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RESEARCH ARTICLE

Primary Detection of the Establishment of Blacklegged Ticks, *Ixodes scapularis*, in British Columbia, Canada

John D Scott* and Catherine M Scott

Upper Grand Tick Centre, 365 St. David Street South, Fergus, Ontario N1M 2L7, Canada

Abstract

Ticks transport and transmit microbial pathogens that inflict malevolent diseases on domestic and wildlife animals, and humans. We reveal the first-time record of the blacklegged tick, *Ixodes scapularis*, in British Columbia (BC) and, concurrently, far western North America. We unveil the primary tick-host record of *I. scapularis* parasitizing a Mallard duck, *Anas platyrhynchos*. In our study, the most pronounced *Ixodes* species was *I. scapularis* (61%) followed by the western blacklegged tick, *Ixodes pacificus* (34%). The most frequently occurring mammalian host parasitized by *I. scapularis* was the eastern cottontail, *Sylvilagus floridanus*, a lagomorph of grassland habitats. Healthcare professionals must be aware that both *I. pacificus*, and *I. scapularis* bite humans in BC, and transmit at least six tick-borne human zoonotic pathogens that cause insidious diseases.

Introduction

Blacklegged ticks, *Ixodes scapularis* (Acari: Ixodidae), are considered the tenet of propagating and dispersing at least six tick-borne zoonotic pathogens in North America [1]. These human pathogens include many genospecies or genomospecies within the *Borrelia burgdorferi* sensu lato (Bbsl) complex [2,3], as well as *Babesia* spp. (Bspp) [4-6], *Anaplasma phagocytophilum* (Aph) [7,8], *Borrelia miyamotoi* [9,10], *Ehrlichia muris eauclairensis* [11], and the virus of Powassan Virus Disease [12-14].

During tick studies in the early 1990's, British Columbia (BC) researchers discovered Bbsl in western blacklegged ticks, *Ixodes pacificus*, collected in 24 locations in southwest BC [15,16]. More recently, *A. phagacytophilum* [17,18], *Borrelia miyamotoi* [19], and *Babesia odocoilei* [20] have been detected in *I. pacificus*. *Babesia odocoilei* has been reported in Washington state, directly south of BC, but the tick species was not given [21].

Songbirds (order: Passeriformes) play a major role in the wide dispersal of songbird-transported ticks in Canada [22-35]. Notably, *I. auritulus*, *I. pacificus*, and *I. scapularis* infest passerines, whereas *I. angustus* does not parasitize avifauna. Researchers recently discovered three tick-borne zoonotic pathogens (Aph, Bbsl, and *B. odocoilei*) in the brachial blood of ground-foraging songbirds that were infested with juvenile *I. scapularis* [34].

***Corresponding author(s)**

John D Scott, Upper Grand Tick Centre, 365 St. David Street South, Fergus, Ontario N1M 2L7, Canada

Email: jkscott@bserv.com

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The purpose of this tick-host study was to evaluate tick species that dwell in southern BC.

Material and Methods

Tick collection

Ticks were collected opportunistically in southwestern BC by veterinarians, veterinary technicians, wildlife rehabilitators, wildlife assistants, and the public. For the most part, ticks were inserted directly into micro tubes containing 94% ethyl alcohol. However, ticks collected by wildlife rehabilitators and wildlife assistants were kept alive, and sent for identification and further ecological study. A tick log was kept to record tick evidence. A professionally trained acarologist (J.D.S.) with 33 years experience made the tick identifications and confirmed them by taxonomic keys [36-38]. An Olympus SZX16 stereoscopic microscope was employed.

Tick propagation

Live, juvenile ticks, which were partially or fully engorged, were held in the tick laboratory at 20.5˚C and 90-95% humidity to molt to the next life stage. When ticks molted to the next life stage, they were held for several days to sclerotize, and mature.

Results

Tick collection

In total, 59 ticks were collected from avian and mammalian hosts (Table 1). They consisted of five species (i.e., *Ixodes angustus*, *n* = 1; *Ixodes auritulus*, *n* = 1; *Ixodes pacificus*, *n* = 20; *Ixodes scapularis*, *n* = 36; and *Ixodes texanus*, *n* = 1). Collectively, all three motile stages (i.e., larvae, nymphs, adults {males, females}) of *I. scapularis* were obtained on Vancouver Island. These developmental life stages indicate that an established population of *I. scapularis* is present in this location. As well, *I. scapularis* were collected on the mainland in the Fraser River Valley and elsewhere in the Lower Mainland Region.

Ixodes scapularis females have cornuae (backward-pointing projections on the posterior corners of the basis capitulum), and these short, apparent projections are absent on *I. pacificus*.

Life stage propagation of *Ixodes scapularis*

Two fully engorged *I. scapularis* females parasitized a single eastern cottontail, *Sylvilagus floridanus* (Lagomorpha: Leporidae), from Vancouver Island, and each female laid a clutch of eggs. Each clutch hatched to viable larvae in approximately 10 d. All mobile life stages on the eastern cottontails were *I. scapularis*. Larval and nymphal stages of *I. scapularis* were also collected from an eastern cottontail. This lagomorph was parasitized with four nymphs, and all molted to *I. scapularis* adults, namely two males and two females. The presence of all three mobile stages at this Vancouver Island locality clearly indicates that an established population of *I. scapularis* is present. Multiple *I. scapularis* males and females were also collected from three other eastern cottontails. Once mated, the females had the potential to acquire blood meals, lay viable eggs, initiate new breeding colonies, and transmit pathogens to hosts.

A Mallard Duck (duckling), *Anas platyrhynchos* (order: Anseriformes), was recovered at Victoria, BC, on 28 May 2022, and two fully engorged *I. scapularis* nymphs were collected. Notably, the nymphs had the distinguishing physical characteristics of *I. scapularis*. This bird parasitism represents a novel tick-host index for avifauna. In the laboratory (J.D.S.), the nymphs molted to females in 53 d and 54 d. These females had the differentiating morphological characteristics of *I. scapularis*. This unique parasitism is the initial record of *I. scapularis* ticks parasitizing a dabbling duck (Anseriformes: Anatidae). Each of the distinguishing physical characteristics for *I. scapularis* keyed out to those of *I. scapularis* listed for *Ixodes* nymphs in the temperate zone of the Nearctic region (continental United States and Canada).

Table 1: Ticks collected from avian and mammalian hosts in British Columbia, Canada, 2022.

Tick species	No. of Ticks (%)	Hosts
Ixodes angustus	1 (1.7)	Domestic dog, *Canis lupus familiaris*
Ixodes auritulus	1 (1.7)	Golden-crowned Sparrow, *Zonotrichia atricapilla*
Ixodes pacificus	20 (33.9)	Domestic dog
Ixodes scapularis	36 (61.0)	Eastern cottontail, *Sylvilagus floridanus* Mallard Duck, *Anas platyrhynchos*
Ixodes texanus	1 (1.7)	Domestic dog

Discussion

The presence of *I. scapularis* on Canada's West Coast seems strange because *I. pacificus* has been considered the principal vector of tick-borne zoonotic pathogens in far-western North America. In other words, the acknowledgement of *I. scapularis* flies in the face of tradition. Accurate tick identification has been an oversight in BC. In myriad cases, *I. pacificus* have been misidentified and, what were thought to be *I. pacificus*, were really *I. scapularis*. Based on the ticks collected in the present study, a substantial portion of the *Ixodes* ticks presented to healthcare professionals would have been *I. scapularis*. Depending on tick species, each tick has its own bevy of pathogens. Because *Ixodes ticks* harbor and transmit pathogens that are infective to humans, ticks must be correctly identified by an acarologist, or parasitologist or pathologist skilled in tick taxonomy.

Ixodes scapularis parasitizing Mallard Duck in BC

We provide the first documentation of *I. scapularis* infesting a waterfowl bird in North America. Two *I. scapularis* nymphs parasitized a Mallard Duck at Victoria, BC (Figure 1). Typically, ticks are found on ground-forage songbirds as they are being assessed in bird banding or bird monitoring programmes. The collection of the two fully engorged *I. scapularis* nymphs on the Mallard Duck indicates that this tick species is host-seeking in southwestern BC in the later part of May. In this case, the duckling was submitted to the local rehabilitation station for physical assessment.

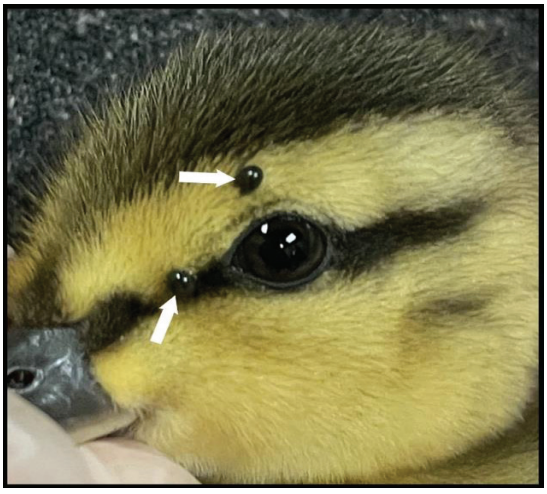

Figure 1. Mallard Duck, duckling parasitized by two fully *engorged Ixodes* scapularis nymphs. White arrows point to nymphal ticks. Photo: Catherine Bass.

Not only have we unveiled the initial *I. scapularis* on a waterfowl in Canada, we are the first to announce a tick parasitizing a waterfowl bird in North America. Collectively, scientists have reported *Ixodes* ticks on three other orders of birds, namely Passeriformes (perching birds), Falconiformes (raptors), and Galliformes (gallinaceous birds).

New habitat range of *Ixodes scapularis*

During bidirectional migrations, migratory songbirds can traverse bodies of water en route to their breeding and nesting grounds. Birds have the capability to overcome terrestrial barriers, such as mountain ranges and bodies of waters along the Pacific flyway. These migrants have the capacity to disperse bird-transported ticks hundreds of kilometres and, thus, have the potential to establish new tick populations in remote locations and regions [22-34,39,40]. Passerines, raptors, and waterfowl, provide an aerial mode of transport for *I. scapularis* between Vancouver Island, offshore islands in the Salish Sea, and the mainland.

Songbirds have the flight capacity to reach short-distance and long-distant localities. In fact, certain avian *Ixodes* species (i.e., *I. pacificus*, *I. scapularis*) parasitize mammalian and reptilian hosts, and greatly broaden their habitat range. Canadian researchers collected avian coastal ticks, *I. auritulus*, from a Cooper's Hawk, a raptor, on Vancouver Island, BC [41]. As well, wildlife biologists have collected *I. auritulus*, *I. pacificus* and *Ixodes spinipalpis* ticks from gallinaceous (chicken-like) birds on Vancouver Island, BC. [42]. In Quebec, wildlife rehabilitators collected a fully engorged *I. scapularis* nymph from the base of the oral cavity of an American Kestrel; this is the earliest documentation of *I. scapularis* parasitizing a raptor in Canada [43].

Ixodes scapularis on eastern cottontails in BC

In 1927, a game farm manager in Washington state bought two dozen eastern cottontails from a dealer in the state of Kansas. Upon return to Washington state, 13 died and 11 were released to the wild in Washington state as a food source and for hunters [44].

Six years later, three other residents obtained more cottontail rabbits from Missouri, and released them into the wild in southern Washington state [44]. Because of their high fecundity, these eastern cottontails quickly multiplied. These rabbits expanded into Oregon and, also, northward, along

the east side of Puget Sound into southwestern BC [44]. By 1952, these lagomorphs had spread south of the lower Fraser River. We contend that the eastern cottontails were infested with *I. scapularis* when they were transported from the Midwest where *I. scapularis* are indigenous [37].

Also, in 1964, a Washington resident introduced eastern cottontails to Metchosin, BC located on the south shore of Vancouver Island [45]. From this seashore locality, these cottontail rabbits gradually expanded northward to Port Alberni, Duncan, Courtenay, and Campbell River [45]. These prolific lagomorphs soon became an invasive species in southwestern BC. We postulate that the eastern cottontails were infested with *I. scapularis* ticks during their northward movement on Vancouver Island. Although *I. pacificus* has been identified previously in BC [15,16], we provide the foremost formal proclamation of *I. scapularis* in BC and, concomitantly, in far-western North America.

At one collection site on Vancouver Island, we observed *I. pacificus* and *I. scapularis* on a single dog that were collected on different days. Because these ticks were coalesced in juxtaposition, they are sympatric. Although these *Ixodes* tick species have different morphological traits, they share similar vertebrate hosts and evironmental niches. Epidemiologically, *I. pacificus* is an important vector for *B. burgdorferi* sensu lato, *A. phagocytophilum*, and *B. odocoilei* in far-western North America [18,21]. Based on tick-pathogen studies across North America, *I. scapularis* typically have a higher Bbsl prevalence than *I. pacificus* [21]. In a recent tick-host-pathogen study conducted in eastern Canada, 26% of the *I. scapularis* (i.e., nymphs and adults) were infected with Bbsl [31]. In comparison, *I. pacificus* nymphs in California had a Bbsl infection prevalence that ranged from 4% (bordering hardwood forest) to 13% (forest leaf litter) [46]. In essence, the Bbsl prevalence for *I. scapularis* and *I. pacificus* differs by about 4 to 1.

Each tick species has its own distinguishing morphologic characteristics. For *I. scapularis* females, the presence of cornuae is a distinguishing characteristic (Figure 2) [38]. Indeed, *I. pacificus* females have none. For *I. scapularis* nymphs, the posterior margin of the basis capitulum is dorsally sinuous and the hypostome is pointed [37]. In contrast, the posterior margin of the basis capitulum of *I. pacificus* nymph is slightly curved to straight [37]. Of note, the palp of the *I. scapularis* nymph is very narrow. Depending on the original territory of the tick, the palp length to width ratio varies from 4.00 to 5.05 mm [47]. Notably, these characteristics were evident in the two *I. scapularis* nymphs parasitizing the Mallard Duck (duckling) [37]. With these taxonomic comparisons, *I. scapularis* can now be correctly associated as carriers and transmitters of tick-borne zoonotic pathogens in BC and Pacific Northwest states.

Year-round questing of Ixodes scapularis in coastal areas

Blacklegged tick adults have host-seeking activities when the ambient temperatures are above 0˚C, and there is no snow cover [33,34,48-50]. Since the temperatures in coastal areas of BC are very seldom below freezing, and rarely have snow cover, *I. scapularis* adults will be questing continually throughout the year. In low-elevation, coastal areas, outdoors people can be exposed to *I. scapularis* tick bites year-round.

Conclusion

We provide the first authentic discovery of *I. scapularis* in southwestern BC. We elucidated the fact that *I. scapularis* has broadened its habitat range

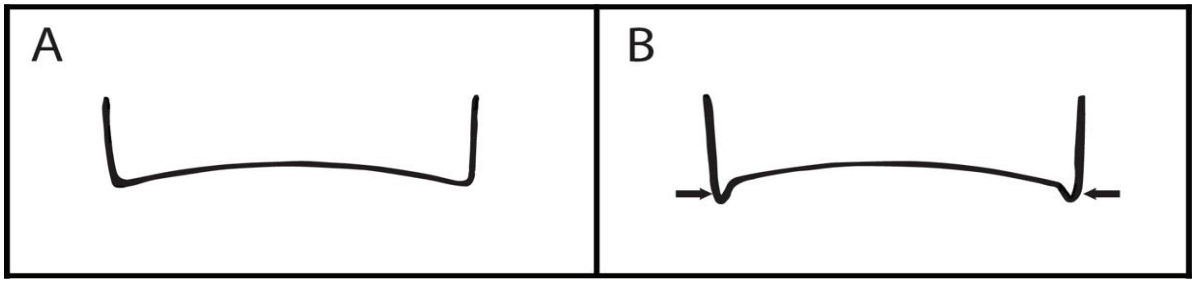

Figure 2 A). *Ixodes pacificus*, female, basis capitulum with no cornuae. **B).** *Ixodes scapularis*, female, cornuae on the posterior corners of the basis capitulum. Arrows point to cornuae.

in North America. When eastern cottontails were introduced to Metchosin, BC, in 1964, via Washington state, we believe that *I. scapularis* were introduced at the same time. Based on the life stages of *I. scapularis* on eastern cottontails, we have concluded that *I. scapularis* are established in southern BC. We provide the original fundamental account of *I. scapularis* ticks parasitizing a Mallard Duck, *A. platyrhynchos*, in North America. The *I. scapularis* nymphs collected from the Mallard Duck unequivocally indicate that *I. scapularis* are a public health risk in the later part of May in southwestern BC. Because ambient temperatures in coastal areas are typically above zero and there is no snow cover, *I. scapularis* can quest throughout the year. Healthcare professionals must be aware that *I. scapularis* can harbor and transmit at least six tick-borne zoonotic pathogens in BC, and cause pathogenic diseases in humans.

Acknowledgments

Ethical consideration

Ethical approval is not required to remove ticks from avian and mammalian hosts. Regulatory approval is not required to hold ticks to molt.

Authors' contributions

Conceptualization and design: JDS. Collection and methodology: JDS. Formal analysis: JDS and CMS. Drafting of manuscript: JDS and CMS. Accuracy of data: JDS and CMS. All authors participated in the tick-host study, and read and approved the final version of the scientific manuscript.

Competing financial and investments interests

The authors declare that they have no competing financial or investment interests relating to this tick-host study.

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