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Summary: Tick Species in Ontario

Synthesis

May 2023

Public Health Ontario

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Contents

Summary

Ticks are biting pests and transmit pathogens to humans, companion animals, livestock and wildlife. Range expansion of ticks is a challenge for public and veterinary health professionals assessing tick-borne disease risks, necessitating up-to-date information on local tick populations and potential threats. Public Health Ontario's (PHO) *Summary: Tick Species in Ontario*, brings together the current knowledge of the province's ticks and provides an account of each tick's population status (established, adventive or travel-related), hosts and public and veterinary health significance.

Through a review of the scientific literature and tick surveillance data, we report on 43 tick species recorded from Ontario, including 13 established, 16 adventive and 14 travel-related species. For established species, there were eight *Ixodes* species reported, two species each for *Dermacentor* and *Haemaphysalis*, and one *Rhipicephalus* species. Among species established in Ontario, an average of nine species were reported per public health unit (PHU), with the highest number in Sudbury and District and North Bay Parry Sound District (n=12) and the lowest number in Lambton (n=5).

The greatest tick-borne disease threat to public and veterinary health in Ontario is from established vector species (e.g., blacklegged tick, *Ixodes scapularis*), followed by adventive species that could potentially expand into Ontario from the United States of America (USA) (i.e., lone star tick, *Amblyomma americanum*). Travel-related species represent the lowest risk to Ontarians, as they typically enter the province in low numbers on humans and are unlikely to establish local populations.

Introduction

Ontario is a large province with diverse ecozones (i.e., Hudson Bay Lowlands, Mixedwoods Plains and Ontario Shield), providing suitable habitat and climate for a variety of tick species.[1] Historically, the climate in many parts of the province was considered too cool for certain species of ticks to establish populations or expand out of localized populations; however, the province's climate has become more suitable for ticks such as the blacklegged tick and the American dog tick (*Dermacentor variabilis*).

Well known as biting pests, ticks are more importantly vectors of bacteria, protozoa and viruses. Lyme disease, caused by *Borrelia burgdorferi* sensu stricto (s.s.) and transmitted by blacklegged ticks, was once a rare occurrence in Ontario but is now the most commonly reported vector-borne disease.[2] Other ticks and tick-borne pathogens have the potential to arise from the northward expansion of tick populations, such as the lone star tick and the associated pathogen *Ehrlichia chaffeensis* (cause of ehrlichiosis).[3]

The tick fauna and the distribution of ticks in Ontario are changing, presenting a challenge to public and veterinary health professionals.[4,5] Factors contributing to shifting tick distributions are synergistic, and include climate change, increased regional and global travel and human-driven landscape changes.[6-10] Ontario's shifting tick landscape requires a robust and nimble surveillance system, coupled with active research programs, to monitor the distribution of ticks.[11] The scientific literature on the ticks of Ontario, while relatively strong, is scattered and not available as a single resource. The purpose of this document is to bring together the literature and surveillance information on the ticks of Ontario.

Methods

The cornerstones of tick ecology in Canada and Ontario–and a starting point for this work–are *A Handbook to the Ticks of Canada (Ixodida: Ixodidae, Argasidae)* and *The Ixodoidea of Canada*.[12,13] Scientific literature relating to ticks in Ontario (PubMed search up to October 10, 2022 for English-language articles) was reviewed to prepare this Focus On. A Focus On document provides an overview of a public health topic without systematically reviewing the literature on that topic. Titles and abstracts were screened for relevant information (i.e., ticks collected in Ontario), then reviewed full-text articles were reviewed and relevant information was extracted from each article. For each article included in a full-text review, references were screened to identify additional articles of interest.

To accompany records from published literature, data was reviewed from Ontario's active and passive tick surveillance programs (1999–2020) along with database entries for tick specimens housed at the Canadian National Collection of Insects, Arachnids and Nematodes.[14-17] Of note, historical records of a tick species in an area does not necessarily mean the tick is still present.

For consistency, official common names for ticks are used as maintained in the common name database of the Entomological Society of America.[18] If a non-official common name was available, then it is presented after the scientific name with quotation marks. For specific Ontario hosts of ticks, mammalian and avian common names adhered to databases maintained by American Society of Mammalogists and American Ornithologists' Union, respectively.[19,20]

The results are organized by established, adventive and travel-related tick species. Within each group of species, we provide a summary table with tick common names and tick stages that bite humans. For each species, we provide an overview of its geographic distribution, hosts and public and veterinary health importance. For established species, we also provide distribution (presence or absence) of each tick species by PHU.

Definitions

Population Status of Tick Species

Established: An established tick species is one with locally reproducing populations in Ontario; i.e., all tick life stages found at the appropriate time of year for at least two calendar years. There are biases associated with defining the population status of ticks, primarily because of inadequate sampling of specific hosts or habitats. For example, we cannot confirm the establishment of *Ixodes baergi* in Ontario, since there has been no targeted examination of their host, the cliff swallow, throughout the year.

Adventive: An adventive tick species lacks locally reproducing populations in Ontario and are collected primarily from animals that originate outside Ontario (e.g., migratory birds). In some instances, an adventive tick can be collected on an animal or human who has not travelled outside of Ontario.

Travel-related: A travel-related tick species is one without locally reproducing populations in Ontario and submitted from humans following travel outside of Ontario.

Tick Relative Abundance

We describe the relative abundance of each tick species in the Annotated List as rare, occasional or common. We base relative abundance descriptions on passive surveillance data of ticks submitted from human hosts in Ontario.[16] This description of each tick's relative abundance does not necessarily correlate with biting frequency on humans.

Rare: A tick species with an average of less than one submission per year in Ontario.

Occasional: A tick species with an average of 1–49 submissions per year in Ontario.

Common: A tick species with an average of greater than or equal to 50 submissions per year in Ontario.

Tick Sources

Travel: This category is only included in the Annotated List when there is a human host reported for an adventive or travel-related tick species.

Mammalian host: This category identifies the mammalian host(s) of ticks collected in Ontario. Unless otherwise indicated, all ticks were collected from resident mammalian hosts in Ontario.

Avian host: This category identifies the bird host(s) of ticks collected in Ontario. In general, most bird hosts are migratory birds and not year-round residents of Ontario (except year-round residents such as ruffed grouse and wild turkey).

Other sources: This category is used to describe off-host sources of ticks in Ontario (e.g., collections from the environment or from active surveillance/tick dragging) or unidentified animal sources.

Results

The focussed review found reports of 43 tick species from Ontario, including 13 established, 16 adventive and 14 travel-related (from the literature and surveillance reports). Most established tick species were in the genus *Ixodes* (n=8), followed by *Dermacentor* (n=2), *Haemaphysalis* (n=2) and *Rhipicephalus* (n=1). An overview of each established tick species' presence or absence by PHU is provided (Table 1); however, this is not a measure of the number of established tick species in each PHU.

Most adventive and travel-related tick species were in the genus *Amblyomma* (n=12), followed by *Ixodes* (n=10), *Rhipicephalus* (n=3), *Dermacentor* (n=2), *Haemaphysalis* (n=1), *Hyalomma* (n=1) and *Otobius* (n=1).

There was one soft tick species (Argasidae) reported from Ontario, compared to 42 hard tick species (Ixodidae). A soft tick lacks a scutum (dorsal shield), is inornate and its mouthparts are not usually visible dorsally.[16] A hard tick has a scutum that can be ornate, with its mouthparts visible dorsally.

Table 1. Presence and absence of tick genus and species considered established in Ontario, by public health unit*

Public health unit	*D. albipictus*	*D. variabilis*	*H. chordeilis*	*H. leporispalustris*	*I. angustus*	*I. banksi*	*I. cookei*	*I. gregsoni*	*I. marxi*	*I. muris*	*I. scapularis*	*I. texanus*	*R. sanguineus*	Total species
Algoma District	X	X	-	X	X	X	X	X	X	X	X	-	X	11
Brant County	-	X	-	-	-	-	X	-	X	X	X	X	X	7
Chatham-Kent	-	X	-	-	-	-	X	-	X	-	X	X	X	6
Durham Regional	X	X	-	X	-	-	X	-	X	X	X	X	X	9
Eastern Ontario	X	X	-	X	-	-	X	-	X	X	X	X	X	9
Grey Bruce	-	X	-	X	-	-	X	-	X	-	X	X	X	7
Halton Regional	X	X	X	-	X	-	X	-	X	X	X	X	X	10
Hamilton	X	X	-	-	X	-	X	-	X	X	X	X	X	9
Haldimand-Norfolk	X	X	-	X	-	-	X	-	X	X	X	X	X	9
Haliburton-Kawartha-Pine Ridge District	X	X	-	-	X	X	X	-	X	X	X	X	X	10
Hastings and Prince Edward Counties	X	X	X	X	X	X	X	-	X	X	X	-	X	11
Huron Perth County	-	X	-	-	-	-	X	-	X	X	X	X	X	7
Kingston-Frontenac and Lennox & Addington	X	X	-	X	X	X	X	-	X	X	X	X	X	11

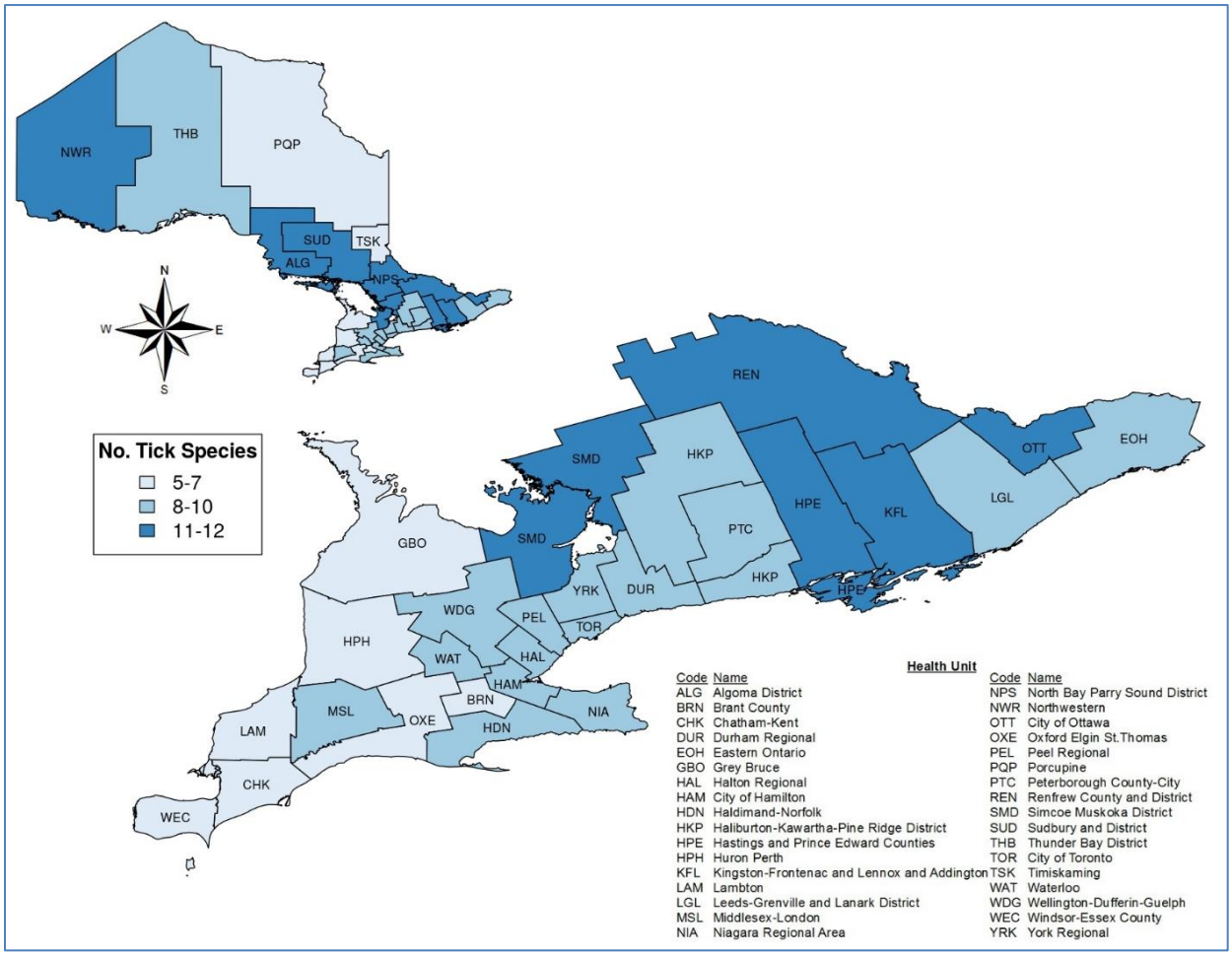
Public health unit	*D. albipictus*	*D. variabilis*	*H. chordeilis*	*H. leporispalustris*	*I. angustus*	*I. banksi*	*I. cookei*	*I. gregsoni*	*I. marxi*	*I. muris*	*I. scapularis*	*I. texanus*	*R. sanguineus*	Total species
Lambton	-	X	-	-	-	-	X	-	X	-	X	X	-	5
Leeds-Grenville and Lanark District	X	X	-	X	-	-	X	-	X	X	X	X	X	9
Middlesex-London	-	X	-	X	X	-	X	-	X	X	X	X	X	9
Niagara Regional	-	X	-	X	-	-	X	X	X	X	X	X	X	9
North Bay Parry Sound District	X	X	X	X	X	X	X	-	X	X	X	X	X	12
Northwestern	X	X	-	X	X	X	X	X	X	X	X	-	X	11
Ottawa	X	X	X	X	X	-	X	-	X	X	X	X	X	11
Oxford Elgin-St. Thomas	-	X	-	-	-	-	X	-	X	X	X	-	X	6
Peel Regional	X	X	-	-	-	-	X	-	X	X	X	X	X	8
Porcupine	X	X	-	X	-	X	X	-	X		X	-	-	7
Peterborough County-City	X	X	-	-	-	X	X	-	X	X	X	X	X	9
Renfrew County and District	X	X	X	X	X	X	X	-	X	-	X	X	X	11
Simcoe Muskoka District	X	X	X	X	X	-	X	-	X	X	X	X	X	11

Public health unit	*D. albipictus*	*D. variabilis*	*H. chordeilis*	*H. leporispalustris*	*I. angustus*	*I. banksi*	*I. cookei*	*I. gregsoni*	*I. marxi*	*I. muris*	*I. scapularis*	*I. texanus*	*R. sanguineus*	Total species
Sudbury and District	X	X	X	X	X	X	X	X	X	X	X	-	X	12
Thunder Bay District	X	X	-	X	X	-	X	-	X	X	X	X	X	10
Toronto	-	X	X	X	-	-	X	-	X	X	X	X	X	9
Timiskaming	X	X	-	-	X	-	X	-	X	-	X	-	X	7
Waterloo	X	X	-	-	X	-	X	-	X	X	X	X	X	9
Wellington-Dufferin-Guelph	X	X	X	X	-	-	X	-	X	X	X	X	X	10
Windsor-Essex County	-	X	-	-	-	-	X	-	X	X	X	X	X	7
York Regional	X	X	-	X	-	-	X	-	X	X	X	-	X	8

*Presence indicated by "X" and absence by "-". Presence of tick species in a PHU does not necessarily mean there is an established population present; rather, at least one tick has been reported from the PHU. In addition, we do not always know the travel history of humans or non-human animals from which ticks were collected. There was an average of nine tick species reported per PHU. The PHUs with the highest number of reported tick species was Sudbury and District and North Bay Parry Sound District (n=12), with lowest number in Lambton (n=5) (Figure 1).

Note: Abbreviations: *D., Dermacentor; H., Haemaphysalis; I., Ixodes; R., Rhipicephalus*

Figure 1. Number of established tick species by public health unit, Ontario, Canada



Blacklegged ticks and American dog ticks are the most common species associated with humans in Ontario, representing approximately 55% and 36%, respectively, of all ticks submitted through passive surveillance in the province.[21] Passive surveillance is biased towards ticks associated with humans and does not necessarily reflect the relative abundance of each tick species in the environment.

The remaining 41 (out of 43) tick species reported in Ontario are relatively uncommon because they:

- rarely, or only occasionally, bite humans;
- are from seldom-examined hosts;
- are nidicolous (being found most frequently on the body of their preferred hosts and within the burrows, caves, dens or nests of their hosts); or
- are hitchhikers on animals (humans, migratory birds) that travelled outside of the province.

Three of Ontario's established species readily bite humans: *Dermacentor variabilis*, *Ixodes scapularis* and *Rhipicephalus sanguineus*. The remaining established tick species do not, or only occasionally, bite humans.

Annotated List of Ticks Reported in Ontario

Established Species

Table 2. Summary of established tick species in Ontario

Tick species	Common name	Stage(s) that bites humans
Dermacentor albipictus	winter tick	adult
Dermacentor variabilis	American dog tick	adult
Haemaphysalis chordeilis	bird tick	adult
Haemaphysalis leporispalustris	rabbit tick	adult
Ixodes angustus	“coastal squirrel tick”	adult
Ixodes banksi	“beaver tick”	not applicable
Ixodes cookei	“groundhog tick”	nymph, adult
Ixodes gregsoni	no common name	not applicable
Ixodes marxi	“squirrel tick”	nymph, adult
Ixodes muris	“mouse tick”	nymph, adult
Ixodes scapularis	blacklegged tick	nymph, adult
Ixodes texanus	“raccoon tick”	nymph, adult
Rhipicephalus sanguineus	brown dog tick	nymph, adult

IXODIDAE (HARD TICKS)

GENUS *DERMACENTOR*

Dermacentor albipictus

Dermacentor albipictus (winter tick or "moose tick") occurs throughout North America, and south into Central America. The preferred host of the winter tick is the moose, but they will parasitize other large mammals (caribou, cattle, deer, elk, horses).[13] The winter tick is an occasional ectoparasite of humans in Ontario, but is usually associated with ungulates (hoofed mammals).

Dermacentor albipictus is an enzootic vector (pathogen transmitted between non-human hosts) of *Anaplasma marginale* (bovine anaplasmosis) and *Babesia duncani* (babesiosis).[22]

- **Mammalian hosts**: dog, horse, human, moose, snowshoe hare, white-tailed deer[12,13,21,23]
- **Avian hosts**: none reported
- **Other sources**: collected from unidentified domestic animals[16]

Dermacentor variabilis

Dermacentor variabilis (American dog tick) occurs throughout central and eastern North America, and south into Mexico. Larvae and nymphs of the American dog tick feed on mice and voles, and adults feed on dogs, opossums, raccoons and humans. *Dermacentor variabilis* is the second most common (≈36%) tick submitted from humans in Ontario.[21]

Dermacentor variabilis is a vector of *Cytauxzoon felis* (feline cytauxzoonosis), *Francisella tularensis* (tularemia) and *Rickettsia rickettsii* (Rocky Mountain spotted fever).[13,24] The American dog tick can cause tick paralysis (disease caused by neurotoxin in tick saliva, not by an infectious agent) in dogs and humans.[13]

- **Mammalian hosts**: cat, cattle, coyote, dog, "donkey/mule," horse, human, meadow vole, North American deermouse, North American porcupine, northern raccoon, southern red-backed vole, stripped skunk, Virginia opossum, white-footed mouse[21,23,25-29]
- **Avian hosts**: none reported
- **Other sources**: found in the environment by tick submitters, collected in the environment during drag sampling, unidentified wildlife[16]

GENUS *HAEMAPHYSALIS*

Haemaphysalis chordeilis

Haemaphysalis chordeilis (bird tick or "grouse tick") occurs throughout North America. The bird tick feeds primarily on grouse and pheasants, but will occasionally infest cattle, dogs and humans.[13]

Haemaphysalis chordeilis is not a vector of public or veterinary health concern.

- **Mammalian hosts**: none reported
- **Avian hosts**: chicken, chipping sparrow, ruffed grouse, spruce grouse[12,30,31]
- **Other sources**: none reported

Haemaphysalis leporispalustris

Haemaphysalis leporispalustris (rabbit tick) occurs throughout North America, and south into Mexico, Central America and South America. The rabbit tick is a nidicolous tick that is most commonly associated with lagomorphs (hares, rabbits), but will feed on birds.[13] The rabbit tick is a rare ectoparasite of humans in Ontario, and is usually associated with lagomorphs and migratory birds.

Haemaphysalis leporispalustris is an enzootic vector of *Francisella tularensis* and *Rickettsia rickettsii*.[32,33]

- **Mammalian hosts**: American red squirrel, eastern cottontail rabbit, European hare, human, snowshoe hare, white-tailed deer[12,21,34]
- **Avian hosts**: American robin, Baltimore oriole, barred owl, blue jay, brown thrasher, Carolina wren, chipping sparrow, common yellowthroat, dark-eyed junco, gray catbird, gray-cheeked thrush, "grouse," house wren, Lincoln's sparrow, Nashville warbler, northern cardinal, red-winged blackbird, ruby-crowned kinglet, ruffed grouse, song sparrow, Swainson's thrush, swamp sparrow, veery, white-throated sparrow, wild turkey, wood thrush[23,30,31,34-37]
- **Other sources**: found in the environment by tick submitters, collected in the environment during drag sampling[16,25]

GENUS *IXODES*

Ixodes angustus

Ixodes angustus ("coastal squirrel tick") occurs throughout North America and eastern Asia.[13] *Ixodes angustus* is a nidicolous tick that feeds primarily on chipmunks, mice, squirrels and voles. *Ixodes angustus* is a rare ectoparasite of humans in Ontario, and is usually associated with rodents.

Ixodes angustus is an enzootic vector of *Anaplasma phagocytophilum* (anaplasmosis) and *Borrelia burgdorferi* s.s.[38]

- **Mammalian hosts**: American red squirrel, common muskrat, dog, eastern chipmunk, hairy-tailed mole, human, least chipmunk, meadow vole, North American deermouse, northern short-tailed shrew, southern bog lemming, southern red-backed vole, white-footed mouse[12,23,26]
- **Avian hosts**: none reported
- **Other sources**: collected from unidentified wildlife[16]

Ixodes banksi

Ixodes banksi ("beaver tick") occurs throughout eastern North America.[13] The beaver tick feeds almost exclusively on beavers, but will occasionally feed on muskrats.

Ixodes banksi is not a vector of public or veterinary health concern.

- **Mammalian hosts**: American beaver, northern river otter[12,13,17]
- **Avian hosts**: none reported
- **Other sources**: none reported

Ixodes cookei

Ixodes cookei ("groundhog tick") occurs throughout eastern North America.[13] The groundhog tick is a nidicolous tick and a common ectoparasite of cats, dogs, groundhogs, mink, porcupines, racoons and skunks. *Ixodes cookei* is the third most common (≈6% of submissions) tick submitted in Ontario from humans.

Ixodes cookei is an enzootic vector of Powassan virus (Powassan virus disease).[39]

- **Mammalian hosts**: American beaver, American marten, American mink, cat, common muskrat, dog, eastern chipmunk, eastern gray squirrel, "ferret," fisher, human, North American porcupine, North American red squirrel, northern raccoon, red fox, short-tailed weasel, striped skunk, woodchuck[12,21,27,40,41]
- **Avian hosts**: Canada goose[40]
- **Other sources**: collected in the environment during drag sampling[16]

Ixodes gregsoni

Ixodes gregsoni occurs throughout the northern portion of eastern North America.[42] *Ixodes gregsoni* is an ectoparasite of mustelids (martens, mink, weasels).

Ixodes gregsoni is not a vector of public or veterinary health concern.

- **Mammalian hosts**: American marten, American mink[23,42]
- **Avian hosts**: none reported
- **Other sources**: none reported

Ixodes marxi

Ixodes marxi ("squirrel tick") occurs throughout eastern North America. The squirrel tick is primarily an ectoparasite of squirrels, but occasionally feeds on other small mammals (cats, dogs).[13] *Ixodes marxi* is an occasional ectoparasite of humans in Ontario, but is usually associated with squirrels.

Ixodes marxi is an enzootic vector of Powassan virus.[36]

- **Mammalian hosts**: American marten, cat, dog, eastern gray squirrel, fisher, human, least chipmunk, North American red squirrel, northern flying squirrel, northern raccoon, red fox, stripped skunk[27,31,36,40]
- **Avian hosts**: Baltimore oriole[37]
- **Other sources**: found in the environment by tick submitters, collected in the environment during drag sampling, collected from unidentified wildlife[16]

Ixodes muris

Ixodes muris ("mouse tick") occurs throughout eastern North America. The mouse tick is a nidicolous tick and an ectoparasite of rodents (mice, rats, voles) and birds.[13] *Ixodes muris* is an occasional ectoparasite of humans in Ontario, but is usually associated with rodents and migratory birds.

Ixodes muris is a potential enzootic vector of *Borrelia burgdorferi* s.s.[43]

- **Mammalian hosts**: cat, dog, human, northern short-tailed shrew, southern red-backed vole, white-footed mouse[23,26,44]
- **Avian hosts**: black-throated blue warbler, common yellowthroat, dark-eyed junco, hermit thrush, northern waterthrush, song sparrow, white-throated sparrow, winter wren[23,35,45]
- **Other sources**: collected in the environment during drag sampling[16]

Ixodes scapularis

Ixodes scapularis (blacklegged tick) occurs throughout central and eastern North America. Larvae and nymphs feed on rodents (mice, chipmunks) and birds, while adults feed on small to large mammals (dogs, raccoons, white-tailed deer).[13] Blacklegged tick nymphs and adults will feed on humans. The blacklegged tick is the most commonly (≈55%) submitted tick from humans in Ontario.[21]

Blacklegged ticks are the primary vectors of *Anaplasma phagocytophilum*, *Babesia microti* (babesiosis), *Babesia odocoilei* (deer babesiosis), *Borrelia burgdorferi* s.s. and other *Borrelia* including *Borrelia miyamotoi*, deer tick virus (Powassan virus lineage II) and *Ehrlichia muris eauclairensis* (ehrlichiosis).[21]

- **Mammalian hosts**: American black bear, cat, cattle, coyote, dog, eastern chipmunk, eastern cottontail rabbit, eastern grey squirrel, fisher, horse, human, masked shrew, meadow vole, North American deermouse, North American porcupine, North American red squirrel, northern raccoon, northern short-tailed shrew, red fox, southern red-backed vole, white-footed mouse, white-tailed deer[13,25,27,40,46-49]
- **Avian hosts**: American redstart, American robin, Baltimore oriole, black-capped chickadee, blackpoll warbler, blue jay, brown creeper, brown-headed cowbird, brown thrasher, Canada warbler, Carolina wren, cedar waxwing, chipping sparrow, common grackle, common yellowthroat, dark-eyed junco, eastern towhee, European starling, gray catbird, grey-cheeked thrush, hermit thrush, hooded warbler, house wren, indigo bunting, Lincoln's sparrow, mourning warbler, Nashville warbler, northern waterthrush, ovenbird, palm warbler, red-eyed vireo, red-winged blackbird, rose-breasted grosbeak, song sparrow, Swainson's thrush, swamp sparrow, Tennessee warbler, veery, white-crowned sparrow, white-throated sparrow, winter wren, wood thrush, yellow warbler[9,31,35,37,45,46,50-53]
- **Other sources**: found in the environment by tick submitters, collected in the environment during drag sampling, collected from unidentified domestic animals and unidentified wildlife[16]

Ixodes texanus

Ixodes texanus ("raccoon tick") occurs throughout North America.[12,13] The raccoon tick feeds primarily on small and medium-sized mammals (raccoons, skunks). *Ixodes texanus* is a rare ectoparasite of humans in Ontario, and is usually associated with raccoons and skunks.

Ixodes texanus is not a vector of public or veterinary health concern.

- **Mammalian hosts**: American mink, cat, human, northern raccoon, red fox, stripped skunk[12,13,21,27,30,54]
- **Avian hosts**: none reported
- **Other sources**: found in the environment by tick submitters[16]

GENUS *RHIPICEPHALUS*

Rhipicephalus sanguineus

Rhipicephalus sanguineus (brown dog tick) occurs worldwide wherever dogs occur. Unlike all other established tick species in Canada, the brown dog tick can complete its entire life cycle indoors. The brown dog tick is an occasional ectoparasite of humans in Ontario, but is usually associated with dogs. Infested dogs have often travelled or have spent time in a kennel with other animals that have travelled.

The brown dog tick is a vector of *Babesia canis vogeli* (canine babesiosis), *Ehrlichia canis* (canine ehrlichiosis), *Hepatozoon canis* (canine hepatozoonosis) and *Rickettsia rickettsii*.[13,55]

- **Mammalian hosts**: cat, dog, human[12,13,21,44]
- **Avian hosts**: none reported
- **Other sources**: found in the environment by tick submitters, collected in the environment during drag sampling[56]

Adventive Species

Table 3. Summary of adventive tick species collected in Ontario

Tick species	Common name	Stage(s) that bites humans
Amblyomma americanum	lone star tick	nymph, adult
Amblyomma dissimile	“iguana tick”	not applicable
Amblyomma exornatum	“monitor lizard tick”	not applicable
Amblyomma inornatum	no common name	adult
Amblyomma longirostre	no common name	not applicable
Amblyomma maculatum	Gulf Coast tick	adult
Amblyomma rotundatum	no common name	not applicable
Amblyomma sabanerae	“Neotropical tortoise tick”	not applicable
Amblyomma tenellum	no common name	not applicable
Ixodes affinis	no common name	not applicable
Ixodes auritulus	no common name	not applicable
Ixodes baergi	no common name	not applicable
Ixodes brunneus	no common name	not applicable
Ixodes dentatus	no common name	adult
Ixodes minor	no common name	not applicable
Rhipicephalus annulatus	“southern cattle tick”	adult

IXODIDAE (HARD TICKS)

GENUS *AMBLYOMMA*

Amblyomma americanum

Amblyomma americanum (lone star tick) occurs throughout the eastern USA and south into Mexico.[57] Lone star ticks feed on small to medium (dogs, raccoons, rodents) and large mammals (deer), birds (wild turkey) and humans. The lone star tick is a common tick in Ontario; however, research has not demonstrated established populations in the province.[4,21] *Amblyomma americanum* are most frequently removed from hosts with known travel to parts of the USA. Occasionally, these ticks are removed from hosts in Ontario who did not travel, and it is assumed these specimens were introduced into Canada on migratory birds or other host animals.

The lone star tick is a vector of *Ehrlichia chaffeensis*, *Ehrlichia ewingii* (ehrlichiosis), *Francisella tularemia* and *Theileria cervi* (deer theileriosis).[4] In addition, lone star ticks are associated with galactose-alpha-1,3-galactose (alpha-gal) allergy, which can cause an allergy to red meat.[58]

- **Travel**: Antigua and Barbuda, Belize, Costa Rica, Ecuador, Mexico, Peru, USA (Alabama, Arkansas, Delaware, Florida, Georgia, Illinois, Indiana, Kentucky, Maryland, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, West Virginia)[16,56]
- **Mammalian hosts**: cat, dog, human[4,21,27,44,56]
- **Avian hosts**: gray-cheeked thrush, red-eyed vireo, veery[23,37]
- **Other sources**: found in the environment by tick submitters, collected in the environment during drag sampling[16]

Amblyomma dissimile

Amblyomma dissimile ("iguana tick") occurs in the southeastern USA (Florida), Caribbean, Central America and South America. The iguana tick is mostly associated with reptiles and, to a lesser extent, amphibians, birds and mammals.[59] In Ontario, *Amblyomma dissimile* is associated with migratory birds originating from the Neotropics (i.e., coastal Mexico, Central America, Caribbean and South America).

Amblyomma dissimile is a potential enzootic vector of *Ehrlichia ruminantium* (heartwater in ruminants).[60]

- **Mammalian hosts**: none reported
- **Avian hosts**: veery[23,61]
- **Other sources**: none reported

Amblyomma exornatum

Amblyomma exornatum ("monitor lizard tick") occurs throughout southern Africa.[62] The monitor lizard tick is a one-host tick that feeds on African monitor lizards.

Amblyomma exornatum is not a vector of public or veterinary health concern.

- **Mammalian hosts**: none reported
- **Avian hosts**: none reported
- **Other sources**: zoological garden (host not reported)[17,56]

Amblyomma inornatum

Amblyomma inornatum occurs in the southern USA, south into Mexico and Central America.[63] *Amblyomma inornatum* is most commonly associated with small to large mammals (cattle, deer, rabbits, raccoons), and occasionally birds and humans. *Amblyomma inornatum* is a rare ectoparasite of humans in Ontario, and is usually associated with travel to the southern USA or Neotropics.

Amblyomma inornatum is not a vector of public or veterinary health concern.

- **Travel**: USA (Florida, Maryland, Virginia)[16]
- **Mammalian hosts**: human[16,21]
- **Avian hosts**: gray-cheeked thrush, veery[46,64]
- **Other sources**: none reported

Amblyomma longirostre

Amblyomma longirostre occurs throughout Central America and South America.[59] Larvae and nymphs are most commonly associated with birds and adults are associated with Neotropical porcupines. In Ontario, *Amblyomma longirostre* is associated with migratory birds originating from the Neotropics.

Amblyomma longirostre is not a vector of public or veterinary health concern.

- **Mammalian hosts**: none reported
- **Avian hosts**: Acadian flycatcher, black-and-white warbler, Canada warbler, chestnut-sided warbler, magnolia warbler, red-eyed vireo, willow flycatcher, yellow warbler[23,45,46,50]
- **Other sources**: none reported

Amblyomma maculatum

Amblyomma maculatum (Gulf Coast tick) occurs throughout the southeastern USA, south into Mexico, Central America and South America.[65] Gulf Coast ticks feed on a variety of small rodents to large mammals (cattle, deer, dogs, horses), birds and humans. *Amblyomma maculatum* is an occasional ectoparasite of humans in Ontario, but is usually associated with migratory birds originating from the southern USA or Neotropics.

Amblyomma maculatum is a vector of *Hepatozoon americanum* (American canine hepatozoonosis) and *Rickettsia parkeri* (*Rickettsia parkeri* rickettsiosis).[66,67]

- **Travel**: travel outside of Ontario not reported[16]
- **Mammalian hosts**: dog, human[16,21,23]
- **Avian hosts**: gray-cheeked thrush, hermit thrush, magnolia warbler, Philadelphia vireo, red-eyed vireo, Swainson's thrush[45,46,50]
- **Other sources**: none reported

Amblyomma rotundatum

Amblyomma rotundatum occurs in the southern USA (Florida), Mexico, Caribbean, Central America and South America.[59] *Amblyomma rotundatum* is most commonly associated with amphibians, reptiles and birds. In Ontario, *Amblyomma rotundatum* is associated with migratory birds originating from the southern USA or Neotropics.

Amblyomma rotundatum is an enzootic vector of *Hemolivia stellata* (frog hematozoonosis).[68]

- **Mammalian hosts**: none reported
- **Avian hosts**: veery[69]
- **Other sources**: none reported

Amblyomma sabanerae

Amblyomma sabanerae ("Neotropical tortoise tick") occurs throughout Central America and South America.[59] Neotropical tortoise ticks are primarily ectoparasites of turtles and tortoises, but are known to feed on amphibians and birds. In Ontario, *Amblyomma sabanerae* is associated with migratory birds originating from the Neotropics.

Amblyomma sabanerae is an enzootic vector of *Hemolivia stellata*.[70]

- **Mammalian hosts**: none reported
- **Avian hosts**: black-and-white warbler, veery[45,50]
- **Other sources**: none reported

Amblyomma tenellum

Amblyomma tenellum (formerly *Amblyomma imitator*) occurs in the southern USA (Texas), south into Central America. *Amblyomma tenellum* is associated with a variety of birds and mammals.[71] In Ontario, *Amblyomma tenellum* is associated with migratory birds originating from the southern USA or Neotropics.

Amblyomma tenellum is a suspected enzootic vector of *Rickettsia rickettsii*.[72]

- **Mammalian hosts**: none reported
- **Avian hosts**: gray catbird, gray-cheeked thrush[46,50]
- **Other sources**: none reported

GENUS *IXODES*

Ixodes affinis

Ixodes affinis occurs throughout the southeastern USA.[73] *Ixodes affinis* feeds on rodents, small to large mammals (cats, deer, dogs, raccoons) and birds. In Ontario, *Ixodes affinis* is associated with migratory birds originating from the southeastern USA.

Ixodes affinis is an enzootic vector of *Borrelia burgdorferi* s.s.[74]

- **Mammalian hosts**: none reported
- **Avian hosts**: dark-eyed junco, house wren, slate-colored junco, Swainson's thrush[23]
- **Other sources**: none reported

Ixodes auritulus

Ixodes auritulus is a coastal species and occurs in western USA, south into Mexico, Central America, South America and Africa.[13] *Ixodes auritulus* is an ectoparasite of seabirds and ground-feeding birds. In a single Ontario report, an unidentified vole likely acquired the tick after it dropped from a migratory bird.[12]

Ixodes auritulus is not a vector of public or veterinary health concern.

- **Mammalian hosts**: unidentified vole[12]
- **Avian hosts**: none reported
- **Other sources**: none reported

Ixodes baergi

Ixodes baergi occurs throughout the eastern USA, wherever cliff swallows occur.[13] There has been little work on the ectoparasites of cliff swallows in Ontario; therefore, the establishment status of *Ixodes baergi* in Ontario is unclear.

Ixodes baergi is not a vector of public or veterinary health concern.

- **Mammalian hosts**: none reported
- **Avian hosts**: cliff swallow[45]
- **Other sources**: none reported

Ixodes brunneus

Ixodes brunneus occurs primarily in eastern North America, but isolated populations exist in western USA.[13] *Ixodes brunneus* feeds on a wide variety of birds. In Ontario, *Ixodes brunneus* is associated with migratory birds originating from the USA.

Ixodes brunneus can cause tick paralysis in birds.

- **Mammalian hosts**: none reported
- **Avian hosts**: dark-eyed junco, fox sparrow, gray catbird, hermit thrush, ruby-crowned kinglet, rusty blackbird, song sparrow, white-throated sparrow[23,35,45,53]
- **Other sources**: none reported

Ixodes dentatus

Ixodes dentatus occurs throughout the eastern USA.[13] *Ixodes dentatus* is an ectoparasite of hares and rabbits, but will infest birds. *Ixodes dentatus* is a rare ectoparasite of humans in Ontario, and is usually associated with migratory birds originating from the USA.

Ixodes dentatus is an enzootic vector of *Anaplasma phagocytophilum* and *Borrelia burgdorferi* s.s.[75,76]

- **Travel**: travel outside of Ontario not reported[16]
- **Mammalian hosts**: human[21]
- **Avian hosts**: Carolina wren, chipping sparrow, common yellowthroat, gray catbird, Lincoln's sparrow, Swainson's thrush, swamp sparrow, white-crowned sparrow, white-throated sparrow[9,23,25,31,35,37,50]
- **Other sources**: collected in the environment during drag sampling[25]

Ixodes minor

Ixodes minor occurs throughout the southeastern USA (Florida, Georgia, South Carolina).[77] *Ixodes minor* is an ectoparasite of rodents. In Ontario, *Ixodes minor* is associated with migratory birds likely originating from the southeastern USA.

Ixodes minor is an enzootic vector of *Borrelia burgdorferi* s.s.[74]

- **Mammalian hosts**: none reported
- **Avian hosts**: common yellowthroat[23]
- **Other sources**: none reported

GENUS *RHIPICEPHALUS*

Rhipicephalus annulatus

Rhipicephalus annulatus (formerly *Boophilus annulatus* or *Boophilus bovis*, "cattle tick") occurs in tropical and subtropical regions of the world.[78] *Rhipicephalus annulatus* are usually associated with cattle, but infest other large mammals (horses, sheep). *Rhipicephalus annulatus* was imported into Ontario on cattle (collection at an unknown date before 1910; origin of cattle was not reported).[79]

Rhipicephalus annulatus is an enzootic vector of several pathogens, including two agents of bovine babesiosis (*Babesia bigemina* and *Babesia bovis*).[78]

- **Mammalian hosts**: cattle[79]
- **Avian hosts**: none reported
- **Other sources**: none reported

Travel-Related Species

Table 4. Summary of travel-related tick species collected in Ontario

Tick species	Common name	Stage(s) that bites humans
Amblyomma cajennense s.l.	Cayenne tick	nymph, adult
Amblyomma hebraeum	"South African bont tick"	adult
Amblyomma tuberculatum	gopher tortoise tick	adult
Dermacentor andersoni	Rocky Mountain wood tick	adult
Dermacentor reticulatus	"meadow tick"	adult
Haemaphysalis punctata	"red sheep tick"	adult
Hyalomma anatolicum	"Asiatic *Hyalomma*"	adult
Ixodes holocyclus	"Australian paralysis tick"	nymph, adult
Ixodes pacificus	western blacklegged tick	nymph, adult
Ixodes persulcatus	"taiga tick"	nymph, adult
Ixodes ricinus	"castor bean tick"	nymph, adult
Otobius megnini	ear tick	larva, nymph
Rhipicephalus pulchellus	"zebra tick"	adult
Rhipicephalus senegalensis	no common name	adult

ARGASIDAE (SOFT TICKS)

GENUS *OTOBIUS*

Otobius megnini

Otobius megnini (ear tick or "spinose ear tick") has a worldwide distribution, with Canadian records primarily from British Columbia.[13] Spinose ear tick larvae and nymphs are pests of cattle, goats, horses and sheep; adult ear ticks do not blood feed. The spinose ear tick is a rare ectoparasite of humans or other animals in Ontario.

Otobius megnini infest the ears of their hosts, causing otitis (inflammation of the ear).

- **Travel:** travel outside of Ontario not reported or unknown[16]
- **Mammalian host**: dog (*Otobius* sp., but likely *Otobius megnini*), human[16,17,80]
- **Avian host**: none reported
- **Other sources**: none reported

IXODIDAE (HARD TICKS)

GENUS *AMBLYOMMA*

***Amblyomma cajennense* sensu lato**

Amblyomma cajennense sensu lato (s.l.) (Cayenne tick) occurs throughout the southern USA, Caribbean, Central America and South America. *Amblyomma cajennense* s.l. is a complex of six species: *Amblyomma cajennense* s.s., *Amblyomma interandinum*, *Amblyomma mixtum*, *Amblyomma patinoi*, *Amblyomma sculptum* and *Amblyomma tonelliae*.[81] Based on travel history and the known distribution of these *Amblyomma* species, it is hypothesized that most specimens detected in Ontario are *Amblyomma cajennense* s.s., *Amblyomma mixtum* and/or *Amblyomma sculptum*; however, further work is needed to identify species collected in Ontario. *Amblyomma cajennense* s.l. feed on small to large mammals (capybaras, cats, dogs, horses, rabbits, tapirs), birds and humans.[82] The Cayenne tick is an occasional ectoparasite of humans in Ontario, and is associated with travel to the southern USA or Neotropics.

Amblyomma cajennense s.l. is a vector of *Rickettsia rickettsii*.[83]

- **Travel**: Belize, Brazil, Costa Rica, Cuba, Guyana, Honduras, Jamaica, Mexico, Nicaragua, Panama, Trinidad and Tobago, USA (District of Columbia, Florida, Kentucky, Maryland, Mississippi, New York, North Carolina, South Carolina, Tennessee, Texas, West Virginia)[16]
- **Mammalian hosts**: human[16,21,84]
- **Avian hosts**: none reported
- **Other sources**: none reported

Amblyomma hebraeum

Amblyomma hebraeum ("South African bont tick") occurs throughout southern Africa.[78] South African bont ticks feed primarily on large ruminants (cattle, giraffes, water buffalo). *Amblyomma hebraeum* is a rare ectoparasite of humans in Ontario, and is associated with presumed travel to southern Africa.

Amblyomma hebraeum is a vector of *Ehrlichia ruminantium* and *Rickettsia africae* (African tick-bite fever in humans).[78,85]

- **Travel**: travel outside of Ontario not reported or unknown[16]
- **Mammalian hosts**: human[16]
- **Avian hosts**: none reported
- **Other sources**: none reported

Amblyomma tuberculatum

Amblyomma tuberculatum (gopher tortoise tick) occurs in the southeastern USA.[86] Nymphal and adult gopher tortoise ticks almost exclusively feed on the gopher tortoise; however, larvae occasionally bite small mammals, birds and humans.[71] *Amblyomma tuberculatum* is a rare ectoparasite of humans in Ontario, and is associated with presumed travel to the southeastern USA.

Amblyomma tuberculatum is not a vector of public or veterinary health concern.

- **Travel**: travel outside of Ontario not reported or unknown[17]
- **Mammalian hosts**: human[17]
- **Avian hosts**: none reported
- **Other sources**: none reported

GENUS *DERMACENTOR*

Dermacentor andersoni

Dermacentor andersoni (Rocky Mountain wood tick) occurs throughout western North America. The Rocky Mountain wood tick feeds on small mammals (mice, rabbits, squirrels), medium to large mammals (cattle, dogs, horses, sheep) and humans.[13] *Dermacentor andersoni* is a rare ectoparasite of humans in Ontario, and is associated with travel to western North America.

Dermacentor andersoni is a vector of *Anaplasma marginale* and Colorado tick fever virus (Colorado tick fever).[87] The Rocky Mountain wood tick can cause tick paralysis in cattle and humans.[13]

- **Travel**: Canada (Alberta, British Columbia), USA (Arizona, Missouri, Utah)[16,56]
- **Mammalian hosts**: human[16,21,56]
- **Avian hosts**: none reported
- **Other sources**: none reported

Dermacentor reticulatus

Dermacentor reticulatus ("meadow tick") occurs throughout Europe and into Asia.[88] Meadow tick larvae and nymphs feed on small mammals (hedgehogs, rabbits, voles) and birds, while adults feed on medium to large mammals (cattle, deer, dogs, foxes, horses) and humans. *Dermacentor reticulatus* is a rare ectoparasite of humans in Ontario, and is associated with presumed travel to Europe or Asia.

Dermacentor reticulatus is a vector of *Babesia caballi* (equine babesiosis), *Babesia canis*, *Rickettsia raoultii* (spotted fever rickettsiosis in humans), *Theileria equi* (equine theileriosis) and tick-borne encephalitis virus (tick-borne encephalitis).[88]

- **Travel**: travel outside of Ontario not reported or unknown[17]
- **Mammalian hosts**: human[17]
- **Avian hosts**: none reported
- **Other sources**: none reported

GENUS *HAEMAPHYSALIS*

Haemaphysalis punctata

Haemaphysalis punctata ("red sheep tick") occurs throughout Europe, and east into central Asia.[89] The red sheep tick feeds on small to large mammals (cattle, deer, goats, rabbits, sheep). *Haemaphysalis punctata* is a rare ectoparasite of humans in Ontario, and is associated with travel to Asia.

Haemaphysalis punctata is a vector of several pathogens, including *Babesia major* (bovine babesiosis) and *Rickettsia aeschlimannii* (spotted fever rickettsiosis in humans).[90]

- **Travel**: Kazakhstan[21]
- **Mammalian hosts**: human[21]
- **Avian hosts**: none reported
- **Other sources**: none reported

GENUS *HYALOMMA*

Hyalomma anatolicum

Hyalomma anatolicum ("Asiatic *Hyalomma*") occurs in northern Africa, southern Europe and east to China.[91] *Hyalomma anatolicum* feeds on livestock such as cattle, goats and sheep. *Hyalomma anatolicum* is a rare ectoparasite of humans in Ontario, and is associated with travel to Asia.

Hyalomma anatolicum is a vector of Crimean-Congo hemorrhagic fever virus (Crimean-Congo hemorrhagic fever in humans) and an enzootic vector of several pathogens, including *Babesia caballi* and *Theileria annulata* (tropical theileriosis in cattle).[90]

- **Travel**: India[16]
- **Mammalian hosts**: human[16]
- **Avian hosts**: none reported
- **Other sources**: none reported

GENUS *IXODES*

Ixodes holocyclus

Ixodes holocyclus ("Australian paralysis tick") occurs in Australia along the east coast of New South Wales, Queensland and Victoria.[92] Australian paralysis ticks commonly infest bandicoots, echidnas, koalas and opossums, along with livestock (cattle, goats, sheep) and humans. The Australian paralysis tick is a rare ectoparasite of humans in Ontario, and is associated with travel to Australia.

Ixodes holocyclus are vectors of several *Rickettsia* species (e.g., *Rickettsia honei*, agent of Flinders Island spotted fever) and causes tick paralysis in humans and other animals.[92]

- **Travel**: Australia[16]
- **Mammalian hosts**: human[16]
- **Avian hosts**: none reported
- **Other sources**: none reported

Ixodes pacificus

Ixodes pacificus (western blacklegged tick) occurs along the west coast of North America.[13] Western blacklegged ticks feed on small (rodents) to large mammals (cats, dogs, sheep), reptiles, birds and humans.[12] *Ixodes pacificus* is not established in Ontario and only people who travel to areas of North America where these species reside are occasionally infested and return to Ontario with this species.

Ixodes pacificus is a vector of *Anaplasma phagocytophilum* and *Borrelia burgdorferi* s.s and can cause tick paralysis in cattle, deer, dogs and mice.[13]

- **Travel**: Canada (British Columbia), USA (California, Washington)[16]
- **Mammalian hosts**: human[16,21]
- **Avian hosts**: none reported
- **Other sources**: none reported

Ixodes persulcatus

Ixodes persulcatus ("taiga tick") occurs throughout northern Europe, east into Asia and Japan.[93] *Ixodes persulcatus* nymphs and larvae feed on birds and small mammals, while adults feed primarily on large mammals (deer, moose, reindeer) and humans. *Ixodes persulcatus* is a rare ectoparasite of humans in Ontario, and is associated with presumed travel to Europe or Asia.

Ixodes persulcatus is a vector of several pathogens, including *Anaplasma centrale* (bovine anaplasmosis), *Borrelia burgdorferi* s.l. and tick-borne encephalitis virus.[90]

- **Travel**: travel outside of Ontario not reported or unknown[16]
- **Mammalian hosts**: human[16]
- **Avian hosts**: none reported
- **Other sources**: none reported

Ixodes ricinus

Ixodes ricinus ("castor bean tick" or "sheep tick") occurs throughout Europe and northern Africa.[94] *Ixodes ricinus* feeds on small mammals (hedgehogs, mice, squirrels), large mammals (cattle, roe deer, sheep), birds and humans. *Ixodes ricinus* is a rare ectoparasite of humans in Ontario, and is associated with travel to Europe.

Ixodes ricinus is a vector of *Anaplasma phagocytophilum*, *Borrelia burgdorferi* s.l., looping ill virus (looping ill in sheep) and tick-borne encephalitis virus.[90]

- **Travel**: Belgium, Bulgaria, Denmark, France, Germany, Macedonia, Netherlands, Norway, Poland, Scotland, Spain, Sweden, Switzerland, United Kingdom[16]
- **Mammalian hosts**: human[16,21]
- **Avian hosts**: none reported
- **Other sources**: none reported

GENUS *RHIPICEPHALUS*

Rhipicephalus pulchellus

Rhipicephalus pulchellus ("zebra tick") occurs throughout eastern Africa.[78] Zebra ticks are found on large mammals (antelope, camels, cattle, eland, giraffes, zebras) and humans. The zebra tick is a rare ectoparasite of humans in Ontario, and is associated with travel to eastern Africa.

Rhipicephalus pulchellus is a vector of several pathogens, including *Rickettsia conorii* ("Kenyan tick typhus" in humans) and *Theileria taurotragi* (benign bovine theileriosis).[90]

- **Travel**: Kenya, Tanzania[16,95]
- **Mammalian hosts**: human[16,95]
- **Avian hosts**: none reported
- **Other sources**: none reported

Rhipicephalus senegalensis

Rhipicephalus senegalensis occurs from western Africa (Senegal) to eastern Africa (South Sudan). *Rhipicephalus senegalensis* feeds on small to large animals (e.g., cattle, dogs, warthogs). *Rhipicephalus senegalensis* is a rare ectoparasite of humans in Ontario, and is associated with presumed travel to Africa.

Rhipicephalus senegalensis is not a vector of public or veterinary health concern.

- **Travel**: travel outside of Ontario not reported or unknown[17]
- **Mammalian hosts**: human[17]
- **Avian hosts**: none reported
- **Other sources**: none reported

Ticks of Potential Interest for Ontario

There is insufficient sampling effort for several tick species (examination of primary hosts) to determine whether they are established in Ontario, including *Ixodes baergi*, *Ixodes brunneus* and *Ixodes dentatus*. In addition, several tick species will likely take up residence in Ontario in the future, based on:

- reported collections of the tick in close proximity to Ontario;
- suitable host(s) of the tick is(are) present in Ontario; and/or
- Ontario's climate is amenable to the tick's survival and establishment.

Species on this list would include species already described such as *Amblyomma americanum*, *Amblyomma maculatum* and the following species.

Haemaphysalis longicornis

Haemaphysalis longicornis (Asian longhorned tick), native to eastern Asia, Australia and New Zealand, has recently become established in several states in the USA.[96,97] Asian longhorned ticks feed primarily on livestock (cattle, goats, sheep), but will opportunistically feed on small mammals (cats, dogs, rabbits), birds and humans. While not reported from Ontario, research demonstrates that much of southern Ontario has suitable habitat and climate for the establishment of *Haemaphysalis longicornis*.[98]

The Asian longhorned tick is associated with numerous pathogens, but only a demonstrated vector of Dabie bandavirus (agent of severe fever with thrombocytopenia syndrome, Thogoto virus (THOV infection in cattle and sheep), several *Babesia* species (bovine babesiosis) and *Theileria luwenshuni* (sheep, goat and deer theileriosis).[99] Recently, *Theileria orientalis* Ikeda genotype was detected for the first time in the USA from cattle in Virginia and West Virginia, with the Asian longhorned tick implicated as the vector.[100] For further information on the Asian longhorned tick, refer to PHO's *The Asian Longhorned Tick: Assessing Public Health Implications for Ontario*.[101]

Ixodes kingi

Ixodes kingi (rotund tick) occurs primarily in western North America and are mostly associated with ground squirrels.[13] The Franklin's ground squirrel, a host of the rotund tick, is present in northwestern Ontario near the Manitoba border. In addition, other hosts occur in Ontario such as badgers, cats, dogs and rabbits.[102] The closest reports of this tick to Ontario are from eastern Manitoba and northern Michigan (Schoolcraft County).[13,103] The rotund tick is not a significant vector of public or veterinary health concern.

Ixodes sculptus

Ixodes sculptus occurs mostly in western to central North America.[13] *Ixodes sculptus* is a nidicolous tick and primarily an ectoparasite of burrowing ground squirrels, pocket gophers and prairie dogs. Ground squirrels and other hosts (mustelids, rabbits) of *Ixodes sculptus* are present in Ontario. The closest reports of this tick to Ontario are from western Manitoba and Michigan.[13,103] *Ixodes sculptus* is not a significant vector of public or veterinary health concern.

Ornithodoros kelleyi

Ornithodoros kelleyi (*Carios kelleyi* of Klompen and Oliver, 1993) is a soft tick found throughout the USA and western Canada.[13,104] *Ornithodoros kelleyi* is a nidicolous tick and an ectoparasite of bats, such as big brown bats and little brown bats. The closest collections of *Ornithodoros kelleyi* to Ontario are from western New York (Niagara County) and eastern Michigan (Washtenaw County).[12,105] *Ornithodoros kelleyi* is not a significant vector of public or veterinary health concern.

Discussion

Approximately 38 species of ticks (30 Ixodidae and 8 Argasidae) are thought to be established in Canada, with the highest species richness in British Columbia (n≈23 species).[13] Ontario has at least 13 established tick species, which is similar to the neighbouring provinces of Manitoba (n≈11) and Quebec (n≈12).[13] Neighbouring states show a slightly higher number of established tick species compared to Ontario (e.g., Michigan, New York and Wisconsin: n≈16 in each state), but there is significant overlap in species among these jurisdictions.[103,106,107]

The 43 tick species reported from Ontario are challenging to compare to other jurisdictions, as most published lists of tick species do not include adventive and travel-related species. A recent 117-year study of ticks detected in Pennsylvania, including adventive species, reported 24 species (15 established species).[106,108] Another reason it is difficult to compare the species richness between jurisdictions is that tick surveillance effort, and the body of research, varies by location.

The greatest threat to public and veterinary health in Ontario is from established tick species that are demonstrated vectors (*Ixodes scapularis*). In addition, adventive ticks could potentially expand their populations into Ontario from the USA and pose a threat in the future (i.e., *Amblyomma americanum*, *Amblyomma maculatum*). Travel-related species enter Ontario in low numbers on humans and are not likely to establish local populations, thus do not represent a significant public or veterinary health risk.

While not meant to assess tick species richness, Table 1 and Figure 1 highlighted spatial trends. For example, PHUs with more tick species tended to be more rural and located within the Georgian Bay Ecoregion of the Ontario Shield Ecozone. In addition, PHUs with low numbers of tick species tended to be in agricultural areas of southwestern Ontario where there is relatively little forest cover.[109] Intensive and systematic tick collections would be required in each PHU in order for these trends to be confirmed; however, we would expect more species in mixed-forest-rural areas that have a higher diversity of hosts and habitat.

In addition to the species outlined here, researchers will detect more species on migratory birds in the future. Migratory birds contributed to the detection of at least 18 of the 43 tick species reported in Ontario. The extensive work on migratory birds and associated ticks has highlighted how ticks can traverse long distances, from the Neotropics to Ontario.[9,23,31,35,45,50,51] Some of these adventitious ticks have a good chance of surviving in Ontario after feeding upon migratory birds due to the presence of suitable climate, habitat and hosts, while others will die due to the cool climate and lack of preferred hosts. There are likely numerous other migratory birds not accounted for in this annotated list, as many studies had a Canada-wide focus and did not always identify the province of bird-tick association.[9,46,50,51]

Beside migratory birds carrying adventive ticks into Ontario, humans and other animals bring ticks into the province. In general, adventitious and travel-related importations are rare (less than 3% of passive tick submissions).[21] With increased travel and trade, ticks from just about anywhere in the world are merely a plane ride away from Ontario. Travellers have returned to Ontario with ticks from far-flung reaches of the globe, including *Ixodes holocyclus* from Australia and *Hyalomma anatolicum* from India.

Limitations, Strengths, Gaps and Future Directions

Detailed travel history for adventive and travel-related tick species submitted through passive surveillance (from humans) was not always reported; therefore, some locations of tick acquisition are missing or inaccurate. For instance, *Amblyomma americanum* was reported from countries where it is not known to occur (i.e., Belize, Costa Rica, Ecuador, Peru) and *Amblyomma inornatum* was reported from USA states where it is not known to occur (i.e., Maryland, Virginia). There remains a possibility that people acquired these ticks in locales where the tick is also adventive/travel-related or that travel history was incomplete.

Certain tick species are relatively well studied in Ontario, such as the blacklegged tick; therefore, we know more about their hosts and distribution. In Ontario, the blacklegged tick is associated with 22 mammalian and 43 avian species. In contrast and due to a lack of field studies, there are established species for which we know very little about their hosts and distribution in Ontario, such as *Haemaphysalis chordeilis* and *Ixodes angustus*.

The literature on ticks in Ontario focuses largely on ticks from humans, companion animals, migratory birds and accessible wildlife (easily trapped animals such as rodents). While the hosts of Ontario ticks appear robust, there are numerous other host-tick associations not accounted for, especially ticks from nidicolous animals (living in nests, burrows and dens), livestock (no reports from goats, sheep, swine), bats (no reports from bats) and resident bird populations (e.g., crows, gulls, pigeons). Undoubtedly, the 2019 initiation of eTick (an image-web-based surveillance application where the public can submit their ticks for identification) in Ontario will further our knowledge on tick distribution and hosts, and possibly detect new adventive species.[110]

Conclusions

The emergence of Lyme disease and the subsequent range expansion of blacklegged tick populations in Ontario during the late 1990s and early 2000s led to the development and refinement of Ontario's tick surveillance program. While focusing on blacklegged ticks, passive surveillance furthered a realization of the number of ticks associated with humans and, to a lesser extent, companion animals in Ontario. Ontario's active and passive tick surveillance programs, coupled with continued research, will foster a better understanding of the ticks of Ontario. *Summary: Tick Species in Ontario* provides a baseline for monitoring the tick fauna of Ontario and assessing the human or animal health risk from tick-borne diseases.

Additional Resources

To learn more about each tick species, refer to species- (in Results) or region-specific references: Africa;[79,111] Asia;[112] Australia;[113] Canada;[12,13] Caribbean, Central America and South America;[59,81,112,114,115] Europe[111,112] and USA.[71,77,106,116-122]

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