provides an audit of known zoonoses in the North with a specific focus on foodborne, environmental and emerging zoonotic infectious diseases, including parasites. The AZSIG white paper will identify knowledge and infrastructure gaps and outline challenges and opportunities to addressing gaps related to public health impact, diagnostics and surveillance, data management and analysis, messaging and interventions, and evaluation. Ultimately it will be used as a basis for making recommendations for essential actions, partnerships and resources needed to improve the control of zoonoses in the North.

The Research Group for Arctic Parasitology (RGAP), established in 1994, is a multidisciplinary group of scientists with academic bases at the Universities of Saskatchewan and Calgary and members that include wildlife biologists and veterinarians in provincial and territorial governments, as well as parasitologists at the USDA and the WHO Collaborating Centre for the Molecular Epidemiology of Parasitic Infections in Australia. Members of RGAP are actively engaged in research on the ecology of parasitic infections with emphasis on northern and arctic wildlife, impacts of climate change on northern host-parasite systems, and parasitic zoonoses in indigenous and northern communities. RGAP founded and continues to participate in the International Workshops for Arctic Parasitology and the recently established Polar Parasitology Network (PoPaN) (7).

### TABLE 1. Food- and environmentally-acquired parasitic infections of concern in Canada (cont.)

<table>
<thead>
<tr>
<th>Infection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichinellosis</td>
<td>Case of infection with <em>D. ursi</em> reported in North Vancouver, British Columbia (24); case of infection with <em>D. nihonkaiense</em> in France acquired from Pacific salmon imported from Canada (31); case of infection with <em>D. nihonkaiense</em> in Czech tourist to Canada who ate raw Pacific salmon (30).</td>
</tr>
<tr>
<td></td>
<td>This number represents all cases of trichinellosis reported in Canada and may include infections with species other than <em>T. spiralis</em>. Trichinellosis was removed from the nationally notifiable diseases list in Canada in 2000.</td>
</tr>
<tr>
<td></td>
<td>Cases reported in Nunavik, Quebec [Jean-François Proulx, Department of Public Health, Nunavik Regional Board of Health and Social Services, Personal Communication, 2011]. Since 2000, there have been 3 human outbreaks of trichinellosis in Canada (British Columbia, Saskatchewan and Quebec) caused by T2 and all were associated with the consumption of black bear meat. A fourth clinically diagnosed outbreak occurred in Nunavut in 2009 following the consumption of grizzly bear meat and was probably associated with T2 [Lorry Forbes, Centre for Foodborne and Animal Parasitology, Canadian Food Inspection Agency, Personal Communication, 2011].</td>
</tr>
<tr>
<td></td>
<td>Documentation of genotypes infecting humans is usually associated with outbreaks in which there are multiple clinical cases and source meat is available for recovery of larvae. Subclinical and mild clinical infections likely occur more frequently than outbreaks, but are not reported. Thus the lack of reported cases of <em>Trichinella</em> genotypes T4, T5, and T6 may not reflect the true situation in Canada [Lorry Forbes, Centre for Foodborne and Animal Parasitology, Canadian Food Inspection Agency, Personal Communication, 2011].</td>
</tr>
<tr>
<td></td>
<td>Seroprevalence for antibodies to <em>T. canis</em> in people in large urban centers in Canada (17).</td>
</tr>
<tr>
<td></td>
<td>Two cases reported in Ontario (4).</td>
</tr>
<tr>
<td></td>
<td>Based on published cases of anisakiasis in Canada (2, 6, 19).</td>
</tr>
<tr>
<td></td>
<td>Based on a published case of infection with <em>Phocanema</em> (=<em>Pseudoterranova</em>) in Canada (18).</td>
</tr>
</tbody>
</table>

The Research Group for Arctic Parasitology (RGAP), established in 1994, is a multidisciplinary group of scientists with academic bases at the Universities of Saskatchewan and Calgary and members that include wildlife biologists and veterinarians in provincial and territorial governments, as well as parasitologists at the USDA and the WHO Collaborating Centre for the Molecular Epidemiology of Parasitic Infections in Australia. Members of RGAP are actively engaged in research on the ecology of parasitic infections with emphasis on northern and arctic wildlife, impacts of climate change on northern host-parasite systems, and parasitic zoonoses in indigenous and northern communities. RGAP founded and continues to participate in the International Workshops for Arctic Parasitology and the recently established Polar Parasitology Network (PoPaN) (7).
One other, smaller regional society is the Atlantic Canadian Association of Parasitologists (ACAP), whose members predominantly represent universities in the Maritime provinces.

Given the growing importance and impact of parasitic infections in Canada transmitted through food, water and the environment, there was clearly a need for a formal national network specifically addressing these issues.

FOOD AND ENVIRONMENTAL PARASITOLOGY NETWORK

Early in 2009, the Bureau of Microbial Hazards, Food Directorate, Health Canada, established a network of Canadian researchers, regulators, and public health officials with an active involvement in the important and emerging fields of food and environmental parasitology. The major objectives of the Food and Environmental Parasitology Network (FEPN) are to: (i) identify and communicate risks and research gaps relevant to the fields of food and environmental parasitology; (ii) facilitate discussion, development of grant applications, and collaborative research among members, or with external researchers and organizations; (iii) develop and validate standardized methods for the isolation, detection, identification, molecular characterization, and control of foodborne and environmental parasites; (iv) develop and validate methods for the surveillance and investigation of parasitic infection in humans and animals; (v) generate data for the development of risk assessments, policies, and guidelines; and (vi) provide expert advice and testing in support of outbreak investigations and surveillance studies.

SCOPE OF THE FEPN

The scope of the Network includes all foodborne and environmental protozoan and helminth parasites, as well as ectoparasites, that are of public health concern in Canada. The following major issues and parasites are of particular interest to the FEPN, and internal working groups are currently being established to focus on these:

i. Transmission of human-specific as well as zoonotic genotypes (i.e., livestock, wildlife, fisheries and aquaculture, companion animals) of protozoan parasites through foodborne (i.e., imported and domestic produce, meats, and fish) and waterborne (i.e., potable, non-potable, recreational) routes, particularly: *C. cayetanensis*, *T. gondii*, *Cryptosporidium* spp., and *G. duodenalis*;

ii. Helminth parasites, including *Trichinella* spp., and *Taenia* spp., transmitted through the consumption of contaminated meat from domestic animals and wildlife;

iii. Zoonotic parasites in Northern and Aboriginal communities transmitted through country foods or water, including the helminths: *Trichinella* spp., *Echinococcus* spp., *Diphyllobothrium* spp., ascarid roundworms, *anisakid* roundworms; and the protozoans: *T. gondii*, *Cryptosporidium* spp., and *G. duodenalis*;

iv. Zoonotic nematodes and cestodes associated with fisheries and aquaculture including *Anisakis* spp., *Pseudoterranova* spp., and *Diphyllobothrium* spp.; and zoonotic trematodes associated with domestic and imported freshwater fishes, frogs, and shellfish, e.g., *Clonorchis sinensis*, *Metorchis conjunctus*, *Alaria* spp., and *Paragonimus* spp.

One of the future goals of the FEPN will be to organize regular scientific conferences where members and a few external experts can present and discuss research and regulatory projects. The FEPN will also seek linkages to similar or complementary national and international networks and databases. The FEPN currently has links through its membership to the Water/Food Safety and Enterics Issue Group of the Canadian Public Health Laboratory Network (CPHLN) (https://www.nlm-inm.gc.ca/cphln-rlscp/index-eng.htm) (accessed October 7, 2013), the Arctic Zoonoses Sub-Issue Group, the Parasitology Section of the Canadian Society of Zoologists, the Centre for Host-Parasite Interactions, the Research Group for Arctic Parasitology, and the Atlantic Canadian Association of Parasitologists. The FEPN is also currently a collaborating center within the Canadian Network for Public Health Intelligence (CNPHI) (https://www.cnphi-crsrp.ca/cnphi/index.jsp) (accessed September 17, 2013), and is listed as a participating network in the Global Laboratory Directory (GLaD) (https://www.cnphi-crsrp.ca/glad/faces/public/search.jsp) (accessed September 17, 2013), whose mission is to support, connect and sustain laboratory networks and their members globally. Other, more long-term objectives of the FEPN include the establishment of reference laboratories for the identification and culture collection of foodborne and environmental parasites, and databases for laboratory test results, prevalence data, case/outbreak reports and genomic data.

CURRENT STATUS OF THE FEPN

The Food and Environmental Parasitology Network currently has approximately 65 members from across Canada, representing federal and provincial governments, academia, non-government organizations, and industry. Membership in the Network is open to all individuals with a research, regulatory, or public health involvement in the fields of foodborne or environmental parasitology in Canada. The executive of the FEPN consists of a Chair, Co-Chair and Secretary.

Annual ad hoc face-to-face meetings of the FEPN are held in conjunction with national scientific conferences. In addition, teleconference meetings are held at least two
times per year. The first face-to-face meeting of the FEPN was held in Ottawa, Ontario, in November, 2009. During this meeting, breakout groups discussed issues such as foodborne, waterborne and zoonotic protozoan parasites, aquaculture and fisheries, helminth parasites, and Northern and Aboriginal issues. Specifically, discussions surrounded the pathogens of major concern, routes of transmission, susceptible populations and health determinants, as well as significant research gaps such as those in standard methods for testing and surveillance studies. In subsequent plenary sessions, attendees identified preliminary research priorities, explored funding opportunities and linkages to other existing networks, and began developing working groups to address the major issues. During subsequent FEPN meetings, working groups on toxoplasmosis, Northern / Aboriginal Issues, and water issues were established, and discussions were initiated on collaborative research projects and grant applications.

An FEPN website has been developed and includes a brief discussion of the issues and parasites of concern in Canada, as well as the Terms of Reference of the FEPN (http://www.fepn.net/) (accessed September 17, 2013). A directory of members, including an index showing members’ research interests, has also been developed and will be maintained and updated on the website. The status of the various FEPN working groups, and information on their research and surveillance projects, will also be maintained on this website.

CONCLUSIONS

Parasitic diseases are of public health significance in Canada, especially in rural and remote areas. While data on the incidence of some parasites is available, knowledge of the true burden of parasitic infections in Canadians is limited. Waterborne and foodborne parasites, in particular, contribute significantly to the overall number of parasitic infections reported in Canada. A number of centers of expertise in Canada study various aspects of parasitology, but few formal societies or networks of parasitologists currently exist in Canada, and previously, none focused specifically on food and environmental transmission. The Food and Environmental Parasitology Network is the first of its kind in Canada and brings together researchers, regulators and public health officials with an active involvement in issues related to these increasingly important fields. The major objectives of the Network include identifying research gaps, facilitating discussion and collaborative research, developing standardized methods, generating data for risk assessments, policies, and guidelines, and providing expert advice and testing. Issues considered by the FEPN include contaminated foods and infected food animals, potable and non-potable water, Northern and Aboriginal issues, zoonotic transmission, and epidemiology. Collaborative research within different FEPN working groups is under way, and the Network is currently linking to similar or complementary national and international networks and databases. New FEPN members are welcome.

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CONTACT INFORMATION

For more information on the FEPN, or to become a member, please contact Dr. Brent Dixon, FEPN Chair, at Brent.Dixon@hc-sc.gc.ca, or visit the FEPN Web site at http://www.fepn.net/. Membership is currently restricted to Canadian researchers from academia, government or industry, regulators, public health officials, and others with an active involvement in the fields of food and environmental parasitology. However, international experts are encouraged to contact the FEPN regarding potential collaborations on issues relevant to the Network.
REFERENCES


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APPENDIX

Current and past members of the FEPN and their affiliations are listed by province below.

**British Columbia:** Judith Isaac-Renton, MD, DPH, FRCP(C); Muhammad Morshed, PhD, SCCM; Natalie Prystajecky, PhD (British Columbia Centre for Disease Control, Vancouver); Jane Pritchard, DVM, MVetSc (British Columbia Ministry of Agriculture, Abbotsford); Waren Baticados, DVM, PhD (Maxxam Analytics, Burnaby).

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