Survey of nasal mites (Rhinonyssidae, Ereynetidae, and Turbinoptidae) associated with birds in Alberta and Manitoba, Canada

Wayne Knee[1]

Department of Biology, Carleton University, Ottawa, Ontario, Canada K1S 5B6

Heather Proctor

Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada T6G 2E9

Terry Galloway

Department of Entomology, University of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2

Abstract—Three major lineages of mites (Arachnida: Acari) are parasitic in the nasal passages of birds: Rhinonyssidae (Mesostigmata), Ereynetidae (Prostigmata), Cytoditidae, and Turbinoptidae (Astigmata). The most diverse group of avian nasal mites is the Rhinonyssidae, which are obligate endoparasites of non-ratite birds worldwide. Prior to this study, there were only four published and three unpublished records of nasal mites from birds in Canada. In Alberta, 15% of 450 birds (154 species) examined during 2003–2007 were infested with nasal mites; in Manitoba, 16% of 2447 birds (196 species) examined during 1996–2006 were infested. We have expanded the known records of host – nasal mite species in Canada from 7 to 102, a 14-fold increase. There are now 50 species of Rhinonyssidae, 7 species of Ereynetidae, and 1 species of Turbinoptidae known from birds in Alberta and Manitoba. We predict that at least 70 species of rhinonyssid mites can be found in Canada.

Résumé—Trois lignées principales d'acariens (Arachnides : Acari) sont parasites dans les passages nasaux des oiseaux : Rhinonyssidae (Mesostigmata), Ereynetidae (Prostigmata), Cytoditidae et Turbinoptidae (Astigmata). Le groupe le plus diversifié d'acariens nasaux aviaires sont les Rhinonyssidae, qui sont des endoparasites obligatoires des oiseaux autres que ratites dans le monde entier. Avant cette étude, il y avait seulement quatre mentions publiées ainsi que trois cas non publiés d'acariens nasaux des oiseaux au Canada. En Alberta, 15 % de 450 oiseaux (154 espèces) examinés entre 2003 et 2007 étaient infestés avec des acariens nasaux; au Manitoba, 16 % de 2447 oiseaux (196 espèces) examinés entre 1996 et 2006 étaient infestés. Cette étude fait passer la liste des mentions d'acariens nasaux sur un hôte aviaire au Canada de sept à 102, soit une augmentation de l'ordre de 14 fois. Il y a maintenant 50 espèces de Rhinonyssidae, 7 espèces d'Ereynetidae, et 1 espèce de Turbinoptidae connues associées aux oiseaux en Alberta et au Manitoba. Nous prévoyons qu'au moins 70 espèces d'acariens rhinonyssides peuvent être trouvées au Canada.

Introduction

Mites are among the most diverse groups of symbionts associated with birds, with at least 40 families and approximately 3000 described species known from avian hosts (Proctor and Owens 2000). Representatives of almost all major mite groups have been collected from birds, including the normally soil-dwelling Oribatida (Krivolutsky and Lebedeva 2004), but most of the true bird associates are in the Mesostigmata, Prostigmata, and Astigmata (taxa traditionally ranked as suborders). Members of each of these groups can be found in the plumage or on the skin of birds and also inside their respiratory passages.

There are at least 500 described species of avian nasal mites worldwide (Fain 1994). The most diverse group is the Rhinonyssidae (Mesostigmata), the members of which are obligate

Received 28 January 2008. Accepted 16 March 2008.

[1]Corresponding author (e-mail: wknee@connect.carleton.ca).

© 2008 Entomological Society of Canada

haematophagous endoparasites in the nasal passages of non-ratite birds worldwide. Rhinonyssids are distributed among eight genera, believed to have descended from ectoparasitic ancestors related to the Macronyssidae (Strandtmann 1948). They probably first evolved as parasites of bats and secondarily became parasites of reptiles, birds, and other mammals (Radovsky 1985). Rhinonyssid genera vary in their degree of host specificity, with some genera being restricted to one host family and others found in hosts from different orders (Pence 1973). In North America, genera with broad host ranges are *Ptilonyssus* (Berlese and Trouessart) (passeriform, caprimulgiform, falconiform, and apodiform hosts), *Rhinonyssus* Trouessart (anseriform, podicipediform, and charadriiform hosts), *Sternostoma* Berlese and Trouessart (passeriform, piciform, and charadriiform hosts), and *Tinaminyssus* Strandtmann and Wharton (ciconiiform and columbiform hosts). Among more host-specific rhinonyssids, *Rhinoecius* Cooreman species parasitize owls (Strigiformes), with each species generally occurring in a different species of owl; *Rallinyssus* Strandtmann species parasitize rails (Rallidae); and *Larinyssus* Strandtmann species parasitize gulls and terns (Laridae).

Rhinonyssids are slow-moving, sluggish mites that occur predominantly in association with the nasal turbinates, a scroll of highly vascularized epithelial tissue, but some species invade the tracheal tissues, lungs, and body cavity (Porter and Strandtmann 1952; Krantz 1978). Feeding by rhinonyssids may cause trauma to the nasal epithelium (De-Rojas *et al.* 2002), but generally these mites are not considered to cause significant pathology to their hosts. The main exception is *Sternostoma tracheacolum* Lawrence, which invades the lower respiratory tract, lungs, and air sacs of the host (Stephan *et al.* 1950). Including captive and wild records, this mite has been reported to infest 37 species, 32 genera, and 11 families of birds (Bell 1996*a*). Captive birds are reported to experience more severe pathology than wild birds (Fain and Hyland 1962). The decline of the Australian endangered Gouldian finch, *Erythrura gouldiae* (Gould), may be the result of *S. tracheacolum* infesting wild birds from individuals originally held in captivity (Tidemann *et al.* 1992).

Other taxa of avian nasal mites are much less diverse than the Rhinonyssidae. The Speleognathinae (Prostigmata: Ereynetidae) are tissue-feeding intranasal parasites of birds and mammals worldwide (Akimov *et al.* 2003). Only four genera of speleognathines are known from at least 11 orders of birds in North America: *Boydaia* Womersley, *Neoboydaia* Fain, *Opthalomophagus* Dubinin, and *Astrida* Fain. They are very active mites, and appear to have a hydrophobic cuticle, allowing them to move rapidly on top of the mucosal surface (Porter and Strandtmann 1952). Speleognathines are reported to occupy the anteroventral chambers of the nasal cavity (Akimov *et al.* 2003). Avian speleognathines are not known to cause any significant pathology to host individuals.

Members of the family Turbinoptidae (Astigmata) are obligate tissue-feeding parasites, eating the corneous layers of the skin in the anteriormost portion of the nasal cavity (Fain 1994). Four genera of turbinoptids are known from birds in North America: *Turbinoptes* Boyd, *Colinoptes* Fain, *Schoutedenocoptes* Fain, and *Congocoptes* Fain (Pence 1973). These small sluggish mites are collected infrequently, but often occur in large numbers in particular host individuals (Porter and Strandtmann 1952). In North America, *Turbinoptes* is represented by one widespread species, *T. strandtmanni* Boyd, which parasitizes charadriiform birds (Pence 1973). *Colinoptes* is represented by one species, *C. cubanensis* Fain, known from the northern bobwhite, *Colinus virginianus* (L.) (Galliformes: Phasianidae). *Schoutedenocoptes* is represented by one species, *S. americanus* Fain and Hyland, collected from cuculiform birds. *Congocoptes* is represented by several species parasitizing piciform birds (Pence 1973). Turbinoptids are not known to cause significant pathology to host individuals.

The Cytoditidae (Astigmata) is a small group represented by two genera and three species of tissue-feeding mites in North America. *Cytonyssus troglodyti* Pence and *Cytodites therae* Hyland have been collected from the nasal passages of troglodytid and cuculiform birds, respectively (Pence 1973). *Cytodites nudus* (Vizioli) feeds on host tissues in the lungs and air sacs of galliform hosts, occasionally causing chronic inflammation (Fain 1960; Fain and Hyland 1962).

Nasal mites have been surveyed in many geographic locations, including Taiwan, Australia, Louisiana, Guatemala, and Texas, at prevalences of 16%–25% of host individuals examined (Hyland 1963; Maa and Kuo 1965; Domrow 1969; Pence 1973; Spicer 1984, 1987). There are no published survey results for Canada. Canadian records include only four published records:

© 2008 Entomological Society of Canada

Rhinonyssus sp. from the common murre, *Uria aalge* (Pontoppidan) (Ballard and Ring 1979), *S. tracheacolum* from the red-winged blackbird, *Agelaius phoeniceus* (L.) (Hood and Welch 1980), *Ptilonyssus japuibensis* Castro from the chipping sparrow, *Spizella passerina* (Bechstein) (Pence 1975), and *Ptilonyssus sairae* Castro, also from the chipping sparrow (George 1961). In addition to these, there are three unpublished species records from specimens deposited in the Canadian National Collection of Insects, Arachnids and Nematodes (CNC) in Ottawa: *Ptilonyssus bombycillae* Fain from the bohemian waxwing, *Bombycilla garrulous* (L.), *Rhinonyssus coniventris* Trouessart from the red knot, *Calidris canutus* (L.), and *Sternostoma boydi* Strandtmann from the ruddy turnstone, *Arenaria interpres* (L.) (mite identifications verified by W.K.).

The main objectives of this study were to identify the species of nasal mites that occur in birds in Alberta and Manitoba and to determine how the observed diversity compares with the results of similar studies elsewhere in North America. We provide the foundation for subsequent work on nasal mites in Canada. Having established host records in place may help us to recognize new species invasions and allow us to evaluate the potential role of nasal mites in causing avian disease.

Materials and methods

Collection of mites from birds took place independently in the laboratories of H.P. at the University of Alberta and T.G. at the University of Manitoba. At the University of Alberta we examined approximately 450 frozen bird carcasses from Alberta, largely the contributions of the Alberta Fish and Wildlife Forensic Laboratory, the Royal Alberta Museum, waterfowl hunters, and colleagues at the University of Alberta. Collection data were sparse for many of these specimens; for some it can only be said that they were collected somewhere in Alberta. Bird bodies were maintained at –20 °C until processed. A partially thawed bird was placed in a container of a suitable size, ranging from 4 to 18 L, with a drop of dish detergent, enough 95% ethanol to soak the plumage of the bird, and enough water to submerge it. The nares and mouth were rinsed with 95% ethanol as well. The whole bird was washed to collect all mites and lice (Phthiraptera) associated with the host; samples are in the possession of H.P. The sealed container was then shaken vigorously for 5 min. Particularly large birds were washed in a basin and thoroughly massaged while in the solution. Each bird was then removed from the container and rinsed thoroughly over a Fisher Scientific 53 µm mesh sieve; large birds were rinsed over the washing basin. The washing liquid was filtered and the container and lid were rinsed thoroughly over the same 53 µm mesh sieve. The material remaining in the sieve was stored in 80% ethanol in 30 mL snap-cap or scintillation vials.

Mites were also collected from some birds by dissecting the host's nasal cavities under a laminar-flow exhaust hood. The host was decapitated and the head was secured in a tabletop drill-press vice. Depending on the size of the bird, a scalpel, molybdenum-steel scissors, or molybdenum-steel bone shears were used to section the head sagittally and expose the nasal cavities. The dissected halves were placed in appropriately sized vials and stored at –20 °C until inspection. The dissected heads were placed in a glass dish with 80% ethanol and examined under a dissecting stereomicroscope.

At the University of Manitoba, nasal cavities were flushed using orthodontic syringes (15 mL for larger birds and 3 mL for smaller birds). A solution of warm water and mild soap was flushed through each nostril, back out the mouth, and into a Petri dish. Occasionally nasal mites were also collected in whole-body washings of birds. Body-washing methods were similar to those described above, except that ethanol was not added to the washing solution, and the washing solution was filtered through a 90 µm mesh sieve. Specimens were preserved in 70% ethanol.

Mites were removed from ethanol and cleared in 85% lactic acid for 1–24 h depending on the degree of original opacity. Mites were mounted in a polyvinyl alcohol medium (6371A, BioQuip Products, Rancho Dominguez, California). Slides were cured on a slide warmer at about 40 °C for 3–4 days. Slide-mounted specimens were examined on a Leica DMLB compound microscope with differential interference contrast at 400× magnification. Species-level identifications were made using keys (Pence 1975) and species descriptions in the primary literature. Voucher specimens are deposited in the University of Alberta E.H. Strickland Museum of Entomology and the University of Manitoba J.B. Wallis Museum of Entomology. Host taxonomy and authorities follow Clements (1991) provided by

© 2008 Entomological Society of Canada

Andrew and McAllan (1998), selecting the "Clements 1991–1996" taxonomy option in Nomina version 1.0.

Results

From Alberta, 450 individual birds were examined, representing 16 orders, 41 families, 103 genera, and 154 species (Table 1). Approximately one-half of the bird taxa examined were Passeriformes (55 genera, 77 species). Charadriiformes, Anseriformes, and Falconiformes were also well represented (Table 1). In Manitoba, 2447 individual birds were examined, representing 16 orders, 43 families, 126 genera, and 196 species (Table 1). Of the 2447 birds examined, 401 had nasal mites; 114 of these nasal mite samples were examined by W.K. Only a limited number of Manitoba samples were available to be examined; the samples that were examined were selected on the basis of which host species had already been examined; the remaining samples are in the possession of Dr. Serge Mironov (Russian Academy of Sciences, St. Petersburg, Russia). From Alberta and Manitoba together, 230 species of birds were examined for nasal mites (Appendix A), representing 35% of Canada's 665 bird species (Lepage 2007).

Fifty-six species of nasal mites were identified from this material (Tables 2 and 3). Most species were in the family Rhinonyssidae (48 species), within which the genus *Ptilonyssus* was the most species-rich (26 species). Species-level identifications were possible only for adult female specimens; thus, where only adult male and (or) juvenile specimens were collected, only genus-level identifications could be made. In some cases, however, some new species or new records could be determined with adult male or nymphal specimens. In Alberta, a black-headed grosbeak, *Pheucticus melanocephalus* (Swainson), had one adult male *Ptilonyssus* sp. In North America only *P. sairae* has been reported from black-headed grosbeaks (Pence and Casto 1976*b*) but, when compared with the species description, the male mite collected in Alberta was definitely not *P. sairae* and so was treated as a potential new species record for Canada. In Manitoba, an eastern kingbird, *Tyrannus tyrannus* (L.), had nymphs of *Ptilonyssus* sp., which was treated as a potential new species record for Canada because only *P. spinosus* has been recorded from this host species (Pence 1975) and has not yet been reported in Canada. A grey-cheeked thrush, *Catharus minimus* (Lafresnaye), from Manitoba was infested with nymphs of *Sternostoma* sp., which was also treated as a potential new record for Canada. Pence (1975) collected *S. hutsoni* and *S. spatulatum* from species of *Catharus* Bonaparte; neither of these species has been reported from Canada.

Table 1. Orders of birds examined for nasal mites in Alberta and Manitoba and numbers of host families, genera, and species examined from each order.

Host order	No. of host families	No. of host genera	No. of host species
Anseriformes	1	11	28
Apodiformes	2	2	2
Caprimulgiformes	1	2	2
Charadriiformes	4	12	23
Ciconiiformes	1	3	4
Columbiformes	1	2	2
Coraciiformes	1	1	1
Falconiformes	3	8	17
Galliformes	1	7	7
Gaviiformes	1	1	2
Gruiformes	2	4	4
Passeriformes	21	66	115
Pelecaniformes	2	2	2
Piciformes	1	4	6
Podicipediformes	1	3	4
Strigiformes	1	8	11
Total	44	136	230

In Alberta, 15% of 450 individual birds and 28% of 154 host species examined had nasal mites. Most infected host individuals had 1 species of nasal mite; a few hosts that had more than 1 (indicated by an asterisk in Tables 2 and 3). Of 450 individuals examined, one long-eared owl, *Asio otus* (L.), had 2 species of nasal mites, *Rhinoecius brikinboricus* Butenko and *Neoboydaia colymbiformi* Clark, representing 0.2% of examined hosts or 1.5% of all infected birds. In Manitoba, 16% of 2447 individual birds and 35% of 196 host species examined had nasal mites. Of the 114 Manitoban samples examined that had nasal mites, 4 (3.5%) had 2 species of rhinonyssids (three pairs of which were congeneric): a rock dove, *Columba livia* Gmelin, had *Tinaminyssus melloi* (Castro) and *T. columbae* (Crossley); a snow bunting, *Plectrophenax nivalis* (L.), had *Ptilonyssus morofskyi* Hyland and *P. nivalis* Knee; a great crested flycatcher, *Myiarchus crinitus* (L.), had *Ptilonyssus callinectoides* (Brooks and Strandtmann) and *P. icteridius* (Strandtmann and Furman); and an

© 2008 Entomological Society of Canada

Table 2. Host species records and prevalence values for Rhinonyssidae from birds of Alberta and Manitoba and the status of these records in North America.

Host order	Host family	Host species	Province	No. of individuals examined	No. of individuals with mites	Mite species	Status of record[a]
Anseriformes	Anatidae	*Aix sponsa*	Man.	na	1	*Rhinonyssus rhinolethrum* (Trouessart)	Previous (1)
		Anas platyrhynchos	Alta.	1	1	*R. rhinolethrum*	Previous (1)
		Anser rossii	Man.	na	1	*R. rhinolethrum*	Previous (2)
		Branta canadensis	Man.	na	1	*R. rhinolethrum*	Previous (1)
		Cygnus columbianus	Man.	na	1	*R. rhinolethrum*	Previous (3)
Columbiformes	Columbidae	*Columba livia*	Man.	na	1*	*Tinaminyssus melloi* (Castro)	Previous (1)
		C. livia	Alta., Man.	3/na	1/1*	*Tinaminyssus columbae* (Crossley)	Previous (1)
		Zenaida macroura	Man.	na	2	*Tinaminyssus zenaidurae* (Crossley)	Previous (1)
		Z. macroura	Man.	na	1	*T. melloi*	New
Falconiformes	Falconidae	*Falco sparverius*	Man.	na	4	*Ptilonyssus cerchneis* Fain	Previous (1)
Gruiformes	Rallidae	*Fulica americana*	Man.	na	2	*Rallinyssus caudistigmus* Strandtmann	Previous (1)
		Porzana carolina	Man.	na	1	*Ptilonyssus icteridius* (Strandtmann and Furman)	New
Passeriformes	Bombycillidae	*Bombycilla cedrorum*	Man.	na	1	*Ptilonyssus* sp. Berlese and Trouessart	Previous (1)
		B. cedrorum	Alta.	9	1	*Ptilonyssus bombycillae* Fain	Previous (1)
		B. garrulus	Alta.	20	3	*P. bombycillae*	Previous (4)
	Corvidae	*Perisoreus canadensis*	Alta.	1	1	*Ptilonyssus perisorei* George	Previous (1)
	Emberizidae	*Junco hyemalis*	Man.	na	1	*Ptilonyssus morofskyi* Hyland	Previous (1)
		Passerella iliaca	Man.	na	2	*P. morofskyi*	Previous (1)
		Pheucticus ludovicianus	Man.	na	1	*Ptilonyssus* sp.	New
		P. ludovicianus	Alta., Man.	3/na	3/1	*Ptilonyssus japuibensis* Castro	New
		P. melanocephalus	Alta.	1	1	*Ptilonyssus* sp.	New
		Piranga ludoviciana	Alta.	2	1	*Ptilonyssus pirangae* (Cerny)	New
		Plectrophenax nivalis	Man.	na	4*	*P. morofskyi*	New
		P. nivalis	Man.	na	1*	*Ptilonyssus nivalis* Knee	New
		P. nivalis	Alta.	5	1	*Ptilonyssus* sp.	New
		Spizella pallida	Man.	na	2	*P. japuibensis*	New
		S. passerina	Alta., Man.	7/na	1/3	*Ptilonyssus calvaria* Knee	New
		Zonotrichia albicollis	Man.	na	1	*P. japuibensis*	Previous (1)
	Fringillidae	*Carduelis flammea*	Alta., Man.	12/na	5/2	*Ptilonyssus carduelis* Fain	Previous (5)
		C. flammea	Alta.	12	1	*P. morofskyi*	New
		C. tristis	Alta.	2	1	*P. morofskyi*	Previous (6)
		Carpodacus purpureus	Alta.	8	1	*Ptilonyssus plesiotypicus* Knee	New
		Coccothraustes vespertinus	Alta., Man.	7/na	2/1	*Ptilonyssus coccothraustis* Fain and Bafort	New
		Loxia leucoptera	Alta.	7	3	*P. carduelis*	New

© 2008 Entomological Society of Canada

Table 2 (*continued*).

Host order	Host family	Host species	Province	No. of individuals examined	No. of individuals with mites	Mite species	Status of record[a]
Passeriformes	Fringillidae	*Pinicola enucleator*	Alta., Man.	9/na	4/1	*Ptilonyssus pinicola* Knee	New
		P. enucleator	Alta.	9	1	*Sternostoma cryptorhynchum* Berlese and Trouessart	New
	Hirundinidae	*Hirundo rustica*	Alta., Man.	5/na	2/1	*Ptilonyssus echinatus* Berlese and Trouessart	Previous (1)
		Petrochelidon pyrrhonota	Man.	na	1	*P. echinatus*	Previous (1)
		Progne subis	Man.	na	1	*Ptilonyssus angrensis* (Castro)	Previous (1)
		Riparia riparia	Alta.	1	1	*Sternostoma sialiphilus* Hyland and Ford	New
		Tachycineta bicolor	Man.	na	1	*P. echinatus*	Previous (1)
	Icteridae	*Agelaius phoeniceus*	Alta., Man.	3/na	2/2	*P. icteridius*	Previous (1)
		Euphagus cyanocephalus	Alta.	2	1	*P. icteridius*	Previous (1)
		Icterus galbula	Alta., Man.	5/na	4/6	*P. icteridius*	Previous (1)
		Molothrus ater	Alta.	2	1	*P. icteridius*	Previous (1)
		M. ater	Alta.	2	1	*P. japuibensis*	Previous (7)
		Quiscalus quiscula	Alta., Man.	1/na	1/1	*P. icteridius*	Previous (1)
	Mimidae	*Dumetella carolinensis*	Alta.	5	1	*Ptilonyssus euroturdi* Fain and Hyland	Previous (1)
	Parulidae	*Dendroica coronata*	Man.	na	1	*P. japuibensis*	Previous (8)
		D. magnolia	Man.	na	2	*P. japuibensis*	Previous (1)
		D. petechia	Man.	na	2	*P. japuibensis*	Previous (1)
		D. petechia	Man.	na	1	*Sternostoma loxiae* Fain	New
		D. pinus	Man.	na	1	*Ptilonyssus japuibensis*	Previous (8)
		D. pinus	Man.	na	1	*P. morofskyi*	Previous (1)
		D. striata	Man.	na	1	*P. japuibensis*	Previous (9)
		D. tigrina	Man.	na	1	*P. japuibensis*	Previous (1)
		Geothlypis trichas	Man.	na	3	*Ptilonyssus sairae* Castro	Previous (9)
		Mniotilta varia	Man.	na	1	*P. sairae*	Previous (1)
		M. varia	Man.	na	1	*Sternostoma trachaecolum* Lawrence	New
		Seiurus aurocapillus	Man.	na	3	*P. japuibensis*	Previous (9)
		S. noveboracensis	Man.	na	1	*P. japuibensis*	New
		Setophaga ruticilla	Man.	na	2	*P. morofskyi*	New
		S. ruticilla	Man.	na	1	*P. japuibensis*	Previous (1)
		Vermivora celata	Alta.	2	1	*P. sairae*	Previous (7)
		V. peregrina	Man.	na	1	*P. morofskyi*	New
		V. peregrina	Man.	na	1	*P. japuibensis*	New
		Wilsonia canadensis	Man.	na	1	*P. japuibensis*	New
	Passeridae	*Passer domesticus*	Man.	na	3	*Ptilonyssus nudus* Berlese and Trouessart	Previous (10)

© 2008 Entomological Society of Canada

Table 2 (*concluded*).

Host order	Host family	Host species	Province	No. of individuals examined	No. of individuals with mites	Mite species	Status of record[a]
Passeriformes	Passeridae	*Passer domesticus*	Man.	na	6	*Ptilonyssus hirsti* (Castro and Periera)	Previous (1)
		P. domesticus	Man.	na	5	*Ptilonyssus* sp.	Previous (1)
		P. domesticus	Man.	na	1	*T. melloi*	New
	Regulidae	*Regulus calendula*	Man.	na	1	*Ptilonyssus acrocephali* Fain	Previous (1)
	Troglodytidae	*Troglodytes troglodytes*	Alta.	1	1	*Ptilonyssus troglodytis* Fain	New
	Turdidae	*Catharus minimus*	Man.	na	1	*Sternostoma* sp. Berlese and Trouessart	New
		C. ustulatus	Alta.	5	1	*Sternostoma lanorium* Fain	New
		Sialia currucoides	Alta.	4	1	*S. loxiae*	New
		Turdus migratorius	Alta.	12	1	*Sternostoma technaui* Vitzthum	Previous (1)
	Tyrannidae	*Contopus sordidulus*	Alta.	1	1	*Ptilonyssus tyrannus* (Brooks and Strandtmann)	Previous (1)
		Empidonax minimus	Man.	na	1	*Sternostoma setifer* Knee	New
		Myiarchus crinitus	Man.	na	1*	*Ptilonyssus callinectoides* (Brooks and Strandtmann)	Previous (11)
		M. crinitus	Man.	na	1*	*P. icteridius*	New
		Sayornis phoebe	Man.	na	1	*P. tyrannus*	Previous (1)
		Tyrannus tyrannus	Man.	na	1*	*Sternostoma longisetosae* Hyland	Previous (1)
		T. tyrannus	Man.	na	1*	*Ptilonyssus* sp.	Previous (1)
	Vireonidae	*Vireo olivaceus*	Man.	na	1	*Ptilonyssus vireonis* (Dusbabek)	Previous (11)
		V. solitarius	Man.	na	1	*P. vireonis*	New
Piciformes	Picidae	*Colaptes auratus*	Alta., Man.	7/na	2/3	*Sternostoma porteri* Hyland	Previous (1)
		Picoides pubescens	Man.	na	1	*Sternostoma hylandi* Fain and Johnston	Previous (1)
		Sphyrapicus varius	Man.	na	2	*S. porteri*	New
Strigiformes	Strigidae	*Aegolius acadicus*	Man.	na	3	*Rhinoecius aegolii* Butenko	New
		A. funereus	Alta.	4	1	*R. aegolii*	New
		Asio flammeus	Man.	na	3	*Rhinoecius alifanovi* Butenko	New
		A. flammeus	Alta.	3	1	*Rhinoecius* sp. Cooreman	New
		A. otus	Alta.	3	1*	*Rhinoecius brikinboricus* Butenko	New
		Bubo virginianus	Alta., Man.	1/na	1/3	*Rhinoecius grandis* Strandtmann	Previous (1)
		Nyctea scandiaca	Man.	na	2	*Rhinoecius nycteae* Butenko	New
		Strix nebulosa	Alta.	2	1	*Rhinoecius cooremani* Strandtmann	New

Note: "na" indicates that total counts of individuals examined in Manitoba were not available. An asterisk indicates that two species of nasal mites were collected from a single host individual.

[a]1, Pence 1975: 2, Mitchell and Rhodes 1960; 3, Strandtmann 1956; 4, Spicer 1978; 5, Wilson and Haas 1980; 6, Hyland 1962; 7, Spicer 1987; 8, George 1961; 9, Pence and Castro 1976*a*; 10, Porter and Strandtmann 1952; 11, Pence 1972.

© 2008 Entomological Society of Canada

Table 3. Host species records and prevalence values for Ereynetidae and Turbinoptidae from birds of Alberta and Manitoba and the status of these records in North America.

Host order	Host family	Host species	Province	No. of individuals examined	No. of individuals with mites	Mite family	Mite species	Status of record[a]
Anseriformes	Anatidae	*Aythya americana*	Man.	4	1	Ereynetidae	*Boydaia aratingae* Fain	New
Charadriiformes	Laridae	*Larus californicus*	Alta.	1	1	Turbinoptidae	*Turbinoptes strandtmanni* Boyd	Previous (1)
		L. delawarensis	Alta.	5	1		*T. strandtmanni*	Previous (2)
Charadriiformes	Scolopacidae	*Tringa melanoleuca*	Alta.	2	1	Ereynetidae	*Neoboydaia* sp. Fain	Previous (3)
Falconiformes	Falconidae	*Falco sparverius*	Alta.	5	1		*Boydaia* sp. Womersley	Previous (4)
Passeriformes	Fringillidae	*Loxia curvirostra*	Alta.	1	1		*Boydaia faini* Cerny and Dusbabek	New
	Hirundinidae	*Tachycineta bicolor*	Alta.	3	1		*Boydaia psalidoprocnei* Fain	Previous (2)
	Sturnidae	*Sturnus vulgaris*	Alta.	3	1		*Boydaia sturni* (Boyd)	Previous (2)
Strigiformes	Strigidae	*Asio otus*	Alta.	3	1*		*Neoboydaia colymbiformi* Clark	New

Note: The asterisk indicates that two species of nasal mites were collected from a single host individual.
[a]1, Spicer 1987; 2, Pence 1975; 3, Clark 1964; 4, Pence and Castro 1976*b*.

eastern kingbird had *Sternostoma longisetosae* Hyland and *Ptilonyssus* sp.

In Alberta a total of 359 rhinonyssids were collected from 59 birds, 11 speleognathines from 6 birds, and 142 turbinoptids from 2 birds. Of the 321 rhinonyssids from Alberta that were slide-mounted and identifiable to life stage, there were 187 adult females, 67 adult males, 11 deutonymphs, 48 protonymphs, and 8 larvae. The rhinonyssid sex ratio was significantly adult female biased, with 187 females to 67 males ($\chi^2 = 56.69$, $P < 0.001$, df = 1), as reported in the literature (Bell 1996*b*). The range in numbers of nasal mites collected from an infected host in Alberta varied from 1 to 43 in the Rhinonyssidae and from 14 to 128 in the Turbinoptidae. In Manitoba the number of rhinonyssids collected from an infected host varied from 1 to 178. Cytoditids were not collected in either Alberta or Manitoba.

In Alberta and Manitoba there were 97 host–parasite species records for rhinonyssids, 41 of these being new records for North America (Table 2) and all but 1 being new for Canada. Five were species new to science (Knee 2008). For the passerines, 42% of host–parasite species records were new for North America but the greatest proportion of new records was in the Strigiformes, with 88% novel records. In Alberta, rhinonyssids were collected from 13% of 450 individual birds and 23% of 154 host species examined. Prevalence per host species in Alberta was highly variable (Table 2). For the 114 samples examined from Manitoba, total counts of individual birds examined from each host species were unavailable; thus, the proportions of birds with mites could not be calculated. Two Manitoba records are likely a result of sample contamination that could have occurred during host collection or processing: *P. icteridius*, normally restricted to the Icteridae, from a sora rail, *Porzana carolina* (L.), and *T. melloi*, normally restricted to pigeons (Columbidae), from a house sparrow, *Passer domesticus* (L.).

In Alberta and Manitoba, speleognathines were collected from 7 host species representing 5 avian orders. Of the 7 host–parasite species records, 3 are new for North America (Table 3) and all 7 are new for Canada. In Alberta, 1.3% of 450 individual birds and 4% of 154 host species examined had speleognathines. The family Turbinoptidae was represented by 1 species, *Turbinoptes strandtmanni* Boyd, collected from two host species in Alberta: California gull, *Larus californicus* Lawrence, and ring-billed gull, *L. delawarensis* Ord

© 2008 Entomological Society of Canada

(Table 3). *Turbinoptes strandtmanni* has been previously reported from both of these hosts in the continental United States (Pence 1975; Spicer 1978). In Alberta, 0.4% of 450 individual birds and 1.3% of 154 host species examined had *T. strandtmanni*.

Discussion

Only a fraction of Canada's bird-associated parasitic arthropod fauna is known. Wheeler and Threlfall (1989) estimated that there are 6000–7000 species of avian-associated Acari in Canada, yet only a small fraction of that diversity has been surveyed. Although we have greatly expanded the number of bird species examined for nasal mites, we examined only 38% of Alberta's 402 bird species (Royal Alberta Museum 2005) and 51% of Manitoba's 382 bird species (Carey *et al.* 2003); in total from Manitoba and Alberta, only 35% of Canada's 665 bird species (Lepage 2007) have been examined for nasal mites. For many of these species sample size was small and further examination may reveal additional mite species. Clearly, a great number of potential host species remain to be examined.

Prior to this study, only 7 species of nasal mites were known from Canada (see Introduction). Herein we have produced an 8-fold increase in the known nasal mites from Canada to 58 species. Nasal mite prevalence values at the level of host individuals (13% of 450) and host species (23% of 154) in Alberta are somewhat lower than those reported in other studies, while prevalence values at the level of host individuals (16% of 2447) and host species (35% of 196) in Manitoba are comparable to those seen in the literature. Pence (1973) found that 16% of 1927 birds and 48% of 193 species of birds from 24 states in the United States of America had nasal mites. Spicer (1987) reported that 17% of 502 individuals and 39% of 103 species of birds in Texas had nasal mites. Instances in which 1 host individual is infested by more than 1 species of nasal mite are rare, and cases where 2 closely related species of the same genus are present are very rare. Spicer (1987) observed only one case in which a host individual had 2 species (from separate genera) of rhinonyssids, representing 1% of infested birds and 0.2% of examined birds. Butenko and Stanyukovich (1999) reported that only 0.3% of mallards, *Anas platyrhynchos* L., they examined had 2 closely related species of rhinonyssids. In the present study, multiple species infestations were also rare. However, in Manitoba the observed frequency of multiple species infestations (3.5%) is higher than previously published records.

As seen in similar studies (Pence 1973; Spicer 1987), rhinonyssids were the most commonly collected nasal mites. Lindquist (1979) estimated that there could be 50 species of rhinonyssids in Canada. This is likely an underestimate, as we collected 48 species from 230 species of birds from Alberta and Manitoba alone. Given that there are 665 species of birds in Canada (Lepage 2007), many of them from groups that we did not sample (*e.g.*, Procellariiformes, marine Charadriiformes), we predict that the final tally of rhinonyssids in Canada is more likely to be 70–80 species. This prediction can only be tested by more extensive sampling — different hosts, and hosts in different parts of the country. Nearly half of the host–parasite species records from the Rhinonyssidae were new for North America and we have produced a 14-fold expansion of the known Canadian records. The largest proportion of new records for North America is in the Strigiformes. Six *Rhinoecius* species were collected from owls in Canada, which is 1 more species than Pence (1973) hypothesized to be in North America. Speleognathine ereynetids were relatively rare and, when present, occurred in low numbers. *Neoboydaia colymbiformi* has been reported from the eared grebe, *Podiceps nigricollis* Brehm, and the pied-billed grebe, *Podilymbus podiceps* (L.) (Pence 1975); however, in this study it was collected from a long-eared owl. It is possible that this actually represents an undescribed speleognathine species, as it seems unlikely that a grebe mite would occur in a long-eared owl, but further investigation is required. Turbinoptids were not collected frequently but, when collected, they often occurred in large numbers (up to 128 mites in one host). Members of the family Cytoditidae are still not known from birds in Canada.

This survey has markedly increased our knowledge of the distribution and diversity of nasal mites in Canada and the rest of North America and draws attention to a relatively obscure yet diverse group of mites. These records will enhance our ability to recognize species invasions and provide additional tools to evaluate the potential role of nasal mites in causing avian disease. Our research provides a basis for

© 2008 Entomological Society of Canada

subsequent work on these mites in Canada and is a necessary precursor for answering ecological, evolutionary, and parasitological questions about these mites. On a broader note, this study also exemplifies the lack of collection, documentation, and study of mites parasitic on birds and other vertebrates throughout Canada (Galloway and Danks 1991).

Acknowledgments

We particularly thank Bob McClymont and other personnel at the Alberta Fish and Wildlife Forensic Laboratory, as well as personnel at the Royal Alberta Museum, for providing numerous specimens. Sergei Mironov forwarded some material from birds from Manitoba. S. Grundke and S. Wojtkiw washed birds during the summer of 2003; N. Romaniuk and M. Pedruski did the same during the summer of 2004. We also thank Dave Holder, Lisa Babey, Chérie Dugal, Todd Whiklo, and Debra Wytrykush for laboratory assistance in Manitoba. This work could not have been done without the support of staff at the Manitoba Wildlife Rehabilitation Organization (now Wildlife Haven) and Manitoba Conservation. This research was conducted with scientific salvage permits to take migratory birds from Environment Canada (permit Nos. CWS03-A009 and CWS99-M023) and permits to salvage found dead wildlife (excluding endangered species) from Alberta Environment (current permit No. 20526) and Manitoba Conservation (permit No. WB02322). This project was funded by Discovery Grants from the Natural Sciences and Engineering Research Council of Canada to H. Proctor and T.D. Galloway, as well as the Alberta Conservation Association Biodiversity Grant to W. Knee.

References

Akimov, A., Badanin, I.V., and Zabludovskaya, S.A. 2003. Ereynetid mites (Prostigmata, Ereynetidae) and the paths of their specialization to parasitism. Acarina, **11**: 65–72.

Andrew, P., and McAllan, I. 1998. Nomina: global bird dictionary, relational taxonomies. CSIRO Publishing, Collingwood, Australia.

Ballard, J.T., and Ring, R.A. 1979. The ectoparasites of some marine birds from Bamfield Marine Station, British Columbia, with particular reference to the common murre (*Uria aalge* (Pont.)). Canadian Journal of Zoology, **57**: 1980–1984.

Bell, P.J. 1996*a*. Survey of the nasal mite fauna (Rhinonyssidae and Kytoditidae) of the Gouldian finch, *Erythrura gouldiae*, and some co-occurring birds in the Northern Territory. Wildlife Research, **23**: 675–685.

Bell, P.J. 1996*b*. The life history and transmission biology of *Sternostoma tracheacolum* Lawrence (Acari: Rhinonyssidae) associated with the Gouldian finch *Erythrura gouldiae*. Experimental and Applied Acarology, **20**: 323–334.

Butenko, O.M., and Stanyukovich, M.K. 1999. The distribution of rhinonyssid mites (Acari, Gamasina, Rhinonyssidae) in the nasal cavities of some anatid birds. Ekologiya, **2**: 52–56.

Carey, B., Christianson, W., Curtis, C.E., de March, L., Holland, G.E., Koes, R.F., Nero, R.W., Parsons, R.J., Taylor, P., Waldron, M., and Waltz, G. 2003. The birds of Manitoba. Manitoba Naturalists' Society, Winnipeg, Manitoba.

Clark, G.M. 1964. One new and one previously unreported nasal mite (Acarina, Speleognathinae) from North American birds, with observations on speleognathid taxonomy. Journal of Parasitology, **50**: 158–162.

Clements, J.F. 1991. Birds of the world: a checklist. 4th ed. Ibis Publishing, Vista, California.

De-Rojas, M., Mora, M.D., Ubeda, J.M., Cutillas, C., Navajas, M., and Guevara, D.C. 2002. Phylogenetic relationships in rhinonyssid mites (Acari: Rhinonyssidae) based on ribosomal DNA sequences: insights for the discrimination of closely related species. Parasitology Research, **88**: 675–681.

Domrow, R. 1969. The nasal mites of Queensland birds (Acari: Dermanyssidae, Ereynetidae, and Epidermoptidae). Proceedings of the Linnaean Society of New South Wales, **93**: 297–426.

Fain, A. 1960. Revision du genre *Cytodites* (Megnin) et description de deux espèces et un genre nouveaux dans la famille Cytoditidae Oudemans. Acarologia, **2**: 238–249.

Fain, A. 1994. Adaptation, specificity and host–parasite coevolution in mites (Acari). International Journal for Parasitology, **24**: 1273–1283.

Fain, A., and Hyland, K.E. 1962. The mites parasitic in the lungs of birds: the variability of *Sternostoma tracheacolum* Lawrence, 1948, in domestic and wild birds. Parasitology, **52**: 401–424.

Galloway, T.D., and Danks, H.V. 1991. Arthropod ectoparasites of vertebrates in Canada. Bulletin of the Entomological Society of Canada, **23**(Suppl.).

George, J.E. 1961. The nasal mites of the genus *Ptilonyssus* (Acarina: Rhinonyssidae) occurring on some North American passeriform birds. Journal of the Kansas Entomological Society, **34**: 105–132.

Hood, D.E., and Welch, H.E. 1980. A seasonal study of the parasites of the red-winged blackbird (*Agelaius phoeniceus* L.) in Manitoba and Arkansas. Canadian Journal of Zoology, **58**: 528–537.

Hyland, K.E. 1962. Two new nasal mites, *Ptilonyssus morofskyi*, n.sp., and *Sternostoma porteri* n.sp., from North American birds (Acarina; Rhinonyssidae).

© 2008 Entomological Society of Canada

Bulletin of the Brooklyn Entomological Society, **57**: 146–156.

Hyland, K.E. 1963. Current trends in the systematics of acarines endoparasitic in vertebrates. *In* Advances in acarology. *Edited by* J.A. Naegele. Comstock Publishing Associates, Ithaca, New York. pp. 365–373.

Knee, W. 2008. Five new species of Rhinonyssidae (Mesostigmata) and one new species of *Dermanyssus* (Mesostigmata: Dermanyssidae) from birds of Alberta and Manitoba, Canada. Journal of Parasitology, **94**: 348–374.

Krantz, G.W. 1978. A manual of acarology. 2nd ed. Oregon State University Book Stores, Corvallis, Oregon.

Krivolutsky, D.A., and Lebedeva, N.V. 2004. Oribatid mites (Oribatei, Acariformes) in bird feathers: non-passerines. Acta Zoologica, **14**: 26–47.

Lepage, D. 2007. Avibase — bird checklists of the world — Canada [online]. Available from http://www.bscoc.org/avibase/avibase.jsp?region=ca&pg=checklist&list=cle ments [accessed 5 June 2007].

Lindquist, E.E., with contributions by Ainscough, B.D., Clulow, F.V., Funk, R.C., Marshall, V.G., Nesbitt, H.H.J., OConnor, B.M., Smith, I.M., and Wilkinson, P.R. 1979. Acari, *In* Canada and its insect fauna. *Edited by* H.V. Danks. Memoirs of the Entomological Society of Canada, **108**: 252–290.

Maa, T.C., and Kuo, J.S. 1965. A field survey of arthropod parasites of birds in Taiwan. Journal of Medical Entomology, **1**: 395–401.

Mitchell, R.W., and Rhodes, W.L. 1960. New host records for the mesostigmatid nasal mite *Rhinonyssus rhinolethrum* (Acarina: Rhinonyssidae). The Southwestern Naturalist, **5**: 107–108.

Pence, D.B. 1972. The nasal mites of birds from Louisiana III. The genus *Ptilonyssus* (Dermanyssidae: Rhinonyssinae) with description of a new species. Journal of Parasitology, **58**: 790–795.

Pence, D.B. 1973. The nasal mites of birds from Louisiana. IX. Synopsis. Journal of Parasitology, **59**: 881–892.

Pence, D.B. 1975. Keys, species and host list, and bibliography for nasal mites of North American birds (Acarina: Rhinonyssinae, Turbinoptinae, Speleognathinae, and Cytoditidae). Special Publications of the Museum of Texas Tech University No. 8.

Pence, D.B., and Casto, S.D. 1976*a*. Nasal mites of the subfamily Speleognathinae (Ereynetidae) from birds in Texas. Journal of Parasitology, **62**: 466–469.

Pence, D.B., and Casto, S.D. 1976*b*. Studies on the variation and morphology of the *Ptilonyssus* "*sairae*" complex (Acarina: Rhinonyssinae) from North American passeriform birds. Journal of Medical Entomology, **13**: 71–95.

Porter, J.C., and Strandtmann, R.W. 1952. Nasal mites of the English sparrow. Texas Journal of Science, **4**: 393–399.

Proctor, H.C., and Owens, I. 2000. Mites and birds: diversity, parasitism and coevolution. Trends in Ecology and Evolution, **15**: 358–364.

Radovsky, F.J. 1985. Evolution of mammalian mesostigmate mites. *In* Coevolution of parasitic arthropods and mammals. *Edited by* K.C. Kim. John Wiley, New York. pp. 441–504.

Royal Alberta Museum. 2005. The official list of the birds of Alberta [online]. Available from http://www.royalalbertamuseum.ca/natural/birds/birdlist/taxon.htm [accessed 31 March 2006].

Spicer, G.S. 1978. A new species and several new host records of avian nasal mites (Acarina: Rhinonyssinae, Turbinoptinae). Journal of Parasitology, **64**: 891–894.

Spicer, G.S. 1984. Nasal mites from birds of a Guatemalan cloud forest (Acarina: Rhinonyssidae). Journal of Parasitology, **70**: 794–802.

Spicer, G.S. 1987. Prevalence and host–parasite list of some nasal mites from birds (Acarina: Rhinonyssidae, Speleognathidae). Journal of Parasitology, **73**: 259–264.

Stephan, S.A.R., Kaschula, V.R., and Canham, F.S. 1950. Respiratory acariasis of canaries. Journal of the South African Veterinary Medical Association, **21**: 103–107.

Strandtmann, R.W. 1948. The mesostigmatic nasal mites of birds. I. Two new genera from shore and marsh birds. Journal of Parasitology, **34**: 505–514.

Strandtmann, R.W. 1956. The mesostigmatic nasal mites of birds. IV. The species and hosts of the genus *Rhinonyssus*. Proceedings of the Entomological Society of Washington, **58**: 129–142.

Tidemann, S.C., McOrist, S., Woinarski, J.C.Z., and Freeland, W.J. 1992. Parasitism of wild Gouldian finches (*Erythrura gouldiae*) by the air-sac mite *Sternostoma tracheacolum*. Journal of Wildlife Diseases, **28**: 80–84.

Wheeler, T.A., and Threlfall, W. 1989. Synopsis of the parasites of vertebrates of Canada: ectoparasites of birds. Animal Health Division, Alberta Agriculture, Edmonton, Alberta.

Wilson, N., and Haas, G.E. 1980. Ectoparasites (Mallophaga, Diptera, Acari) from Alaskan birds. Proceedings of the Entomological Society of Washington, **82**: 541–552.

Appendix A

Appendix appears on the following pages.

© 2008 Entomological Society of Canada

Table A1. Orders, families, and species of birds examined for nasal mites in Alberta and Manitoba, and whether nasal mites were collected.

Host order	Host family	Host species	Mites present?
Anseriformes	Anatidae	*Aix sponsa* (L.)	Yes
		Anas acuta L.	No
		A. americana Gmelin	No
		A. carolinensis Gmelin	No
		A. clypeata L.	No
		A. crecca L.	No
		A. discors L.	No
		A. platyrhynchos L.	Yes
		A. strepera L.	No
		Anser caerulescens (L.)	No
		A. rossii Cassin	Yes
		Aythya affinis (Eyton)	No
		A. americana (Eyton)	No
		A. collaris (Donovan)	No
		A. marila (L.)	No
		Aythya sp. Boie	No
		A. valisineria (Wilson)	No
		Branta bernicla (L.)	No
		B. canadensis (L.)	Yes
		Bucephala albeola (L.)	No
		B. clangula (L.)	No
		Cygnus buccinator Richardson	No
		C. columbianus (Ord)	Yes
		Lophodytes cucullatus (L.)	No
		Melanitta fusca (L.)	No
		Mergus merganser L.	No
		M. serrator L.	No
		Oxyura jamaicensis (Gmelin)	No
Apodiformes	Apodidae	*Chaetura pelagica* (L.)	No
	Trochilidae	*Archilochus colubris* (L.)	No
Caprimulgiformes	Caprimulgidae	*Caprimulgus vociferus* Wilson	No
		Chordeiles minor (Forster)	No
Charadriiformes	Charadriidae	*Charadrius vociferus* L.	No
		Pluvialis dominica (Muller)	No
		P. squatarola (L.)	No
	Laridae	*Chlidonias niger* (L.)	No
		Larus argentatus Pontoppidan	No
		L. californicus Lawrence	No
		L. delawarensis Ord	No
		L. pipixcan Wagler	No
		Sterna forsteri Nuttall	No
		S. hirundo L.	No
	Scolopacidae	*Calidris himantopus* (Bonaparte)	No
		C. melanotos (Vieillot)	No
		C. minutilla (Vieillot)	No
		Gallinago delicata (Ord)	No
		G. gallinago (L.)	No
		Limosa fedoa (L.)	No
		Phalaropus lobatus (L.)	No

© 2008 Entomological Society of Canada

Table A1 (*continued*).

Host order	Host family	Host species	Mites present?
Charadriiformes	Scolopacidae	*Phalaropus tricolor* (Vieillot)	No
		Scolopax minor Gmelin	No
		Tringa flavipes (Gmelin)	No
		T. melanoleuca (Gmelin)	No
		T. solitaria Wilson	No
	Stercorariidae	*Stercorarius parasiticus* (L.)	No
Ciconiiformes	Ardeidae	*Ardea alba* L.	No
		A. herodias L.	No
		Botaurus lentiginosus (Rackett)	No
		Ixobrychus exilis (Gmelin)	No
Columbiformes	Columbidae	*Columba livia* Gmelin	Yes
		Zenaida macroura (L.)	Yes
Coraciiformes	Alcedinidae	*Megaceryle alcyon* (L.)	No
Falconiformes	Accipitridae	*Accipiter cooperii* (Bonaparte)	No
		A. gentilis (L.)	No
		A. striatus Vieillot	No
		Aquila chrysaetos (L.)	No
		Buteo jamaicensis (Gmelin)	No
		B. lagopus (Pontoppidan)	No
		B. platypterus (Vieillot)	No
		B. regalis (Gray)	No
		B. swainsoni Bonaparte	No
		Circus cyaneus (L.)	No
		Haliaeetus leucocephalus (L.)	No
		Pandion haliaetus (L.)	No
	Cathartidae	*Cathartes aura* (L.)	No
	Falconidae	*Falco columbarius* L.	No
		F. mexicanus Schlegel	No
		F. peregrinus Tunstall	No
		F. sparverius L.	Yes
Galliformes	Phasianidae	*Alectoris* sp. Kaup	No
		Bonasa umbellus (L.)	No
		Dendragapus canadensis (L.)	No
		Meleagris gallopavo L.	No
		Perdix perdix (L.)	No
		Phasianus colchicus L.	No
		Tympanuchus phasianellus (L.)	No
Gaviiformes	Gaviidae	*Gavia immer* (Brunnich)	No
		G. pacifica (Lawrence)	No
Gruiformes	Gruidae	*Grus canadensis* (L.)	No
	Rallidae	*Fulica americana* Gmelin	Yes
		Porzana carolina (L.)	Yes
		Rallus limicola Vieillot	No
Passeriformes	Alaudidae	*Eremophila alpestris* (L.)	No
	Bombycillidae	*Bombycilla cedrorum* Vieillot	Yes
		B. garrulus (L.)	Yes
	Certhiidae	*Certhia americana* Bonaparte	No
	Coccyzidae	*Coccyzus erythropthalmus* (Wilson)	No
	Corvidae	*Corvus brachyrhynchos* Brehm	No
		C. corax L.	No

© 2008 Entomological Society of Canada

Table A1 (*continued*).

Host order	Host family	Host species	Mites present?
Passeriformes	Corvidae	*Cyanocitta cristata* (L.)	No
		Perisoreus canadensis (L.)	Yes
		Pica hudsonia (Sabine)	No
	Emberizidae	*Ammodramus leconteii* (Audubon)	No
		Calcarius lapponicus (L.)	No
		Junco hyemalis (L.)	Yes
		Melospiza georgiana (Latham)	No
		M. lincolnii (Audubon)	No
		M. melodia (Wilson)	No
		Passerculus sandwichensis (Gmelin)	No
		Passerella iliaca (Merrem)	Yes
		Passerina cyanea (L.)	No
		Pheucticus ludovicianus (L.)	Yes
		P. melanocephalus (Swainson)	Yes
		Piranga ludoviciana (Wilson)	Yes
		Plectrophenax nivalis L.	Yes
		Spizella arborea (Wilson)	No
		S. pallida (Swainson)	Yes
		S. passerina Bechstein	Yes
		S. pusilla (Wilson)	No
		Zonotrichia albicollis (Gmelin)	Yes
		Z. leucophrys (Forster)	No
		Z. querula (Nuttall)	No
	Fringillidae	*Carduelis flammea* (L.)	Yes
		C. hornemanni (Holboll)	No
		C. pinus (Wilson)	No
		C. tristis (L.)	Yes
		Carpodacus mexicanus (Muller)	No
		C. purpureus Gmelin	Yes
		Coccothraustes vespertinus (Cooper)	Yes
		Loxia curvirostra L.	No
		L. leucoptera Gmelin	Yes
		Pinicola enucleator L.	Yes
	Hirundinidae	*Hirundo rustica* L.	Yes
		Petrochelidon pyrrhonota (Vieillot)	Yes
		Progne subis (L.)	Yes
		Riparia riparia (L.)	Yes
		Tachycineta bicolor (Vieillot)	Yes
	Icteridae	*Agelaius phoeniceus* (L.)	Yes
		Dolichonyx oryzivorus (L.)	No
		Euphagus carolinus (Muller)	No
		E. cyanocephalus (Wagler)	Yes
		Icterus galbula (L.)	Yes
		Molothrus ater (Boddaert)	Yes
		Quiscalus quiscula (L.)	Yes
		Sturnella neglecta Audubon	No
		Xanthocephalus xanthocephalus (Bonaparte)	No
	Laniidae	*Lanius excubitor* L.	No
		L. ludovicianus L.	No
	Mimidae	*Dumetella carolinensis* (L.)	Yes

© 2008 Entomological Society of Canada

Table A1 (*continued*).

Host order	Host family	Host species	Mites present?
Passeriformes	Mimidae	*Toxostoma rufum* (L.)	No
	Paridae	*Poecile atricapilla* (L.)	No
		P. hudsonica (Forster)	No
	Parulidae	*Dendroica castanea* (Wilson)	No
		D. coronata (L.)	Yes
		D. dominica (L.)	No
		D. fusca (Muller)	No
		D. magnolia (Wilson)	Yes
		D. palmarum (Gmelin)	No
		D. pensylvanica (L.)	No
		D. petechia (L.)	Yes
		D. pinus (Wilson)	Yes
		D. striata (Forster)	Yes
		D. tigrina (Gmelin)	Yes
		D. virens (Gmelin)	No
		Geothlypis trichas (L.)	Yes
		Mniotilta varia (L.)	Yes
		Oporornis agilis (Wilson)	No
		O. philadelphia (Wilson)	No
		Seiurus aurocapillus (L.)	Yes
		S. noveboracensis (Gmelin)	Yes
		Setophaga ruticilla (L.)	Yes
		Vermivora celata (Say)	Yes
		V. peregrina (Wilson)	Yes
		V. ruficapilla (Wilson)	No
		Wilsonia canadensis (L.)	Yes
		W. pusilla (Wilson)	No
	Passeridae	*Passer domesticus* (L.)	Yes
	Regulidae	*Regulus calendulaI* (L.)	Yes
		R. satrapa Lichtenstein	No
	Sittidae	*Sitta canadensis* L.	No
		S. carolinensis Latham	No
	Sturnidae	*Sturnus vulgaris* L.	No
	Troglodytidae	*Cistothorus palustris* (Wilson)	No
		C. platensis (Latham)	No
		Troglodytes aedon Vieillot	No
		T. troglodytes (L.)	Yes
	Turdidae	*Catharus guttatus* (Pallas)	No
		C. minimus (Lafresnaye)	Yes
		C. ustulatus (Nuttall)	Yes
		Myadestes townsendi (Audubon)	No
		Sialia currucoides (Bechstein)	Yes
		S. sialis (L.)	No
		Turdus migratorius L.	Yes
	Tyrannidae	*Contopus cooperi* (Nuttall)	No
		C. sordidulus Sclater	Yes
		Empidonax alnorum Brewster	No
		E. minimus Baird and Baird	Yes
		Empidonax sp. Cabanis	No
		Myiarchus crinitus (L.)	Yes

© 2008 Entomological Society of Canada

Table A1 (*concluded*).

Host order	Host family	Host species	Mites present?
Passeriformes	Tyrannidae	*Sayornis phoebe* (Latham)	Yes
		Tyrannus tyrannus (L.)	Yes
		T. verticalis Say	No
	Vireonidae	*Vireo flavifrons* Vieillot	No
		V. gilvus (Vieillot)	No
		V. olivaceus (L.)	Yes
		V. philadelphicus (Cassin)	No
		V. solitarius (Wilson)	Yes
Pelecaniformes	Pelecanidae	*Pelecanus erythrorhynchos* Gmelin	No
	Phalacrocoracidae	*Phalacrocorax auritus* (Lesson)	No
Piciformes	Picidae	*Colaptes auratus* (L.)	Yes
		Dryocopus pileatus (L.)	No
		Picoides pubescens (L.)	Yes
		P. villosus (L.)	No
		Sphyrapicus nuchalis Baird	No
		S. varius (L.)	Yes
Podicipediformes	Podicipedidae	*Aechmophorus occidentalis* (Lawrence)	No
		Podiceps auritus (L.)	No
		P. grisegena (Boddaert)	No
		Podilymbus podiceps (L.)	No
Strigiformes	Strigidae	*Aegolius acadicus* (Gmelin)	Yes
		A. funereus (L.)	Yes
		Asio flammeus (Pontoppidan)	Yes
		A. otus (L.)	Yes
		Athene cunicularia (Molina)	No
		Bubo virginianus (Gmelin)	Yes
		Megascops asio (L.)	No
		Nyctea scandiaca (L.)	Yes
		Strix nebulosa Forster	Yes
		S. varia Barton	No
		Surnia ulula (L.)	No

© 2008 Entomological Society of Canada