Lice (Phthiraptera: Trichodectidae), fleas (Siphonaptera: Pulicidae, Ceratophyllidae) and ticks (Ixodida: Ixodidae) infesting American badger, *Taxidea taxus* (Mammalia: Mustelidae), in Manitoba, Canada

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Abstract — One juvenile and nine adult American badgers, *Taxidea taxus* (Schreber), from Manitoba were examined for ectoparasites by whole body washing or visual inspection. Five of seven adults washed from the Shoal Lake area were infested with one species of chewing louse, *Neotrichodectes interruptofasciatus* (Kellogg and Ferris) (mean intensity – 539); females were significantly more abundant than males. The ratio of nymphs to females was 2.5. The washed juvenile badger was infested with 6384 specimens of *N. interruptofasciatus*, but males (n=286) and females (n=287) were almost equal in number, and the ratio of nymphs to females was 20.3. Adult badgers were infested with five species of fleas: *Pulex irritans* Linnaeus, *Oropsylla rupestris* (Jordan), *O. bruneri* (Baker), *O. tuberculata* (Baker), and *O. arctomys* (Baker). All seven adult badgers from the Shoal Lake area were infested with adult American dog ticks, *Dermacentor variabilis* (Say). Mean intensity was 63.4, with a total of 258 males and 186 females.

Introduction

The American badger (Mammalia: Mustelidae: *Taxidea taxus* (Schreber)) is a superbly adapted fossorial predator of North America's central and western plains and grasslands. In Canada, its range extends from Ontario (*T. t. jacksoni* Schantz), throughout the Prairie Region (*T. t. taxus* (Schreber)) to central British Columbia (*T. t. jeffersonii* (Harkan)) (Naughton 2012). Although some subspecies are listed as endangered in British Columbia and Ontario (COSEWIC 2012), the subspecies in Manitoba, *T. taxus taxus*, remains on the list of fur bearers in the province.

There have been numerous reports of ectoparasites from badgers in North America. Most accounts were tabulated by Wittrock and Wilson (1974). There have been no dedicated studies of ectoparasites of badgers in Canada, though various taxonomic groups have been recorded. Perhaps the most extensively listed for Canada are the fleas, summarized by Holland (1985). Ticks are common ectoparasites of badgers, as cited by Cooley and Kohls (1945), Brown and Kohls (1950), Gregson (1956), and Lindquist *et al*. (2016). Although the chewing louse, *Neotrichodectes interruptofasciatus* (Kellogg and Ferris) is known to infest American badger (Wittrock and Wilson 1974), there are no published records of this louse in Canada (Kennedy and Newman 1986).

I recently had the opportunity to examine a small sample of American badgers from Manitoba that allowed a thorough, quantitative assessment of ectoparasites. These are the first data of their kind collected from this host.

Materials and Methods

Seven badgers were collected during a predator control program conducted by the Delta Waterfowl Foundation in the area of Shoal Lake, southwest of Minnedosa, Manitoba. Seven badgers (three males; four females) were trapped and individually bagged immediately after being euthanized during the period 15 March to 15 July, 2008–2010 and 2013. Precise dates and locations of each badger were not available. Badgers were kept frozen until they were processed for ectoparasites in the laboratory. Each adult badger was thawed overnight at room temperature, to the point where limbs and head were flexible, then washed three times in a plastic garbage can (75-litre capacity), twice containing warm soapy water and once with clean water (Galloway and Lamb 2014, 2016). If ectoparasites were seen on the surface of the last wash in clean water, the animal was returned for subsequent washes in soapy water until no ectoparasites were evident. Badgers were agitated vigorously to dislodge ectoparasites and examined visually and by manual palpation after each wash, especially to detect attached ticks. The water from each wash was passed through a 90µ sieve and the residual preserved in 95% ethanol. Samples were sorted under a dissecting microscope and ectoparasites preserved in 95% ethanol. Representative specimens of lice and all fleas were mounted in Canada balsam using the method described by Richards (1964). Lice were identified using descriptions in Kellogg and Ferris (1915) and Werneck (1948); fleas were identified using keys in Holland (1985); identity of ticks was confirmed using Lindquist *et al*. (2016). Infestation parameters are defined according to Bush *et*

al. (1997) and were calculated using Quantitative Parasitology (QPweb 1.0.15; Reiczigel *et al*. 2019). In addition to the Shoal Lake badgers, one male young-of-the-year badger (1712.4g) from Brandon, Manitoba was submitted to Wildlife Haven (Manitoba Wildlife Rehabilitation Organization) on 22 July, 2021 but it died overnight, 23 July. It was processed as described above for adult badgers, but was washed in a smaller plastic pail (26-litre capacity). One road-killed badger was examined by visual inspection in 1990 during a survey of mammals for the blacklegged tick, *Ixodes scapularis* Say. One additional road-killed badger was similarly examined in 2005 as part of a long-term study on ectoparasites infesting wildlife in Manitoba.

Voucher specimens for all collections were deposited in the J.B. Wallis/R.E. Roughley Museum of Entomology in the Department of Entomology, University of Manitoba, Winnipeg.

Results

Results of collections from the Shoal Lake badgers are presented in Table 1. Five of seven badgers (prevalence = 71.4%) were infested with one species of chewing louse, *N. interruptofasciatus* (Phthiraptera: Trichodectidae). A total of 2695 chewing lice were collected. Sex ratio of total males (n=232) to females (n=714), 0.33, was significantly less than 1.0 ($P < 0.05$, χ^2 goodness of fit, df = 1). The ratio of total nymphs to females was 2.5. Mean intensity of infestation was 539.0 (174–1500; 95% confidence interval, BCa method, 2000 bootstrap replications). The juvenile badger from Brandon was infested only with chewing lice, 6384 *N. interruptofasciatus* (males – 286; females – 287; nymphs – 5811). The sex ratio was almost exactly 1:1, and the ratio of nymphs to females was 20.3.

Four species of fleas were collected from the Shoal Lake badgers: *Pulex irritans* Linnaeus (Siphonaptera: Pulicidae), *Oropsylla* (*Oropsylla*) *rupestris* (Jordan), *Oropsylla* (*Opisocrostis*) *bruneri* (Baker), and *Oropsylla* (*Opisocrostis*) *tuberculata* (Baker) (all three species, Ceratophyllidae) (Table 1). Although all but two badgers were infested with fleas, none of the species of fleas were present in large numbers. Total numbers of fleas never exceeded eight on one host.

One species of tick, *Dermacentor variabilis* (Say) (Ixodida: Ixodidae), was collected from the Shoal Lake badgers. All seven of the badgers were infested with a total of 444 *D. variabilis*. Sex ratio of total males (n=258) to females (n=186), 1.39, was significantly greater than 1.0 ($P < 0.05$, χ^2 goodness of fit, df = 1). Mean intensity of infestation was 63.4 (37.3–103.0; 95% confidence interval, BCa method, 2000 bootstrap replications). No mites were collected from any of the badgers.

Additional records for fleas from two road-killed American badgers in Manitoba include the following: Elm Creek, 18.vii.1990, *Pulex irritans* – 2♂, 3♀, J.E. Christie/D.M. Mitchell; 5 km. south, 5 km. west of Morris, 7.xii.2005, *Oropsylla arctomys* (Baker) – 1♂, 1♀, *Oropsylla bruneri* – 1♀, T.D. Galloway/J.E. Christie. No ticks or lice were collected from any of the road-killed badgers.

Table 1. Summary of ectoparasites collected from seven American badgers (*Taxidea taxus*) from the Shoal Lake area, Manitoba, southwest of Minnedosa, 15 March–15 July, 2008–2010, 2013. Numbers were arbitrarily assigned to individual badgers, and correspond to slides and collection vials in the Wallis/Roughley Museum of Entomology.

Host	**Ectoparasites**
Badger #1 ♀ 6.9kg	*Neotrichodectes interruptofasciatus* – 40♂; 177♀; 54n *Dermacentor variabilis* – 30♂; 15♀
Badger #2 ♂ 8.4kg	*Neotrichodectes interruptofasciatus* – 27♂; 58♀; 142n *Oropsylla bruneri* – 1♀ *Oropsylla tuberculata* – 1♀ *Oropsylla rupestris* – 2♂; 1♀ *Dermacentor variabilis* – 19♂; 21♀
Badger #3 ♂ 11.3kg	*Pulex irritans* – 1♂ *Oropsylla tuberculata* – 1♂; 5♀ *Oropsylla rupestris* – 1♂ *Dermacentor variabilis* – 27♂; 9♀
Badger #4 ♀ 6.7kg	*Neotrichodectes interruptofasciatus* – 33♂; 123♀; 166n *Dermacentor variabilis* – 7♂; 8♀
Badger #5 ♀ 5.9kg	*Pulex irritans* – 1♀ *Oropsylla rupestris* – 2♂ *Dermacentor variabilis* – 59♂; 50♀
Badger #6 ♂ 9.1kg	*Neotrichodectes interruptofasciatus* – 129♂; 343♀; 1352n *Oropsylla rupestris* – 2♀ *Oropsylla tuberculata* – 1♀ *Dermacentor variabilis* – 91♂; 54♀
Badger #7 ♀ 6.6kg	*Neotrichodectes interruptofasciatus* – 3♂; 13♀; 35n *Pulex irritans* – 1♂ *Dermacentor variabilis* – 25♂; 29♀

Discussion

This is the first published record of *N. interruptofasciatus* in Canada, though there is one male specimen in the Canadian National Collection of Insects, Acari and Nematodes in Ottawa, collected by Stuart Criddle at Aweme, Manitoba, 15.i.1914. There are also specimens of *O. arctomys*, and *O. bruneri* collected by S. Criddle on the same date, presumably from the same badger (Holland 1949). The Aweme records are of interest because they were collected during

winter, as were the specimens collected from a road-killed badger near Morris in the present study. American badgers do not hibernate, but they are active throughout winter with intermittent periods of torpor, and will emerge above ground during periods of mild weather (Naughton 2012).

The present study is the first dedicated attempt to quantify infestation parameters of this louse. American badgers are rather large, with coarse thick fur, making collection of chewing lice a challenge. Wittrock and Wilson (1974) reported the numbers of male and female lice from nine of 13 infested badgers (69.2%) in Iowa, comparable to the prevalence of infestation in the current study (71.4%). They reported that some badgers were infested with "extremely large numbers" of lice, but collected only a few. They did not describe their collection methods, nor whether they attempted to randomize their collections. Females of *N. interruptofasciatus* outnumbered males on all five infested Shoal Lake badgers. Males represented 24.5% of total adult lice in the current study. This relationship is not unusual for lice (Marshall 1981), but Wittrock and Wilson (1974) considered males to be "relatively scarce" in their samples, represented by 25.5% of the total adult lice. Wittrock and Wilson (1974) cited records of *N. interruptofasciatus* from badgers in California (Kellogg and Ferris 1915), Colorado (Werneck 1948) and their own study in Iowa. Wilson and Oliver (1979) reported *N. interruptofasciatus* from a badger in Hebbronville, Texas. As in the previous account (Wittrock and Wilson 1974), they found females to outnumber males, 42 to 31. Whitaker and Goff (1979) collected four *N. interruptofasciatus* from two badgers in Indiana, presumably by means of visual inspection, though this is uncertain based on their description of methods. Emerson *et al*. (1984) reported this louse from badgers in Oregon, but provided no quantitative information. Hampton (2005) reported the presence of specimens of *N. interruptofasciatus* from Idaho, deposited in the Idaho National Collection. The infestation on the juvenile badger from Brandon offers some interesting insight, despite being from only one animal. Where male lice had generally been considered "scarce" (Wittrock and Wilson 1974), or were at least significantly outnumbered by females on adult badgers (the current study), this juvenile badger was infested with an almost identical number of males and females, 286 and 287, respectively. In addition, it appears the louse population was in a stage of logarithmic increase, as indicated by the large number of nymphs (5811), with a nymph to female ratio (20.3) considerably greater than seen on any of the infested adult badgers. This juvenile badger would likely have been born in April, making it no more than about three months of age (Drescher 1974). This juvenile may still have been closely associated with its mother, or was in early stages of having been weaned and dispersing from the family group (Naughton 2012). Given the method of collection of lice in this study, it is possible that the sex ratio in *N. interruptofasciatus* approximates 1:1 at the time of hatch, and that the observed female bias in sex ratio on adult badgers in this and other studies is largely the result of subsequent disparity in survival in male versus female lice. However, this hypothesis is dependent on the degree of separation from its mother and siblings. As long as there was intimate association with family members prior to its dispersal, there would have been an avenue for dynamic louse transfer from one individual to another, consequently affecting sex ratio in adult lice and proportion of nymphs relative to females. Although no attempt was made to

estimate the number of eggs on this juvenile badger, there were many present in the sample after washing.

Although there have been no dedicated studies on the ectoparasites of *T. taxus* in Canada, there are scattered records of fleas infesting badgers, perhaps because of their association as vectors of the plague bacillus, *Yersinia pestis* (Lehmann & Neumann) van Loghem (Brown 1944). The badger is not known to have any specific flea parasites, but Brown (1944) and Holland (1949, 1985) listed five species of fleas recorded from badgers in Canada: *P. irritans*, *O. arctomys* (Manitoba), *O. rupestris* (Alberta), *O. bruneri* (Manitoba), and *Oropsylla* (*Opisocrostis*) *labis* (Jordan & Rothschild) (Alberta). All but *O. labis* were collected from badgers in the present study. The latter species is known to occur in Manitoba (Galloway and Christie 1990), but only in the southwest corner of the province. These *Oropsylla* spp. are all parasites of fossorial sciurids, the woodchuck, *Marmota monax* (Linnaeus) in the case of *O. arctomys* (Holland 1985) and the various species of ground squirrels in the province (*Urocitellus richardsonii* (Sabine), *Poliocitellus franklinii* (Sabine), and *Ictidomys tridecemlineatus* (Mitchill)) (Galloway and Christie 1990) for the other three species of fleas. These species of sciurids are all important sources of food for badgers (Messick and Hornocker 1981) and the association with their fleas is likely the result of predatory activity. Benton (1980) reported the pocket gopher flea, *Foxella ignota* (Baker) from an American badger in Minnesota, probably the result of predation. Four specimens of *P. irritans* were collected in the present study from the road-killed badgers near Elm Creek. *Pulex irritans* has also been reported in Canada as infesting badgers in Alberta (Brown 1944) and Saskatchewan (Holland 1985), and adjacent U.S. states, North Dakota (Woods and Larson 1970; Larson 1997) and Montana (Jellison *et al*. 1943). This flea has a very wide geographical distribution and host range (Hopla 1980; Holland 1985), but in Manitoba, most often infests canids, especially red fox, *Vulpes vulpes* (Linnaeus) (Galloway, personal observation). Its association with badgers in the present study is likely accidental. I know of no published records of fleas from subspecies of badgers in either British Columbia or Ontario.

American badgers tend to be solitary (Minta 1993), with adults occupying quite large home range sizes, 3 to 30 km^2 in Wisconsin (Doyle *et al*. 2019), and ranges even greater where prey is less abundant, up to 300 km^2 for males in the Kootenay Region of British Columbia (Kinley and Newhouse 2008). All seven Shoal Lake badgers were infested with *D. variabilis*, at an average of about 63 adult ticks per host. *Dermacentor variabilis* is the most abundantly encountered tick in Manitoba (Dergousoff *et al*. 2013), so it is not surprising to record its prevalence (100%) and intensity of infestation (in some Shoal Lake badgers >100 adult ticks) on *T. taxus* well within the range of this tick in the province. American dog ticks present an ever increasing pattern of expansion in distribution during their life cycle, from the initial focal egg mass, to larvae, to nymphs (both stages infesting small mammal hosts) and then to adults on medium-sized and large mammals (Burachynsky and Galloway 1985). Badgers, especially males, are known to disperse considerable distances, more than 100 km in some cases (Messick and Hornocker 1981). Depending on the time of the year when dispersal takes place, badgers in Manitoba clearly offer considerable potential as important agents of dispersal for adult American dog ticks. In southern grassland regions of Manitoba and Saskatchewan, badgers may contribute to the

expanding ranges of *D. variabilis* and *D. andersoni* (Dergousoff *et al*. 2013). Lindquist *et al*. (2016) cited three additional species of ticks infesting badgers in Canada, none of which were collected in the present study: *Dermacentor andersoni* Stiles (but see Wilkinson (1970)), *Ixodes kingi* Bishopp, and *Ixodes sculptus* Neumann. *Dermacentor andersoni* is not known to occur in Manitoba, *I. kingi* is rarely encountered, and *I. sculptus* is known only from the southwest corner of the province (Lindquist *et al*. 2016).

Among the three subspecies of American badger in Canada, two are considered endangered: *T. taxus jacksoni* in Ontario, and both designatable units of *T. taxus jeffersonii* (East and West Kootenay) (COSEWIC 2012). *Taxidea taxus taxus*, the subspecies examined in the present study, was designated as being of Special Concern by COSEWIC (2012), though it is still categorized as a fur-bearing animal and harvest is permitted in Alberta, Saskatchewan and Manitoba. *Taxidea taxus jacksoni* is the only subspecies in Canada that is isolated from potential gene flow from contiguous populations in the United States, and perhaps therefore of greatest concern. None of the fleas or ticks known to infest badgers are specific parasites of this host. However, the chewing louse, *N. interruptofasciatus*, is a monoxenous parasite of American badger, and completes its entire life cycle on the body of its host. Perèz *et al*. (2013) discussed issues surrounding conservation of parasites, especially where they pose a threat to health and well being of an endangered species of host. The chewing louse, *Trichodectes canis* is known to be associated with hair loss in wild canids in North America (Foreyt *et al*. 1978; Mech *et al*. 1985; Jimenez *et al*. 2010), but I know of no such reports which involve *N. interruptofasciatus* infestations of badgers. Consequently, the conservation status of the various subspecies of American badger in Canada should also be applied appropriately, at least provincially, to *N. interruptofasciatus*. This is especially the case in populations of *T. t. jacksoni* and *T. t. jeffersonii* where the occurrence and status of *N. interruptofasciatus* in Canada are unknown.

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