University of Alberta

Rhinonyssidae (Acari: Mesostigmata) and Other Blood- and Tissue-Feeding

Mites Associated with Birds of Alberta and Manitoba

by

Wayne Knee

A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Science
in
Systematics and Evolution

Department of Biological Sciences

Edmonton, Alberta
Fall 2007

Your file Votre référence
ISBN: 978-0-494-33283-2
Our file Notre référence
ISBN: 978-0-494-33283-2

Abstract

One of the most species-rich groups associated with birds is mites. Some mites are benign; others feed on blood or tissues and may damage the host. Among the latter are avian nasal mites, which are widely distributed but have never previously been surveyed in Canada. I present findings from a survey of nasal mites associated with 172 species of birds from western Canada, expanding the known species records from seven to 66. Five new species of Rhinonyssidae (Mesostigmata) are described. I made Lucid and dichotomous keys to the female Rhinonyssidae of Canada. During the survey I also found new species records of other blood-feeding Mesostigmata. I provide an updated host list for *Ornithonyssus sylviarum* (Macronyssidae), in North America, and describe a new species of *Dermanyssus* (Dermanyssidae). This research provides the fundamental foundation for all subsequent work on avian nasal mites in Canada.

Acknowledgements

I particularly thank Dr. Heather Proctor for providing the facilities to conduct this research, for her tireless wisdom and advice throughout this study. I am grateful to Dr. David Walter for his useful advice with the species descriptions, and our discussions of everything mite related. Drs. Terry Galloway and Serge Mironov provided me with excellent material from Manitoban birds. I also thank my committee members, Drs. G. Ball and A. Shostak, for their enthusiasm and useful insights. I 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 us with numerous specimens. S. Grundke and S. Wojtkiw washed birds during the summer of 2003, and N. Romaniuk and M. Pedruski did the same during the summer of 2004. As well as the numerous colleagues, friends and family members that I subjected to my discussions of everything mite related. I also thank my Proctor lab mates for their help along the way.

This research was conducted with a scientific salvage permit to take migratory birds from Environment Canada (permit no. CWS03-A009), and a permit to salvage found dead wildlife (excluding endangered species) from Alberta Environment (current permit no. 20526). This project was funded by an NSERC Discovery grant to Heather Proctor, an ACA Biodiversity Grant, NSERC USRA and CGS M to W. Knee.

Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

Two interlinked challenges to the field of taxonomy and to the scientific community in general are the biodiversity crisis and the problem of the taxonomic impediment. The biodiversity crisis refers to the human-induced global loss of biodiversity, a mass extinction spanning more than 30,000 years ago to the present, with an accelerated rate of species extinction through time (Wilson 1992). The taxonomic impediment refers to the global shortage of taxonomists and reduction in funding for taxonomic research (Godfray 2002). The biodiversity crisis is strongly linked to the taxonomic impediment; even if we had the necessary funds and organizations directed to solving the biodiversity crisis, we still lack the necessary expertise to describe the biodiversity of the planet (Evenhuis 2007) and therefore are unable to monitor changes in diversity of most taxa. Some argue that the impediment could be lessened by erecting a unified taxonomic society with dedicated taxonomic journals, and universal standards for publications and taxonomic research (Dubois 2003). This would be to counter the widespread attitude that species descriptions, identification materials, and other taxonomic observational data are not true science (Dubois 2003). In fact taxonomic research is the key stone of evolutionary, ecological, conservation biology, and all other fields that are dependent on knowing what taxa exist and where. Programs such as the Tree of Life, Encyclopedia of Life, ALL Species Foundation, Species 2000, Universal Biological Indicator Organizer, and Global Biodiversity Information Facility are working towards indexing species and placing taxonomic information online (Norton 2002). The National Science Foundation's Partnerships for Enhancing Expertise in

Taxonomy program is working to promote taxonomic research and improve taxonomic expertise worldwide (Evenhuis 2007).

Of the world's flora and fauna, the groups most inadequately known are typically those with the smallest physical size, such as bacteria, protozoans, fungi, nematodes, insects, and mites (Wilson 2003). Many of the world's smallest organisms are symbiotic on larger organisms, as commensals, mutualists or parasites. Parasitism is considered to be one of the most common life history modes, and only a fraction of parasite species worldwide have been described (Price 1980). The general public, media, and a large number of biologists typically abhor parasites; however, despite the disdain held by many, parasites are major players in the ecological theatre (Marcogliese 2004). Parasites can affect population dynamics of a host species as well as entire communities. They may put energy demands on hosts, increase mortality, or decrease natality, reduce growth of a host, and may alter host behaviour (Marcogliese 2004). Parasites may influence predator-prey interactions as well as interspecific and intraspecific competitive interactions (Price et al. 1986, Marcogliese 2004). They may also influence mate choice and sex ratio (Minchella and Scott 1991).

One of the taxa with the greatest number of parasitic species is mites (Arachnida: Acari). Mites are a hyperdiverse group, second in diversity to insects, and can be found on every continent. There are approximately 48,200 described species of Acari, with an estimated diversity of 500,000 to 1,000,000 species (Walter and Proctor 1999, Halliday et al. 2000). Mites, whether monophyletic or diphyletic, are divided into two major lineages, the Parasitiformes and Acariformes (with the Acariformes being the most diverse) and one small basal lineage, the Opilioacariformes. There are at least 507 described species of Parasitiformes, and 1,409 described species of Acariformes in Canada (Danks 1979). The Parasitiformes is divided into three orders, Mesostigmata, Ixodida, and Holothyrida, with the Mesostigmata being the most diverse (Walter and Proctor 1999). Mesostigmata is represented mainly by vertebrate parasites, insect associates, and free-living predators (Krantz 1978). With about 474 described species, and an estimated 1,437 species of Mesostigmata in Canada, a high proportion of mesostigmatans remain to be discovered (Danks 1979).

Birds are host to a broad diversity of symbiotic animals. Mites are among the most diverse groups of these symbionts, with at least 40 families and approximately 3,000 described species known from avian hosts (Proctor and Owens 2000). Some species are highly detrimental parasites, such as the nasal mite *Sternostoma tracheacolum* Lawrence, 1948 (Mesostigmata: Rhinonyssidae), while others are relatively benign such as most feather mites (Astigmata: Analgoidea, Pterolichoidea, Freyanoidea) (Proctor and Owens 2000). Mites inhabit all parts of the avian integument, and also occupy subdermal and respiratory habitats. Respiratory endoparasitism in vertebrates has independently evolved in nine families of mites from three major lineages (Fain 1994): Rhinonyssidae (Mesostigmata), Ereynetidae (Prostigmata), Cytoditidae and Turbinoptidae (Astigmata) inhabit respiratory passages of birds; Halarachnidae (Mesostigmata), Ereynetidae (Prostigmata), Pneumocoptidae, Lemurnyssidae and Gastronyssidae (Astigmata) are in mammals; Entonyssidae (Prostigmata) is in snakes; and Ereynetidae (Prostigmata) in amphibians.

There are at least 500 described species of avian nasal mites worldwide (Fain 1994), and the most diverse group of these mites are mesostigmatans of the family

Rhinonyssidae, which are obligate hematophagous 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), which are blood feeding parasites that first evolved as bat parasites 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 single host families, and others found in hosts from different orders (Pence 1973). In North America, passeriform, caprimulgiform, falconiform, and apodiform host species are parasitized by *Ptilonyssus* species. *Sternostoma* species parasitize passeriform, piciform, and charadriiform birds. *Rhinonyssus* species parasitize anseriform, podicipediform, and charadriiform birds. Ciconiiform and columbiform birds are parasitized by *Tinaminyssus* species. Owls (Strigiformes) are parasitized by *Rhinoecius* species; generally each *Rhinoecius* species occurs in a different species of owl. Birds of the family Rallidae are parasitized by *Rallinyssus* species. *Larinyssus* species parasitize gulls and terns (Laridae). Rhinonyssids are slow moving sluggish mites which occur predominately 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 rhinonyssids are not considered to cause significant pathology to a host individual. The main exception is *Sternostoma tracheacolum* which invades the lower respiratory tract, lungs, and air sacs of a host (Stephan et al. 1950). Including captive and wild records this mite has been reported from 37 species, 32 genera and 11 families of birds (Bell

1996). Captive birds are reported to experience more severe pathology than wild birds (Fain and Hyland 1962). *Sternostoma tracheacolum* infestations have been reported to cause inflammation leading to aerocystitis, tracheitis, pneumonia, and occasionally death of the host (Stephan et al. 1950). The decline of the endangered Gouldian Finch, *Erythrura gouldiae* (Gould, 1844), has been considered (Tidemann et al. 1992) to possibly be the result of *S. tracheacolum* infesting wild birds from finches originally held in captivity.

Other taxa of avian nasal mites are much less diverse than the Rhinonyssidae. Speleognathinae (Ereynetidae) are tissue feeding intranasal parasites of birds and mammals worldwide (Akimov et al. 2003). Only four genera of speleognathines are known from birds in North America. 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 considered to cause any significant pathology to host individuals.

Turbinoptids are obligate tissue feeding parasites, eating the corneous layers of the skin in the anteriormost portion of the nasal cavity (Fain 1994). Only four genera of turbinoptids are known from birds in North America; *Turbinoptes, Colinoptes, Schoutedenocoptes,* and *Congocoptes* (Pence 1973). These are small, sluggish mites that are not collected frequently but often occur in large numbers (Porter and Strandtmann 1952). In North America *Turbinoptes* is represented by a single cosmopolitan species *T. strandtmanni* Boyd, 1949 which parasitizes charadriiform birds (Pence 1973). *Colinoptes* is represented by the single species *C. cubanensis* Fain, 1960 known from a single galliform host species *Colinus virginianus* (Linnaeus, 1758). *Schoutedenocoptes* is represented by the single species *S. americanus* Fain and Hyland, 1967 collected from cuculiform birds. *Congocoptes* is represented by several species parasitizing piciform birds (Pence 1973). Turbinoptids are not known to cause any significant pathology to host individuals.

Cytoditidae is a small family represented by two genera and three species of tissue feeding mites in North America. *Cytonyssus troglodyti* Pence, 1972, and *Cytodites therae* Hyland, 1969 have been collected from the nasal passages of troglodytid and cuculiform birds, respectively (Pence 1973). *Cytodites nudus* (Vizioli, 1870) feeds on host exudates in the lungs and air sacs of galliform hosts, occasionally causing chronic inflammation (Fain 1960, Fain and Hyland 1962).

Nasal mites have been surveyed throughout the world, including Taiwan, Australia, Louisiana, Guatemala, and Texas, with variable yet high prevalence values ranging from 16% to 25% of host individuals examined (Hyland 1963, Maa and Kuo 1965, Domrow 1969, Pence 1973, Spicer 1984, Spicer 1987). There has never been a Canadian survey. There are only four published, and three unpublished species records from birds in Canada. It is important to know the identity and distribution of species parasitizing birds of Canada and surrounding areas. An understanding of host-parasite species records is required to accurately model biodiversity losses as a result of coextinction (Koh et al. 2004). The two principal objectives of this thesis are to identify the species of nasal mites that occur in western Canada, and to determine how the diversity here compares to similar studies in North America. In Chapter 2 I present the findings from my survey of nasal mites from birds of Alberta and Manitoba, including the host species examined, mite species found, prevalence values, host-mite species records, as well as a comparison of the effectiveness of different collection techniques. During the survey one new species of *Dermanyssus*, Dugés, 1834 (Mesostigmata: Dermanyssidae), an ectoparasitic nest dwelling mite, and five new species of Rhinonyssidae were collected. In Chapter 3 I illustrate and describe these new species. During the survey I became aware of the need for a computer-based interactive key to rhinonyssids of Canada. In Chapter 4 I provide a Lucid key, as well as HTML-based and hard copy dichotomous keys to Canadian rhinonyssids. The presence of northern fowl mite, *Ornithonyssus sylviarum* (Canestrini and Fanzago, 1877) (Mesostigmata: Macronyssidae) was also recorded during this survey, and in Chapter 5 I provide an updated host list for the northern fowl mite in North America, including the new records from Alberta. Having established host records in place will give others the ability to recognize species invasions, and allow others to evaluate the potential role of these mites in avian disease. This research provides the fundamental basis for all work to follow on avian nasal mites in Canada, and without it subsequent researchers would not be able to answer ecological, evolutionary, and parasitological questions about these diverse yet understudied mites.

Literature cited

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

Bell, P.J. 1996. 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.

Danks, H.V. (Ed.). 1979. Canada and its insect fauna. Memoirs of the Entomological Society of Canada **108**: 573 p.

De-Rojas, M., M.D. Mora, J.M. Ubeda, C. Cutillas, M. Navajas, and D.C. Guevara. 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.

Dubois, A. 2003. The relationships between taxonomy and conservation biology in the century of extinctions. Comptes Rendus Biologies **326**: S9-S21.

Evenhuis, N.L. 2007. Helping solve the "other" taxonomic impediment: completing the eight steps to total enlightenment and taxonomic nirvana. Zootaxa **1407**: 3-12.

Fain, A. 1960. Revision du genre *Cytodites* (Megnin) et description de deux especes 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.

Godfray, H.C.J. 2002. Challenges for taxonomy. Nature **417**: 17-19.

Halliday, R.B., B.M. OConnor, and A.S. Baker. 2000. Global diversity of mites. *In* Nature and human society - the quest for a sustainable world, P. H. Raven (ed.). National Academy Press, Washington, D.C., p. 192-203.

Hyland, K.E. 1963. Current trends in the systematics of acarines endoparasitic in vertebrates. *In* Advances in acarology, J.A. Naegele (ed.). Comstock Publishing Associates, Ithaca, New York, p. 365-373.

Koh, L.P., R.R. Dunn, N.S. Sodhi, R.K. Colwell, H.C. Proctor, and V.S. Smith. 2004. Species coextinctions and the biodiversity crisis. Science **305**: 1632-1634.

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

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

Marcogliese, D.J. 2004. Parasites: small players with crucial roles in the ecological theater. EcoHealth **1**: 151-164.

Minchella, D.J. and M.E. Scott. 1991. Parasitism: a cryptic determinant of animal community structure. Trends in Ecology & Evolution **6**: 250-254.

Norton, G. 2002. Multi-media/internet keys and the taxonomic crisis. Antenna **26**: 245-248.

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

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

Price, P.W. 1980. Evolutionary biology of parasites. Princeton University Press, Princeton, New Jersey.

Price, P.W., M. Westoby, B. Rice, P.R. Atsatt, R.S. Fritz, J.N. Thompson, and K. Mobley. 1986. Parasite mediation in ecological interactions. Annual Review of Ecology and Systematics **17**: 487-505.

Proctor, H.C., and I. Owens. 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, K.C. Kim (ed.). John Wiley, New York, New York, p. 441-504.

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., V.R. Kaschula, and F.S. Canham. 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.

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

Walter, D.E., and H.C. Proctor. 1999. Mites: Ecology, Evolution, and Behaviour. CAB International Publishing, New York, NY, USA. pp. 230-231.

Wilson, E.O. 1992. The diversity of life. Harvard University Press, Cambridge, Massachusetts.

Wilson, E.O. 2003. The future of life. Vintage Books, New York, New York.

Chapter 2

Survey of Nasal Mites (Rhinonyssidae, Ereynetidae, and Turbinoptidae) Associated with Birds of Alberta and Manitoba.

Introduction

Birds are host to a broad array of symbiotic animals. Mites are among the most diverse groups of these symbionts, with at least 40 families and approximately 3,000 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 the host's respiratory passages.

There are at least 500 described species of avian nasal mites worldwide (Fain 1994), and the most diverse group of these mites are mesostigmatans of the family Rhinonyssidae, which are obligate hematophagous 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), which are blood feeding parasites that first evolved as bat parasites 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 single host families, and others found in hosts from different orders (Pence 1973). In North America, passeriform, caprimulgiform, falconiform, and apodiform host species are parasitized by *Ptilonyssus* species. *Sternostoma* species parasitize passeriform, piciform, and charadriiform birds. *Rhinonyssus* species parasitize anseriform, podicipediform, and charadriiform birds. Ciconiiform and columbiform birds are parasitized by *Tinaminyssus* species. Owls (Strigiformes) are parasitized by *Rhinoecius* species; generally each *Rhinoecius* species occurs in a different species of owl. Birds of the family Rallidae are parasitized by *Rallinyssus* species. *Larinyssus* species parasitize gulls and terns (Laridae). Rhinonyssids are slow moving sluggish mites which occur predominately 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 rhinonyssids are not considered to cause significant pathology to a host individual. The main exception is *Sternostoma tracheacolum* Lawrence, 1948 which invades the lower respiratory tract, lungs, and air sacs of a host (Stephan et al. 1950). Including captive and wild records this mite has been reported from 37 species, 32 genera and 11 families of birds (Bell 1996a). Captive birds are reported to experience more severe pathology than wild birds (Fain and Hyland 1962). *Sternostoma tracheacolum* infestations have been reported to cause inflammation leading to aerocystitis, tracheitis, pneumonia, and occasionally death of the host (Stephan et al. 1950). The decline of the endangered Gouldian Finch, *Erythrura gouldiae* (Gould, 1844), has been considered (Tidemann et al. 1992) to possibly be the result of *S. tracheacolum* infesting wild birds from finches originally held in captivity.

Other taxa of avian nasal mites are much less diverse than the Rhinonyssidae. Speleognathinae (Ereynetidae) are tissue feeding intranasal parasites of birds and mammals worldwide (Akimov et al. 2003). Only four genera of speleognathines are known from birds in North America. 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 considered to cause any significant pathology to host individuals.

Within the Astigmata, members of the family Turbinoptidae are obligate tissue feeding parasites, eating the corneous layers of the skin in the anteriormost portion of the nasal cavity (Fain 1994). Only four genera of turbinoptids are known from birds in North America; *Turbinoptes, Colinoptes, Schoutedenocoptes,* and *Congocoptes* (Pence 1973). These small, sluggish mites are not collected frequently but often occur in large numbers (Porter and Strandtmann 1952). In North America *Turbinoptes* is represented by a single cosmopolitan species *T. strandtmanni* Boyd, 1949 which parasitizes charadriiform birds (Pence 1973). *Colinoptes* is represented by the single species *C. cubanensis* Fain, 1960 known from a single galliform host species *Colinus virginianus* (Linnaeus, 1758). *Schoutedenocoptes* is represented by the single species *S. americanus* Fain and Hyland, 1967 collected from cuculiform birds. *Congocoptes* is represented by several species parasitizing piciform birds (Pence 1973). Turbinoptids are not known to cause any significant pathology to host individuals.

The astigmatan family Cytoditidae is a small group represented by two genera and three species of tissue feeding mites in North America. *Cytonyssus troglodyti* Pence, 1972, and *Cytodites therae* Hyland, 1969 have been collected from the nasal passages of troglodytid and cuculiform birds, respectively (Pence 1973). *Cytodites nudus* (Vizioli, 1870) feeds on host exudates 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 worldwide, including Taiwan, Australia, Louisiana, Guatemala, and Texas, with variable yet high prevalence values ranging from 16% to 25% of host individuals examined (Hyland 1963, Maa and Kuo 1965, Domrow 1969, Pence 1973, Spicer 1984, Spicer 1987). There has never been a Canadian survey. Canadian records include only four published species records: *Rhinonyssus* sp. from the Guillemot, *Uria aalge* (Ballard and Ring 1979), *Sternostoma tracheacolum* from the Red-winged Blackbird, *Agelaius phoeniceus* (Hood and Welch 1980), *Ptilonyssus japuibensis* Castro, 1948 from the Chipping Sparrow, *Spizella passerina* (Pence 1975), and *Ptilonyssus sairae* Castro, 1948 from the Chipping Sparrow, *S. passerina* (George 1961). In addition to these, there are three unpublished species records from specimens deposited in the Canadian National Collection of Insects and Arachnids (CNCI&A) in Ottawa: *Ptilonyssus bombycillae* Fain, 1972 from the Bohemian Waxwing, *Bombycilla garrulus*, *Rhinonyssus coniventris* Trouessart, 1894 from the Red Knot, *Calidris canutus*, and *Sternostoma boydi* Strandtmann, 1951 from the Ruddy Turnstone, *Arenaria interpres*. Canada has a diverse and abundant avian fauna, and it is important to know the identity and distribution of species parasitizing birds of Canada and surrounding areas. Having established host records in place will give us the ability to recognize new species invasions, and allow us to evaluate the potential role of nasal mites in avian disease. This survey provides the fundamental foundation for all subsequent nasal mite work in Canada. Herein I present the findings from a survey of nasal mites associated with Canadian birds, focusing on hosts from Alberta and Manitoba.

Materials and Methods

The laboratory of Heather Proctor at the University of Alberta had a collection of approximately 700 bird carcasses from Alberta, largely from the contributions of the Alberta Fish & 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, and for some I can only say that the birds were collected somewhere in Alberta. Host taxonomy and authorities follow Clements (1991) provided by Andrew and McAllan (1998), selecting the 'Clements 1991-1996' taxonomy option in Nomina version 1.0. Bird bodies were maintained at -20°C until processing. Frozen birds were first thawed and then washed using the following method. The bird was placed in a suitably sized container, ranging from 4-18 L, with a drop of dish detergent, enough 95% ethanol to soak the plumage of the bird, and enough water to submerge it. The sealed container was then shaken vigorously for five minutes. 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 filter; 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 filter. The material remaining in the filter was stored in 30 ml snap cap and scintillation vials in 95% ethanol.

Mites were also collected from some individual 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 table top drill press vice. Depending on bird size, I used a scalpel, molybdenum steel scissors, or molybdenum steel bone shears to sagittally section the head and expose the nasal cavities. The dissected halves were placed in appropriately sized vials and stored at -20°C until inspection. For inspection I placed the dissected heads in a glass dish with 80% ethanol and examined the tissues using a dissecting stereomicroscope. To assay the effectiveness of washing compared to dissection for nasal mite retrieval, nine Bohemian Waxwings, *Bombycilla garrulus* (Linnaeus, 1758), nine Common Redpolls, *Carduelis flammea* (Linnaeus, 1758), and nine American Robins, *Turdus migratorius* Linnaeus, 1766 were washed and then dissected.

I also received many nasal mite samples from Dr. Terry Galloway's lab at the University of Manitoba. Galloway's lab performed nasal flushings on Manitoban birds 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 in the Manitoba lab 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 filter.

I examined washings and dissections using Leica MZ16 and MZ6 dissecting microscopes at 20-25x magnification. Mites were removed from ethanol and cleared in 85% lactic acid for 1-24 hours depending on the degree of original opacity. Mites were mounted in a polyvinyl alcohol medium (6371A, BioQuip Products, Rancho Dominguez, CA). Slides were cured on a slide warmer at about 40°C for 3-4 days. I examined slide mounted specimens on a Leica DMLB compound microscope with differential interference contrast (DIC) at 400x magnification. Species level identifications were made using keys (Pence 1975) and species descriptions from the primary literature. A species accumulation curve based upon the Alberta data was made using EstimateS 8.00 (http://viceroy.eeb.uconn.edu/EstimateS).

Results

I examined 450 individual birds from Alberta, representing 16 orders, 41 families, 103 genera and 154 species (Table 2.1). Approximately one-half of the bird taxa examined were members of the Passeriformes (55 genera, 77 species). The orders Charadriiformes, Anseriformes, and Falconiformes had the second-most genera and species examined (Table 2.1). I examined 125 of the 138 Manitoban samples; 114 had nasal mites, and Manitoban hosts represented seven orders, 18 families, 49 genera and 57 species (Table 2.2). Dr. Dan McLaughlin (Concordia University) sent 12 heads representing 4 species of waterfowl collected at Delta Marsh, Manitoba. Nasal washings from these 12 heads yielded a single speleognathine. Together from Alberta and Manitoba I examined 172 bird species for nasal mites (Appendix 2.1), representing 26% of Canada's 665 bird species (Lepage 2007).

Fifty-six species of nasal mites were identified from this material (Table 2.3). Most species were in the family Rhinonyssidae (48 species), and within this the genus *Ptilonyssus* was the most diverse (26 species). Most infected host individuals had a single species of nasal mite, with the exception of a few hosts which had more than one species of nasal mite. Keys only provide species level identifications for female specimens; thus in instances where only male or juvenile specimens were collected from a host only genus level identifications could be made. In Alberta, a Black-headed Grosbeak, *Pheucticus melanocephalus*, had a single male rhinonyssid which was identified as *Ptilonyssus* sp. In North America only *P. sairae* has been reported from Black-headed Grosbeaks (Pence and Casto 1976a), but the male mite collected in Alberta was definitely not *P. sairae*; thus, I treated this as a potential new species record for Canada. In Manitoba, an Eastern Kingbird, *Tyrannus tyrannus*, had *Ptilonyssus* sp. nymphs, which I treated as a potential new species record due to the fact that only *P. spinosus* has been recorded from this host species (Pence 1975). Lastly, a Grey-cheeked Thrush, *Catharus minimus*, from Manitoba had nymphal *Sternostoma* sp., which I also treated as a potential new record since Pence (1975) collected *S. hutsoni* and *S. spatulatum* from *Catharus* species.

In Alberta, 15% of 450 individual birds, and 28% of 154 host species examined, had nasal mites. Of 450 individuals examined, one Long-eared Owl, *Asio otus* (Linnaeus, 1758) had two species of nasal mites, *Rhinoecius brikinboricus* Butenko, 1976 (Rhinonyssidae) and *Neoboydaia colymbiformi* Clark, 1964 (Ereynetidae), representing 0.2% of examined hosts or 1.5% of infected birds. In Manitoba, of 114 samples with nasal mites, four (3.5%) had two species of rhinonyssids (a Rock Dove, *Columba livia* Gmelin, 1789 had *Tinaminyssus melloi* (Castro, 1948) and *T. columbae* (Crossley, 1950), a Snow Bunting, *Plectrophenax nivalis* Linnaeus, 1758 had *Ptilonyssus morofskyi* Hyland, 1962 and *Ptilonyssus nivalis* sp. n., a Great Crested Flycatcher, *Myiarchus crinitus* (Linnaeus, 1758) had *Ptilonyssus callinectoides* (Brooks and Strandtmann, 1969) and *Ptilonyssus icteridius* (Strandtmann and Furman, 1956), and an Eastern Kingbird, *Tyrannus tyrannus* (Linnaeus, 1758) had *Sternostoma longisetosae* Hyland, 1961 and *Ptilonyssus* sp. Berlese and Trouessart, 1889) and three of these samples (2.6%) had two congeneric species. In Alberta a total of 359 rhinonyssid individuals were recovered from 59 birds, 11 speleognathines from six birds, and 142 turbinoptids from two birds. Of the 321 rhinonyssids from Alberta that were slide mounted and identifiable to life stage, there were 187 females, 67 males, 11 deutonymphs, 48 protonymphs, and 8 larvae. The rhinonyssid sex ratio was significantly female biased, with 187 females to 67 males ($X^2 = 56.69$, $P < 0.001$, $df = 1$), as seen in the literature (Bell 1996b). The number of nasal mites collected from an infected host in Alberta varied from 1-43 in the Rhinonyssidae and 14-128 in the Turbinoptidae. I did not recover any Cytoditidae.

In Alberta and Manitoba there were 97 host-parasite species records for rhinonyssids, with 41 of these being new records for North America (Appendix 2.2), and all but one of them being new for Canada (the CNCI&A has *Ptilonyssus bombycillae* previously collected from *Bombycilla garrulus* (Linnaeus, 1758) in Canada). For the passerines, 42% of host-parasite species records were new records for North America, but the greatest proportion of new records was in the Strigiformes with 88% novel records. In Alberta, rhinonyssids were recovered from 13% of 450 individual birds and 23% of 154 host species examined. Prevalence per host species was highly variable (Appendix 2.2): for Manitoba the total counts of individuals examined was unknown, thus, prevalence values could not be calculated. Two Manitoba records are likely a result of laboratory contamination: *Ptilonyssus icteridius*, normally restricted to the Icteridae, from a Sora Rail, *Porzana carolina* (Linnaeus, 1758) and *Tinaminyssus melloi*, normally restricted to pigeons (Columbidae) from a House Sparrow, *Passer domesticus* (Linnaeus, 1758).

I used the program EstimateS 8.00 to randomly resample and plot number of bird species examined in Alberta and number of rhinonyssid species found (Fig. 2.1). The observed trend line was extrapolated to estimate the total number of rhinonyssid species in Canada. Since there are approximately 665 bird species in Canada (Lepage 2007), I estimate at least 75 species of rhinonyssids are in the country.

In Alberta and Manitoba, speleognathines were collected from seven host species representing five avian orders. Of the seven host-parasite species records, three are new for North America (Appendix 2.3), and all seven 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 a single species, *Turbinoptes strandtmanni* Boyd, 1949, collected from two host species in Alberta: California Gull, *Larus californicus* Lawrence, 1854, and Ring-billed gull, *L. delawarensis* Ord, 1815. *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*.

Twenty-seven birds, nine each of Bohemian Waxwings, *Bombycilla garrulus*, Common Redpolls, *Carduelis flammea*, and American Robins, *Turdus migratorius* were washed and then dissected to estimate the effectiveness of nasal mite retrieval from bird washings compared to actual dissections (Appendix 2.4). It would appear that washing is just as effective as dissection for the Bohemian Waxwings and American Robins. For the Common Redpolls, many additional mites were collected during dissection following washing. During dissections I observed that Common Redpolls had markedly more folded tissue in the anterior-most portion of their nasal cavities, than did either the Bohemian Waxwings or American Robins.

Discussion

Nasal mites have been known to the scientific community ever since Berlese and Trouessart described the genus *Ptilonyssus* and the type species *P. echinatus* in 1889. Only a fraction of Canada's avian-associated parasitic arthropod fauna is known. Wheeler and Threlfall (1989) estimated that there are 6000-7000 species of avian-associated Acari in Canada, which does appear to be an overestimate, yet only a small fraction of that diversity has been surveyed. Although the present study has greatly expanded the number of bird species examined for nasal mites, only 38% of Alberta's 402 bird species were examined (based on list from the Royal Alberta Museum 2005), and in total from Manitoba and Alberta, only 26% of Canada's 665 bird species (Lepage 2007) were examined for nasal mites. Clearly, a great number of potential host species remain to be examined in Canada.

Prior to this study only seven species of nasal mites were known from Canada. Herein I have expanded the known number of nasal mite species from Canada by eight times to 58 species. Nasal mite prevalence values at the levels of host individuals (13% of 450) and host species (23% of 154) in Alberta are somewhat lower than those reported in other studies. Pence (1973) found that 16% of 1,927 birds and 48% of 193 species of birds from 24 states in the USA had nasal mites. Spicer (1987) reported that 17% of 502 individuals and 39% of 103 species of Texan birds had nasal mites. Nasal mites appear to have relatively high prevalences considering that approximately one-third of parasitic helminth species associated with birds and mammals have 5% prevalence in most host populations (Poulin 1998).

Instances in which a single host individual has more than one species of nasal mite present are rare, and cases where two closely related species of the same genus are present are very rare. Spicer (1987) observed a single case in which a host individual had two species of rhinonyssids, of separate genera; representing 1% of infected birds, and 0.2% of examined birds. Butenko and Stanyukovich (1999) reported that only 0.3% of the Mallards, *Anas platyrhynchos*, Linnaeus, 1758, they examined had two closely related species of rhinonyssids. In the present study multiple species infestations were also rare. In Manitoba, the observed frequency of multiple species infestations (3.5%) is higher than anything published.

As seen in similar studies (Pence 1973, Spicer 1987), rhinonyssids were the most commonly collected nasal mites. Lindquist (1979) estimated there to be 50 species of rhinonyssids in Canada. I believe there are many more than 50 species in Canada since I found 48 species from Alberta and Manitoba, and the species accumulation curve estimated at least 75 species in Canada. Nearly half of the rhinonyssid host-parasite species records were new for North America, with the greatest proportion of new records in the Strigiformes. The rhinonyssid host-parasite species records reported in this study expands the known Canadian records by 14 times. The greatest proportion of new records for North America are for owls. Six *Rhinoecius* species were collected from owls in Canada, which is one more species than Pence (1973) hypothesized there to be in North America. In the present study *Sternostoma tracheacolum* was collected from a Black and White Warbler, *Mniotilta varia* (Linnaeus, 1766), and in the literature it has being reported from the Red-winged Blackbird, *Agelaius phoeniceus* (Hood and Welch 1980); thus, this rhinonyssid species is now known to occur in two host species in

Canada. Given that this species can cause serious pathology to its hosts, it is important to know the host distribution of *S. tracheacolum* in Canada.

Speleognathine ereynetids were relatively rare, and occurred in low numbers. *Neoboydaia colymbiformi* has been reported from the Eared Grebe, *Podiceps nigricollis* Brehm, 1831 and the Pied-billed Grebe, *Podilymbus podiceps* (Linnaeus, 1758) (Pence 1975); however, in this study it was collected from a Long-eared Owl, *Asio otus*. It is possible that this represents a new speleognathine species since 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, as much as 128 mites in a single host.

The effectiveness of nasal mite retrieval from bird washings and nasal flushings compared to actual dissections differed among bird species. Bird washings may yield nasal mites just as effectively as dissections, depending upon the nasal cavity structure of a given host species, but further investigation is needed. In the Common Redpoll, the compact folded tissue in the anteromost portion of the nasal cavity may have prevented mites from being dislodged during washing. In Taiwan, when birds were dissected for mites following nasal flushing (Yunker's technique) very few additional mites were collected (Maa and Kuo 1965). Washings take much less time to process and perform than dissections; in addition, some hosts can not be destructively sampled; for them, washing would be more appropriate.

This survey has markedly increased our knowledge of the distribution and diversity of nasal mites in Canada and the rest of North America, bringing attention to a relatively obscure yet diverse group of parasitic mites. These records will enhance our ability to recognize species invasions, and provide additional tools to evaluate the potential role of nasal mites in avian disease. This research provides the basis for all work to follow on these mites in Canada, as it is the necessary precursor for answering ecological, evolutionary, and parasitological questions about these mites.

Literature cited

Andrew, P., and I. McAllan. 1998. Nomina: Global Bird Dictionary, Relational Taxonomies. CSIRO Publishing, Collingwood, Australia.

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

Ballard, J.T., and R.A. Ring. 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. 1996a. 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. 1996b. 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 M.K. Stanyukovich. 1999. The distribution of rhinonyssid mites (Acari, Gamasina, Rhinonyssidae) in the nasal cavities of some anatid birds. Ekologiya **2**: 52-56.

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., M.D. Mora, J.M. Ubeda, C. Cutillas, M. Navajas, and D.C. Guevara. 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 especes 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.

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

Hood, D.E., and H.E. Welch. 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). 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, J.A. Naegele (ed.). Comstock Publishing Associates, Ithaca, New York, p. 365-373.

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

Krivolutsky, D.A., and N.V. Lebedeva. 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. http://www.bsc-eoc.org/avibase/avibase.jsp?region=ca&pg=checklist&list=clements (viewed 5 June 2007).

Lindquist, E.E., with contributions by B.D. Ainscough, F.V. Clulow, R.C. Funk, V.G. Marshall, H.H.J. Nesbitt, B.M. OConnor, I.M. Smith, and P.R. Wilkinson. 1979. Acari, p. 252-290. *In* Canada and its insect fauna, H.V. Danks (ed.). Memoirs of the Entomological Society of Canada **108**: 573 p.

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

Mitchell, R.W., and W.L. Rhodes. 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 Texas Tech University **8**: 1-148.

Pence, D.B., and S.D. Casto. 1976a. 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.

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

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

Poulin, R. 1998. Comparison of three estimators of species richness in parasite component communities. Journal of Parasitology **84**: 485-490.

Proctor, H.C., and I. Owens. 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, K.C. Kim (ed.). John Wiley, New York, New York, p. 441-504.

Royal Alberta Museum. 2005. The Official List of the Birds of Alberta. http://www.royalalbertamuseum.ca/natural/birds/birdlist/taxon.htm (viewed 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., V.R. Kaschula, and F.S. Canham. 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., S. McOrist, J.C.Z. Woinarski, and W.J. Freeland. 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 W. Threlfall. 1989. Synopsis of the parasites of vertebrates of Canada: ectoparasites of birds. Alberta Agriculture, Animal Health Division, Edmonton, Canada, 85 p.

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

Table 2.1. Orders of birds examined for nasal mites in Alberta and the number of host genera and species examined from each order.

Host order	**Number of genera examined**	**Number of species examined**	**Number of families examined**
Anseriformes	6	15	1
Apodiformes	1	1	1
Caprimulgiformes	1	1	1
Charadriiformes	7	12	3
Ciconiiformes	1	1	1
Columbiformes	1	1	1
Coraciiformes	1	1	1
Falconiformes	6	15	2
Galliformes	6	6	1
Gaviiformes	1	2	1
Gruiformes	3	3	2
Passeriformes	55	77	21
Pelecaniformes	2	2	2
Piciformes	4	6	1
Podicipediformes	2	3	1
Strigiformes	6	8	1

Table 2.2. Orders of birds from Manitoba with nasal mites, and the number of host genera and species with mites from each order.

Host order	**Number of genera with mites**	**Number of species with mites**	**Number of families with mites**
Anseriformes	5	5	1
Columbiformes	2	2	1
Falconiformes	1	1	1
Gruiformes	2	2	1
Passeriformes	32	40	12
Piciformes	3	3	1
Strigiformes	4	4	1

Table 2.3. Orders, suborders, families, and species of nasal mites found in association with birds of Alberta and Manitoba.

Mite order; suborder	Mite family	Mite species	Authority	Province
Mesostigmata; Monogynaspida	Rhinonyssidae			
		Ptilonyssus acrocephali	Fain, 1964	MB
		Ptilonyssus angrensis	(Castro, 1948)	MB
		Ptilonyssus bombycillae	Fain, 1972	AB
		Ptilonyssus callinectoides	(Brooks and Strandtmann, 1969)	MB
		Ptilonyssus calvaria sp. n.		AB, MB
		Ptilonyssus carduelis	Fain, 1962	AB, MB
		Ptilonyssus cerchneis	Fain, 1957	MB
		Ptilonyssus coccothraustis	Fain and Bafort, 1963	AB, MB
		Ptilonyssus echinatus	Berlese & Trouessart, 1889	AB, MB
		Ptilonyssus euroturdi	Fain & Hyland, 1963	AB
		Ptilonyssus hirsti	(Castro & Periera, 1947)	MB
		Ptilonyssus icteridius	(Strandtmann and Furman, 1956)	AB, MB
		Ptilonyssus japuibensis	Castro, 1948	AB, MB
		Ptilonyssus morofskyi	Hyland, 1962	AB, MB
		Ptilonyssus nivalis sp. n.		MB
		Ptilonyssus nudus	Berlese & Trouessart, 1889	MB
		Ptilonyssus perisorei	George, 1961	AB
		Ptilonyssus pinicola sp. n.		AB, MB
		Ptilonyssus pirangae	(Cerny, 1969)	AB
		Ptilonyssus plesiotypicus sp. n.		AB
		Ptilonyssus sairae	Castro, 1948	AB, MB
		Ptilonyssus sp.	Berlese and Trouessart, 1889	AB
		Ptilonyssus sp.	Berlese and Trouessart, 1889	MB
		Ptilonyssus troglodytis	Fain, 1964	AB
		Ptilonyssus tyrannus	(Brooks and Strandtmann, 1960)	AB, MB

Table 2.3. continued.

Mite order; suborder	Mite family	Mite species	Authority	Province
Mesostigmata; Monogynaspida	Rhinonyssidae			
		Ptilonyssus vireonis	(Dusbabek, 1969)	MB
		Rallinyssus caudistigmus	Strandtmann, 1948	MB
		Rhinoecius aegolii	Butenko, 1971	AB, MB
		Rhinoecius alifanovi	Butenko, 1976	MB
		Rhinoecius brikinboricus	Butenko, 1976	AB
		Rhinoecius cooremani	Strandtmann, 1952	AB
		Rhinoecius grandis	Strandtmann, 1952	AB, MB
		Rhinoecius nycteae	Butenko, 1976	MB
		Rhinonyssus rhinolethrum	(Trouessart, 1895)	AB, MB
		Sternostoma cryptorhynchum	Berlese and Trouessart, 1889	AB
		Sternostoma hylandi	Fain and Johnston, 1966	MB
		Sternostoma lanorium	Fain 1956	AB
		Sternostoma longisetosae	Hyland, 1961	MB
		Sternostoma loxiae	Fain, 1965	AB, MB
		Sternostoma porteri	Hyland, 1962	AB, MB
		Sternostoma sialiphilus	Hyland and Ford, 1961	AB
		Sternostoma sp.	Berlese and Trouessart, 1889	MB
		Sternostoma technaui	Vitzthum, 1935	AB
		Sternostoma trachaecolum	Lawrence, 1948	MB
		Sternostoma setifer sp. n.		MB
		Tinaminyssus columbae	(Crossley, 1950)	AB, MB
		Tinaminyssus melloi	(Castro, 1948)	MB
		Tinaminyssus zenaidurae	(Crossley, 1952)	MB
Sarcoptiformes; Astigmata	Turbinoptidae			
		Turbinoptes strandtmanni	Boyd, 1949	AB

Table 2.3. continued.

Mite order; suborder	Mite family	Mite species	Authority	Province
Trombidiformes; Prostigmata	Ereynetidae			
		Boydaia aratingae	Fain, 1963	MB
		Boydaia faini	Cerny and Dusbabek, 1969	AB
		Boydaia psalidoprocnei	Fain, 1956	AB
		Boydaia sp.	Womersley, 1953	AB
		Boydaia sturni	(Boyd, 1948)	AB
		Neoboydaia colymbiformi	Clark, 1964	AB
		Neoboydaia sp.	Fain, 1958	AB

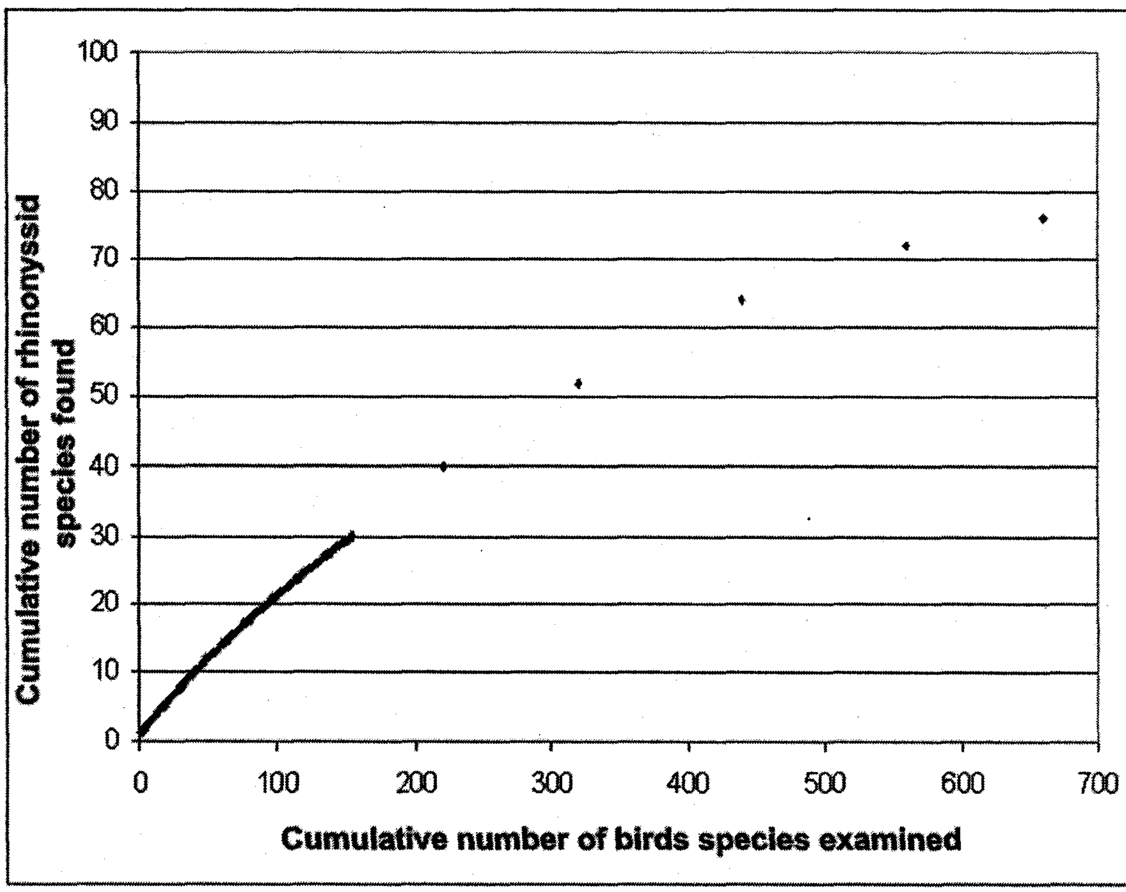


Figure 2.1. Species accumulation curve for the number of bird species examined and rhinonyssid species found in Alberta. Continuous data series is randomized and resampled actual data for Alberta, dots are the projected estimate for Canada.

Appendix 2.1. Orders, families, and species of birds examined for nasal mites in Alberta and Manitoba.

Host order	Host family	Host genus	Host species	Authority
Anseriformes	Anatidae	*Aix*	*sponsa*	(Linnaeus, 1758)
		Anas	*americana*	Gmelin, 1789
		A.	*clypeata*	Linnaeus, 1758
		A.	*crecca*	Linnaeus, 1758
		A.	*discors*	Linnaeus, 1766
		A.	*platyrhynchos*	Linnaeus, 1758
		A.	*strepera*	Linnaeus, 1758
		Anser	*rossii*	Cassin, 1861
		Aythya	*affinis*	(Eyton, 1838)
		A.	*americana*	(Eyton, 1838)
		A.	sp.	Boie, 1822
		A.	*valisineria*	(Wilson, 1814)
		Branta	*canadensis*	(Linnaeus, 1758)
		Bucephala	*albeola*	(Linnaeus, 1758)
		B.	*clangula*	(Linnaeus, 1758)
		Cygnus	*buccinator*	Richardson, 1831
		C.	*columbianus*	(Ord, 1815)
		Mergus	*merganser*	Linnaeus, 1758
		Oxyura	*jamaicensis*	(Gmelin, 1789)
Apodiformes	Trochilidae	*Archilochus*	*colubris*	(Linnaeus, 1758)
Caprimulgiformes	Caprimulgidae	*Chordeiles*	*minor*	(Forster, 1771)
Charadriiformes	Charadriidae	*Charadrius*	*vociferus*	Linnaeus, 1758
		Pluvialis	*squatarola*	(Linnaeus, 1758)
	Laridae	*Chlidonias*	*niger*	(Linnaeus, 1758)
		Larus	*argentatus*	Pontoppidan, 1763
		L.	*californicus*	Lawrence, 1854
		L.	*delawarensis*	Ord, 1815
		L.	*pipixcan*	Wagler, 1831
		Sterna	*forsteri*	Nuttall, 1834
		S.	*hirundo*	Linnaeus, 1758
	Scolopacidae	*Gallinago*	*gallinago*	(Linnaeus, 1758)
		Tringa	*flavipes*	(Gmelin, 1789)
		T.	*melanoleuca*	(Gmelin, 1789)
		T.	*solitaria*	Wilson, 1813
Ciconiiformes	Ardeidae	*Ardea*	*herodias*	Linnaeus, 1758
Columbiformes	Columbidae	*Columba*	*livia*	Gmelin, 1789
		Zenaida	*macroura*	(Linnaeus, 1758)
Coraciiformes	Alcedinidae	*Megaceryle*	*alcyon*	(Linnaeus, 1758)
Falconiformes	Accipitridae	*Accipiter*	*cooperii*	(Bonaparte, 1828)
		A.	*gentilis*	(Linnaeus, 1758)
		A.	*striatus*	Vieillot, 1808
		Aquila	*chrysaetos*	(Linnaeus, 1758)
		Buteo	*jamaicensis*	(Gmelin, 1788)
		B.	*lagopus*	(Pontoppidan, 1763)
		B.	*platypterus*	(Vieillot, 1823)
		B.	*regalis*	(Gray, 1844)
		B.	*swainsoni*	Bonaparte, 1838

Appendix 2.1. continued.

Host order	Host family	Host genus	Host species	Authority
Falconiformes	Accipitridae	*Haliaeetus*	*leucocephalus*	(Linnaeus, 1766)
		Pandion	*haliaetus*	(Linnaeus, 1758)
	Falconidae	*Falco*	*columbarius*	Linnaeus, 1758
		F.	*mexicanus*	Schlegel, 1850
		F.	*peregrinus*	Tunstall, 1771
		F.	*sparverius*	Linnaeus, 1758
Galliformes	Phasianidae	*Alectoris*	*sp.*	Kaup, 1829
		Bonasa	*umbellus*	(Linnaeus, 1766)
		Dendragapus	*canadensis*	(Linnaeus, 1758)
		Perdix	*perdix*	(Linnaeus, 1758)
		Phasianus	*colchicus*	Linnaeus, 1758
		Tympanuchus	*phasianellus*	(Linnaeus, 1758)
Gaviiformes	Gaviidae	*Gavia*	*immer*	(Brunnich, 1764)
		G.	*pacifica*	(Lawrence, 1858)
Gruiformes	Gruidae	*Grus*	*canadensis*	(Linnaeus, 1758)
	Rallidae	*Fulica*	*americana*	Gmelin, 1789
		Porzana	*carolina*	(Linnaeus, 1758)
Passeriformes	Alaudidae	*Eremophila*	*alpestris*	(Linnaeus, 1758)
	Bombycillidae	*Bombycilla*	*cedrorum*	Vieillot, 1808
		B.	*garrulus*	(Linnaeus, 1758)
	Certhiidae	*Certhia*	*americana*	Bonaparte, 1838
	Corvidae	*Corvus*	*brachyrhynchos*	Brehm, 1822
		C.	*corax*	Linnaeus, 1758
		Cyanocitta	*cristata*	(Linnaeus, 1758)
		Perisoreus	*canadensis*	(Linnaeus, 1766)
		Pica	*hudsonia*	(Sabine, 1823)
	Emberizidae	*Ammodramus*	*leconteii*	(Audubon, 1844)
		Junco	*hyemalis*	(Linnaeus, 1758)
		Melospiza	*lincolnii*	(Audubon, 1834)
		Passerculus	*sandwichensis*	(Gmelin, 1789)
		Passerella	*iliaca*	(Merrem, 1786)
		Pheucticus	*ludovicianus*	(Linnaeus, 1766)
		P.	*melanocephalus*	(Swainson, 1827)
		Piranga	*ludoviciana*	(Wilson, 1811)
		Plectrophenax	*nivalis*	Linnaeus, 1758
		Spizella	*arborea*	(Wilson, 1810)
		S.	*pallida*	(Swainson, 1832)
		S.	*passerina*	Bechstein, 1798
		Zonotrichia	*albicollis*	(Gmelin, 1789)
		Z.	*leucophrys*	(Forster, 1772)
	Fringillidae	*Carduelis*	*flammea*	(Linnaeus, 1758)
		C.	*hornemanni*	(Holboll, 1843)
		C.	*pinus*	(Wilson, 1810)
		C.	*tristis*	(Linnaeus, 1758)
		Carpodacus	*mexicanus*	(Muller, 1776)
		C.	*purpureus*	Gmelin, 1789
		Coccothraustes	*vespertinus*	(Cooper, 1825)
		Loxia	*curvirostra*	Linnaeus, 1758

Appendix 2.1. continued.

Host order	Host family	Host genus	Host species	Authority
Passeriformes	Fringillidae	*Loxia*	*leucoptera*	Gmelin, 1789
		Pinicola	*enucleator*	Linnaeus, 1758
	Hirundinidae	*Hirundo*	*rustica*	Linnaeus, 1758
		Petrochelidon	*pyrrhonota*	(Vieillot, 1817)
		Progne	*subis*	(Linnaeus, 1758)
		Riparia	*riparia*	(Linnaeus, 1758)
		Tachycineta	*bicolor*	(Vieillot, 1808)
	Icteridae	*Agelaius*	*phoeniceus*	(Linnaeus, 1766)
		Euphagus	*carolinus*	(Muller, 1776)
		E.	*cyanocephalus*	(Wagler, 1829)
		Icterus	*galbula*	(Linnaeus, 1758)
		Molothrus	*ater*	(Boddaert, 1783)
		Quiscalus	*quiscula*	(Linnaeus, 1758)
		Sturnella	*neglecta*	Audubon, 1844
	Laniidae	*Lanius*	*excubitor*	Linnaeus, 1758
	Mimidae	*Dumetella*	*carolinensis*	(Linnaeus, 1766)
	Paridae	*Parus*	*atricapillus*	(Linnaeus, 1766)
		P.	*hudsonicus*	(Forster, 1772)
	Parulidae	*Dendroica*	*coronata*	(Linnaeus, 1766)
		D.	*magnolia*	(Wilson, 1811)
		D.	*petechia*	(Linnaeus, 1766)
		D.	*pinus*	(Wilson, 1811)
		D.	*striata*	(Forster, 1772)
		D.	*tigrina*	(Gmelin, 1789)
		Geothlypis	*trichas*	(Linnaeus, 1766)
		Mniotilta	*varia*	(Linnaeus, 1766)
		Oporornis	*agilis*	(Wilson, 1812)
		O.	*philadelphia*	(Wilson, 1810)
		Seiurus	*aurocapillus*	(Linnaeus, 1766)
		S.	*noveboracensis*	(Gmelin, 1789)
		Setophaga	*ruticilla*	(Linnaeus, 1758)
		Vermivora	*celata*	(Say, 1823)
		V.	*peregrina*	(Wilson, 1811)
		Wilsonia	*canadensis*	(Linnaeus, 1766)
		W.	*pusilla*	(Wilson, 1811)
	Passeridae	*Passer*	*domesticus*	(Linnaeus, 1758)
	Regulidae	*Regulus*	*calendula*	(Linnaeus, 1766)
		R.	*satrapa*	Lichtenstein, 1823
	Sittidae	*Sitta*	*canadensis*	Linnaeus, 1766
		S.	*carolinensis*	Latham, 1790
	Sturnidae	*Sturnus*	*vulgaris*	Linnaeus, 1758
	Troglodytidae	*Troglodytes*	*troglodytes*	(Linnaeus, 1758)
	Turdidae	*Catharus*	*guttatus*	(Pallas, 1811)
		C.	*minimus*	(Lafresnaye, 1848)
		C.	*ustulatus*	(Nuttall, 1840)
		Myadestes	*townsendi*	(Audubon, 1838)
		Sialia	*currucoides*	(Bechstein, 1798)
		Turdus	*migratorius*	Linnaeus, 1766

Appendix. 2.1. continued.

Host order	Host family	Host genus	Host species	Authority
Passeriformes	Tyrannidae	*Contopus*	*sordidulus*	Sclater, 1859
		Empidonax	*alnorum*	Brewster, 1895
		E.	*minimus*	Baird & Baird, 1843
		Myiarchus	*crinitus*	(Linnaeus, 1758)
		Sayornis	*phoebe*	(Latham, 1790)
		Tyrannus	*tyrannus*	(Linnaeus, 1758)
	Vireonidae	*Vireo*	*olivaceus*	(Linnaeus, 1766)
		V.	*philadelphicus*	(Cassin, 1851)
		V.	*solitarius*	(Wilson, 1810)
Pelecaniformes	Pelecanidae	*Pelecanus*	*erythrorhynchos*	Gmelin, 1789
	Phalacrocoracidae	*Phalacrocorax*	*auritus*	(Lesson, 1831)
Piciformes	Picidae	*Colaptes*	*auratus*	(Linnaeus, 1758)
		Dryocopus	*pileatus*	(Linnaeus, 1758)
		Picoides	*pubescens*	(Linnaeus, 1766)
		P.	*villosus*	(Linnaeus, 1766)
		Sphyrapicus	*nuchalis*	Baird, 1858
		S.	*varius*	(Linnaeus, 1766)
Podicipediformes	Podicipedidae	*Aechmophorus*	*occidentalis*	(Lawrence, 1858)
		Podiceps	*auritus*	(Linnaeus, 1758)
		P.	*grisegena*	(Boddaert, 1783)
Strigiformes	Strigidae	*Aegolius*	*acadicus*	(Gmelin, 1788)
		A.	*funereus*	(Linnaeus, 1758)
		Asio	*flammeus*	(Pontoppidan, 1763)
		A.	*otus*	(Linnaeus, 1758)
		Athene	*cunicularia*	(Molina, 1782)
		Bubo	*virginianus*	(Gmelin, 1788)
		Nyctea	*scandiaca*	(Linnaeus, 1758)
		Strix	*nebulosa*	Forster, 1772
		Surnia	*ulula*	(Linnaeus, 1758)

Appendix 2.2. Rhinonyssidae host species records and prevalence values from birds of Alberta and Manitoba, and the status of these records in North America. (n.a. = total counts of individuals examined in Manitoba were absent; * indicates two species of nasal mites collected from a host individual).

Host order	Host family	Host species	Province	Number of individuals examined	Number of individuals with mites	Mite species	Status
Anseriformes	Anatidae	*Aix sponsa*	MB	n.a.	1	*Rhinonyssus rhinolethrum*	previous record (1)
		Anas platyrhynchos	AB	1	1	*Rhinonyssus rhinolethrum*	previous record (1)
		Anser rossii	MB	n.a.	1	*Rhinonyssus rhinolethrum*	previous record (2)
		Branta canadensis	MB	n.a.	1	*Rhinonyssus rhinolethrum*	previous record (1)
		Cygnus columbianus	MB	n.a.	1	*Rhinonyssus rhinolethrum*	previous record (3)
Columbiformes	Columbidae	*Columba livia*	MB	n.a.	1*	*Tinaminyssus melloi*	previous record (1)
		C. livia	AB/MB	3/n.a.	1/1*	*Tinaminyssus columbae*	previous record (1)
		Zenaida macroura	MB	n.a.	2	*Tinaminyssus zenaidurae*	previous record (1)
		Z. macroura	MB	n.a.	1	*Tinaminyssus melloi*	new record
Falconiformes	Falconidae	*Falco sparverius*	MB	n.a.	4	*Ptilonyssus cerchneis*	previous record (1)
Gruiformes	Rallidae	*Fulica americana*	MB	n.a.	2	*Rallinyssus caudistigmus*	previous record (1)
		Porzana carolina	MB	n.a.	1	*Ptilonyssus icteridius*	new record
Passeriformes	Bombycillidae	*Bombycilla cedrorum*	MB	n.a.	1	*Ptilonyssus* sp.	previous record (1)
		B. cedrorum	AB	9	1	*Ptilonyssus bombycillae*	previous record (1)
		B. garrulus	AB	20	3	*Ptilonyssus bombycillae*	previous record (4)
	Corvidae	*Perisoreus canadensis*	AB	1	1	*Ptilonyssus perisorei*	previous record (1)
	Emberizidae	*Junco hyemalis*	MB	n.a.	1	*Ptilonyssus morofskyi*	previous record (1)
		Passerella iliaca	MB	n.a.	2	*Ptilonyssus morofskyi*	previous record (1)
		Pheucticus ludovicianus	MB	n.a.	1	*Ptilonyssus* sp.	new record
		P. ludovicianus	AB/MB	3/n.a.	3/1	*Ptilonyssus japuibensis*	new record
		P. melanocephalus	AB	1	1	*Ptilonyssus* sp.	new record
		Piranga ludoviciana	AB	2	1	*Ptilonyssus pirangae*	new record
		Plectrophenax nivalis	MB	n.a.	4*	*Ptilonyssus morofskyi*	new record
		P. nivalis	MB	n.a.	1*	*Ptilonyssus nivalis* sp. n.	new record
		P. nivalis	AB	5	1	*Ptilonyssus* sp.	new record
		Spizella pallida	MB	n.a.	2	*Ptilonyssus japuibensis*	new record
		S. passerina	AB/MB	7/n.a.	1/3	*Ptilonyssus calvaria* sp. n.	new record

Appendix 2.2. continued.

Host order	Host family	Host species	Province	Number of individuals examined	Number of individuals with mites	Mite species	Status
Passeriformes	Emberizidae	*Zonotrichia albicollis*	MB	n.a.	1	*Ptilonyssus japuibensis*	previous record (1)
	Fringiliidae	*Carduelis flammea*	AB/MB	12/n.a.	5/2	*Ptilonyssus carduelis*	previous record (5)
		C. flammea	AB	12	1	*Ptilonyssus morofskyi*	new record
		C. tristis	AB	2	1	*Ptilonyssus morofskyi*	previous record (6)
		Carpodacus purpureus	AB	8	1	*Ptilonyssus plesiotypicus* sp. n.	new record
		Coccothraustes vespertinus	AB/MB	7/n.a.	2/1	*Ptilonyssus coccothraustis*	new record
		Loxia leucoptera	AB	7	3	*Ptilonyssus carduelis*	new record
		Pinicola enucleator	AB/MB	9/n.a.	4/1	*Ptilonyssus pinicola* sp. n.	new record
		P. enucleator	AB	9	1	*Sternostoma cryptorhynchum*	new record
	Hirundinidae	*Hirundo rustica*	AB/MB	5/n.a.	2/1	*Ptilonyssus echinatus*	previous record (1)
		Petrochelidon pyrrhonota	MB	n.a.	1	*Ptilonyssus echinatus*	previous record (1)
		Progne subis	MB	n.a.	1	*Ptilonyssus angrensis*	previous record (1)
		Riparia riparia	AB	1	1	*Sternostoma sialiphilus*	new record
		Tachycineta bicolor	MB	n.a.	1	*Ptilonyssus echinatus*	previous record (1)
	Icteridae	*Agelaius phoeniceus*	AB/MB	3/n.a.	2/2	*Ptilonyssus icteridius*	previous record (1)
		Euphagus cyanocephalus	AB	2	1	*Ptilonyssus icteridius*	previous record (1)
		Icterus galbula	AB/MB	5/n.a.	4/6	*Ptilonyssus icteridius*	previous record (1)
		Molothrus ater	AB	2	1	*Ptilonyssus icteridius*	previous record (1)
		M. ater	AB	2	1	*Ptilonyssus japuibensis*	previous record (7)
		Quiscalus quiscula	AB/MB	1/n.a.	1/1	*Ptilonyssus icteridius*	previous record (1)
	Mimidae	*Dumetella carolinensis*	AB	5	1	*Ptilonyssus euroturdi*	previous record (1)
	Parulidae	*Dendroica coronata*	MB	n.a.	1	*Ptilonyssus japuibensis*	previous record (8)
		D. magnolia	MB	n.a.	2	*Ptilonyssus japuibensis*	previous record (1)
		D. petechia	MB	n.a.	2	*Ptilonyssus japuibensis*	previous record (1)
		D. petechia	MB	n.a.	1	*Sternostoma loxiae*	new record
		D. pinus	MB	n.a.	1	*Ptilonyssus japuibensis*	previous record (8)
		D. pinus	MB	n.a.	1	*Ptilonyssus morofskyi*	previous record (1)
		D. striata	MB	n.a.	1	*Ptilonyssus japuibensis*	previous record (9)
		D. tigrina	MB	n.a.	1	*Ptilonyssus japuibensis*	previous record (1)

Appendix. 2.2. continued

Host order	Host family	Host species	Province	Number of individuals examined	Number of individuals with mites	Mite species	Status
Passeriformes	Parulidae	*Geothlypis trichas*	MB	n.a.	3	*Ptilonyssus sairae*	previous record (9)
		Mniotilta varia	MB	n.a.	1	*Ptilonyssus sairae*	previous record (1)
		M. varia	MB	n.a.	1	*Sternostoma trachaecolum*	new record
		Seiurus aurocapillus	MB	n.a.	3	*Ptilonyssus japuibensis*	previous record (9)
		S. noveboracensis	MB	n.a.	1	*Ptilonyssus japuibensis*	new record
		Setophaga ruticilla	MB	n.a.	2	*Ptilonyssus morofskyi*	new record
		S. ruticilla	MB	n.a.	1	*Ptilonyssus japuibensis*	previous record (1)
		Vermivora celata	AB	2	1	*Ptilonyssus sairae*	previous record (7)
		V. peregrina	MB	n.a.	1	*Ptilonyssus morofskyi*	new record
		V. peregrina	MB	n.a.	1	*Ptilonyssus japuibensis*	new record
		Wilsonia canadensis	MB	n.a.	1	*Ptilonyssus japuibensis*	new record
	Passeridae	*Passer domesticus*	MB	n.a.	3	*Ptilonyssus nudus*	previous record (10)
		P. domesticus	MB	n.a.	6	*Ptilonyssus hirsti*	previous record (1)
		P. domesticus	MB	n.a.	5	*Ptilonyssus* sp.	previous record (1)
		P. domesticus	MB	n.a.	1	*Tinaminyssus melloi*	new record
	Regulidae	*Regulus calendula*	MB	n.a.	1	*Ptilonyssus acrocephali*	previous record (1)
	Troglodytidae	*Troglodytes troglodytes*	AB	1	1	*Ptilonyssus troglodytis*	new record
	Turdidae	*Catharus minimus*	MB	n.a.	1	*Sternostoma* sp.	new record
		C. ustulatus	AB	5	1	*Sternostoma lanorium*	new record
		Sialia currucoides	AB	4	1	*Sternostoma loxiae*	new record
		Turdus migratorius	AB	12	1	*Sternostoma technaui*	previous record (1)
	Tyrannidae	*Contopus sordidulus*	AB	1	1	*Ptilonyssus tyrannus*	previous record (1)
		Empidonax minimus	MB	n.a.	1	*Sternostoma setifer* sp. n.	new record
		Myiarchus crinitus	MB	n.a.	1*	*Ptilonyssus callinectoides*	previous record (11)
		M. crinitus	MB	n.a.	1*	*Ptilonyssus icteridius*	new record
		Sayornis phoebe	MB	n.a.	1	*Ptilonyssus tyrannus*	previous record (1)
		Tyrannus tyrannus	MB	n.a.	1*	*Sternostoma longisetosae*	previous record (1)
		T. tyrannus	MB	n.a.	1*	*Ptilonyssus* sp.	previous record (1)
	Vireonidae	*Vireo olivaceus*	MB	n.a.	1	*Ptilonyssus vireonis*	previous record (11)

Appendix 2.2. continued.

Host order	Host family	Host species	Province	Number of individuals examined	Number of individuals with mites	Mite species	Status
Passeriformes	Vireonidae	*Vireo solitarius*	MB	n.a.	1	*Ptilonyssus vireonis*	new record
Piciformes	Picidae	*Colaptes auratus*	AB/MB	7/n.a.	2/3	*Sternostoma porteri*	previous record (1)
		Picoides pubescens	MB	n.a.	1	*Sternostoma hylandi*	previous record (1)
		Sphyrapicus varius	MB	n.a.	2	*Sternostoma porteri*	new record
Strigiformes	Strigidae	*Aegolius acadicus*	MB	n.a.	3	*Rhinoecius aegolii*	new record
		A. funereus	AB	4	1	*Rhinoecius aegolii*	new record
		Asio flammeus	MB	n.a.	3	*Rhinoecius alifanovi*	new record
		A. flammeus	AB	3	1	*Rhinoecius* sp.	new record
		A. otus	AB	3	1*	*Rhinoecius brikinboricus*	new record
		Bubo virginianus	AB/MB	1/n.a.	1/3	*Rhinoecius grandis*	previous record (1)
		Nyctea scandiaca	MB	n.a.	2	*Rhinoecius nycteae*	new record
		Strix nebulosa	AB	2	1	*Rhinoecius cooremani*	new record

[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 Casto 1976a; [10]Porter and Strandtmann 1952; [11]Pence 1972.

Appendix 2.3. Ereynetidae host species records and prevalence values from birds of Alberta and Manitoba, and status of these records in North America. (* indicates two species of nasal mites collected from a host individual).

Host order	Host family	Host species	Province	Number of individuals examined	Number of individuals with mites	Mite species	Status
Anseriformes	Anatidae	*Aythya americana*	MB	4	1	*Boydaia aratingae*	new record
Charadriiformes	Scolopacidae	*Tringa melanoleuca*	AB	2	1	*Neoboydaia* sp.	previous record (1)
Falconiformes	Falconidae	*Falco sparverius*	AB	5	1	*Boydaia* sp.	previous record (2)
Passeriformes	Fringillidae	*Loxia curvirostra*	AB	1	1	*Boydaia faini*	new record
	Hirundinidae	*Tachycineta bicolor*	AB	3	1	*Boydaia psalidoprocnei*	previous record (3)
	Sturnidae	*Sturnus vulgaris*	AB	3	1	*Boydaia sturni*	previous record (3)
Strigiformes	Strigidae	*Asio otus*	AB	3	1*	*Neoboydaia colymbiformi*	new record

[1]Clark 1964; [2]Pence and Casto 1976b; [3]Pence 1975

Appendix 2.4. Number of nasal mites from passeriform hosts washed and dissected.

Host family	Host species	Number of nasal mites from washing	Number of additional nasal mites from dissection
Bombycillidae	*Bombycilla garrulus*	0	0
	B. garrulus	0	4
	B. garrulus	0	0
	B. garrulus	0	0
	B. garrulus	0	0
	B. garrulus	0	0
	B. garrulus	0	0
	B. garrulus	0	0
	B. garrulus	0	0
Fringillidae	*Carduelis flammea*	0	1
	C. flammea	0	15
	C. flammea	0	0
	C. flammea	0	0
	C. flammea	0	0
	C. flammea	0	26
	C. flammea	1	7
	C. flammea	0	0
	C. flammea	0	1
Turdidae	*Turdus migratorius*	0	0
	T. migratorius	0	0
	T. migratorius	0	0
	T. migratorius	0	0
	T. migratorius	0	0
	T. migratorius	0	0
	T. migratorius	0	0
	T. migratorius	0	0
	T. migratorius	2	1

Chapter 3

[1]Five New Species of Rhinonyssidae (Mesostigmata) and One New Species of *Dermanyssus* Dugès, 1834 (Mesostigmata: Dermanyssidae) from Birds of Alberta and Manitoba.

Introduction

Birds are host to a broad diversity of symbiotic animals. Mites are among the most diverse groups of these symbionts, with at least 40 families and approximately 3,000 described species known from avian hosts (Proctor and Owens 2000). The superfamily Dermanyssoidea contains most of the bird-associated Mesostigmata (Radovsky 1994). Within the Dermanyssoidea, species of the families Dermanyssidae, Rhinonyssidae, Laelapidae, and Macronyssidae parasitize birds in North America. Species of Dermanyssidae Kolenati, 1859 are obligate hematophagous ectoparasites on birds and mammals. Members of the genus *Dermanyssus* Dugès, 1834 are ectoparasites of birds worldwide, with generally broad host ranges (Moss 1978). For example *Dermanyssus gallinae* (De Geer, 1778) has been recorded from at least 30 host species, and *D. hirundinis* (Hermann, 1804) from at least 14 host species (Moss 1978). With the exception of *D. gallinae*, *Dermanyssus* species are predominately parasites of cavity-nesting birds such as flickers (Picidae) and swallows (Hirundinidae) (Moss 1978). Most species are nidicolous ectoparasites, briefly feeding on the host at night and returning to the nest and associated substrate during the day (Baker et al. 1956). A few species, including *D. grochovskae* Zemskaya, 1961 and *D. quintus* Vitzthum, 1921, spend most of their life cycle on the host (Moss 1978).

[1] A version of this chapter has been submitted for publication to the Journal of Parasitology.

Rhinonyssids are obligate hematophagous endoparasites in the nasal passages of non-ratite birds worldwide. Rhinonyssid genera vary in their degree of host specificity, with some genera being restricted to single host families, and others found in hosts from different orders (Pence 1973). In North America, passeriform, caprimulgiform, falconiform, and apodiform host species are parasitized by *Ptilonyssus* species. *Sternostoma* species parasitize passeriform, piciform, and charadriiform birds. *Rhinonyssus* species parasitize anseriform, podicipediform, and charadriiform birds. Ciconiiform and columbiform birds are parasitized by *Tinaminyssus* species. Owls (Strigiformes) are parasitized by *Rhinoecius* species; generally each *Rhinoecius* species occurs in a different species of owl. Birds of the family Rallidae are parasitized by *Rallinyssus* species. *Larinyssus* species parasitize gulls and terns (Laridae). Rhinonyssids are slow moving sluggish mites which occur predominately in the nasal passages, but some species invade the tracheal tissues, lungs and body cavity (Porter and Strandtmann 1952, Krantz 1978). Generally rhinonyssids are not considered to cause significant pathology to a host individual, with the exception of *Sternostoma tracheacolum* Lawrence, 1948 which invades the lower respiratory tract, lungs, and air sacs of a host (Stephan et al. 1950).

Nasal mites have been surveyed in many geographic locations worldwide, including Taiwan, Australia, Louisiana, Guatemala, and Texas (Hyland 1963, Maa and Kuo 1965, Domrow 1969, Pence 1973, Spicer 1984, Spicer 1987). There has never been a Canadian survey. Canadian records include only four published species records: *Rhinonyssus* sp. from the Guillemot, *Uria aalge* (Ballard and Ring 1979), *Sternostoma tracheacolum* from the Red-winged Blackbird, *Agelaius phoeniceus* (Hood and Welch

1980), *Ptilonyssus japuibensis* Castro, 1948 from the Chipping Sparrow, *Spizella passerina* (Pence 1975), and *Ptilonyssus sairae* Castro, 1948 from the Chipping Sparrow, *S. passerina* (George 1961). In addition to these, there are three unpublished species records from specimens deposited in the Canadian National Collection of Insects and Arachnids (CNCI&A) in Ottawa: *Ptilonyssus bombycillae* Fain, 1972 from the Bohemian Waxwing, *Bombycilla garrulus*, *Rhinonyssus coniventris* Trouessart, 1894 from the Red Knot, *Calidris canutus*, and *Sternostoma boydi* Strandtmann, 1951 from the Ruddy Turnstone, *Arenaria interpres*. While surveying the nasal mites associated with birds of Alberta and Manitoba, I collected one new species of *Dermanyssus*, and five new species of Rhinonyssidae. Herein I describe and illustrate these six new species.

Materials and Methods

The laboratory of Heather Proctor at the University of Alberta had a collection of approximately 700 bird carcasses from Alberta, largely from the contributions of the Alberta Fish & 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, and for some I can only say that the birds were collected somewhere in Alberta. Host taxonomy and authorities follow Clements (1991) provided by Andrew and McAllan (1998), selecting the 'Clements 1991-1996' taxonomy option in Nomina version 1.0. Bird bodies were maintained at -20°C until processing. Frozen birds were first thawed and then washed using the following method. The bird was placed in a suitably sized container, ranging from 4-18 L, with a drop of dish detergent, enough 95% ethanol to soak the plumage of the bird, and enough water to submerge it. The sealed container was then shaken vigorously for five minutes. Each bird was then removed from the container and rinsed thoroughly over a Fisher Scientific 53 µm mesh filter; 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 filter. The material remaining in the filter was stored in 30 ml snap cap and scintillation vials in 95% ethanol.

Mites were also collected from some individual 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 table top drill press vice. Depending on bird size, I used a scalpel, molybdenum steel scissors, or molybdenum steel bone shears to sagittally section the head and expose the nasal cavities. The dissected halves were placed in appropriately sized vials and stored at -20°C until inspection. For inspection I placed the dissected heads were placed in a glass dish with 80% ethanol and examined the tissues using a dissecting stereomicroscope.

I also received nasal mite samples from Dr. Terry Galloway's lab at the University of Manitoba. Galloway's lab performed nasal flushings on Manitoban birds 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 in the Manitoba lab were similar to those described above, except ethanol was not added to the washing solution, and the washing solution was filtered through a 90 µm filter.

I examined washings and dissections using Leica MZ16 and MZ6 dissecting microscopes at 20-25x magnification. Mites were removed from ethanol and cleared in 85% lactic acid for 1-24 hours depending on the degree of original opacity. Mites were mounted in a polyvinyl alcohol medium (6371A, BioQuip Products, Rancho Dominguez, CA). Slides were cured on a slide warmer at about 40°C for 3-4 days. I examined slide mounted specimens on a Leica DMLB compound microscope with differential interference contrast (DIC) at 400x magnification. Species level identifications were made using keys (Pence 1975, Moss 1978) and species descriptions from the primary literature.

Initial drawings were made with pencil on paper using a camera lucida. These were later merged in Adobe Photoshop CS version 8.0, and redrawn in Adobe Illustrator CS version 11.0 using an Intuos 2 Graphics Tablet from WACOM Co., Ltd. Leg chaetotaxy is based on the system proposed by Evans (1963) and Evans and Till (1965). Idiosomal chaetotaxy is based upon the system proposed by Lindquist and Evans (1965). Palp chaetotaxy is listed from basal to apical segments. Descriptions are based upon the holotype, and paratypes if present. All measurements are in micrometres (μm) and are in the form "holotype (range for paratypes, mean)". In cases where there was no variation, only a single value is presented. Habitus scale bars are 250 μm, all other scale bars are 25 μm. The following designations, adapted from Fain and Hyland (1962), are used in the species descriptions as illustrated (Figs. 3.1-6), and are arranged in the order used in the descriptions:

LB	length of body including palps
WID	width of idiosoma
LPS	length of podosomal shield
WPS	width of podosomal shield
LOS	length of opisthosomal shield
WOS	width of opisthosomal shield
LpS	length of pygidial shield
WpS	width of pygidial shield
LDS	length of dorsal shield
WDSM	width of dorsal shield maximum
WDSm	width of dorsal shield minimum
LSS	length of sternal shield
WSS	width of sternal shield
LGS	length of genital shield
WGS	width of genital shield
LSGS	length of sternogenital shield
WSGS	width of sternogenital shield
LVS	length of ventral shield
WVS	width of ventral shield
LAS	length of anal shield
WAS	width of anal shield
LP	length of peritreme
LG	length of gnathosoma, ventral view, including palps
WG	width of gnathosoma
LCH	length of chelicera
WCH	width of chelicera
LLeg	length of leg, including coxa, excluding ambulacrum (LLeg I to LLeg IV)

Abbreviations for depositories are CNCI&A (Canadian National Collection of Insects and Arachnids, Ottawa, Ontario), UASM (University of Alberta E.H. Strickland Entomological Museum, Edmonton, Alberta), JBWME (J.B. Wallis Museum of Entomology, University of Manitoba, Winnipeg, Manitoba), and ZIN (Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia).

DESCRIPTIONS

Family Dermanyssidae Kolenati, 1859

Genus *Dermanyssus* Dugès, 1834

Diagnosis: Female chelicerae with highly elongate second segment, digits minute. Females of most species lack the j3 setal pair. Sternal shield reduced to a crescent-shaped transverse band, width at least 2.5 times its length. Sternal shield with one or two pairs of setae, but never with three pairs of setae.

***Dermanyssus diphyes* sp. n.**

(Figs. 3.7-8)

Diagnosis: Medium-sized mites with the characteristics of the genus *Dermanyssus*, with undivided dorsal shield. Characters that distinguish this species from closely related species include dorsal shield shape and dimensions, presence of a prominent pair of humeral pores on the dorsal shield, presence of j4 setae, absence of pores on posterior dorsal shield, absence of setae st4, genital shield that constricts anteriorly and expands posteriorly with a rounded terminus, number of ventral opisthosomal setae (16 to 20 pairs), and the peritreme extending beyond the middle of coxa II.

Female (based on holotype and four paratypes, setal measurements based on holotype): LB 850 (845 – 960, 885). WID 358 (390 – 465, 404). LDS 603 (625 – 705, 646). WDSM 305 (313 – 388, 331). WDSm 85 (95 – 125, 99). LSS 20. WSP 155 (150 – 160, 155). LGS 323 (343 – 385, 350). WGS 93 (90 – 125, 102). LAS 123 (123 – 148, 131). WAS 113 (118 – 143, 123). LP 183 (190 – 218, 196). LG 210 (208 – 221, 215).

WG 133 (130 – 143, 137). LLeg I 445 (440 – 490, 460). LLeg II 430 (425 – 470, 441). LLeg III 413 (415 – 470, 431). LLeg IV 480 (480 – 535, 498).

Dorsum: Dorsal shield well sclerotized and occupying most of dorsal idiosoma, bearing eleven pairs of setae (j2, j4-6, J1, J3, J4, z2, z4, z5, s4), two pairs of small pores, and a prominent pair of humeral pores on the dorsal shield posterolateral to setae s4. Dorsal shield setae j4 unpaired in holotype and two paratypes, paired in two paratypes. Scutal setae unequal length, anteriormost pair j2 longest at 48 long, anterolateral setae z2, z4, z5, s4 30 long, remaining scutal setae j4-6, J1, J3, J4 ranging from 15-20 long. Dorsal shield anterior margin straight, widest medially at level with humeral pores, tapering distally to truncate posterior margin. Soft cuticle of dorsum bears one pair of short sharp-tipped setae (j1) 18 long and 19 pairs of long sharp-tipped barbed setae ranging from 40-75 long.

Venter: Sternal shield lightly sclerotized, bearing two pairs of long sharp-tipped setae (st1, st2), one pair of long sharp-tipped setae (st3) off shield in integument. Sternal setae, st1-3, lengths 53, 50, and 58 respectively. Metasternal setae (st4) absent. Genital shield bears pair of short sharp-tipped setae (gen1) and one pair of pores. Genital shield widest anteriorly, constricted medially, expanded posteriorly with rounded terminus. Anal shield well sclerotized bearing short sharp-tipped paranal and postanal setae, paranal setae level with anal opening, paranal and postanal setae equal length. Ventral opisthosoma bears 16 to 20 pairs of long sharp-tipped predominately barbed setae ranging from 38-63 long. Peritreme extends beyond the middle of coxa II.

Gnathosoma: Sharp-tipped subcapitular setae 23 long, sharp-tipped hypostomal setae hyp1 28 long, hyp2 23 long, hyp3 45 long, and single row of 12 deutosternal teeth.

Chaetotaxy of palps: 2-4-6-12-9. Palp genu *al* seta spike-like. Chelicerae highly elongate, digits minute.

Legs: Claws of legs I-IV strongly curved. Leg chaetotaxy as shown in Table 3.1.

Male, nymphs, larva: Unknown.

Taxonomic summary

Type host: Turdus migratorius Linnaeus, 1766, American Robin.

Type locality and collection date: Four mites from Edmonton, Alberta (53°34'N, 113°31'W), 17th July 2005, coll. D. Walter.

Additional locality and collection date: Four mites from Millet, Alberta (53°05'52"N, 113°28'22"W), 13th May 1996.

Types: ♀ holotype, ♀ paratype CNCI&A Nos. 23510, 23511. Two ♀ paratypes UASM Nos. 80557, 80558. One ♀ paratype in possession of author.

Etymology: diphyes (a Greek masculine adjective) means 'of double nature, two-fold'. This name reflects the fact that this species possesses characteristics of two different groups of *Dermanyssus* species, with prominent humeral pores on the dorsal shield and relatively long peritremes.

Remarks

Dermanyssus diphyes sp. n. is most similar to *D. alaudae* (Schrank, 1781), described from *Alauda arvensis*, *D. brevis* Ewing, 1936, described from *Eremophila alpestris merrilli* from Oregon, and *D. hirsutus* Moss and Radovsky, 1967, described from *Colaptes auratus cafer* from Oregon. *Dermanyssus diphyes* sp. n. is distinguished from these species by the following. Dorsal shield length ranging from 603 – 705 and maximum width ranges 305 – 388; *D. brevis* dorsal shield length is 506 and maximum width is 286. Dorsal shield anterior margin straight, widest medially at level with humeral pores, tapering distally to truncate posterior margin (Fig. 3.7); *D. alaudae* and *D. hirsutus* dorsal shield only tapers slightly distally to rounded posterior margin. Prominent pair of humeral pores located on the dorsal shield posterolateral setae s4; *D. hirsutus* humeral pores are located on the dorsal shield but they are very small and barely noticeable. Setae j4 on the dorsal shield; *D. alaudae* setae j4 is absent. No pores on dorsal shield posterior margin; *D. hirsutus* has a pair of pores on dorsal shield posterior margin. Metasternal setae, st4, absent; *D. hirsutus* has metasternal setae. Genital shield widest anteriorly, constricted medially, expanded posteriorly to a rounded terminus; *D. alaudae* and *D. brevis* genital shield is slightly wider anteriorly, tapers slightly to a rounded terminus without expanding distally. Anal shield length ranges 123–148, anal shield width ranges 113–143; *D. brevis* anal shield is 116 long and 105 wide. Ventral opisthosoma bears 16 to 20 pairs of long sharp-tipped predominately barbed setae; *D. hirsutus* has ventral opisthosomal hypertrichy on bearing at least 24 pairs of setae. Peritreme extends anteriorly beyond the middle of coxa II; *D. alaudae* peritreme extends only to middle of coxa III, *D. brevis* peritreme reaches just posterior to the middle of coxa III, and *D. hirsutus* peritreme extends to the middle of coxa II.

Family Rhinonyssidae Trouessart, 1895

Genus *Ptilonyssus* Berlese and Trouessart, 1889

Diagnosis: Peritreme present or rarely absent, gnathosoma terminal, anus ventroterminal, one or two dorsal shields. Chelicerae distally attenuated and digits minute, less than $^1/_{10}$ the length of the chelicerae.

***Ptilonyssus calvaria* sp. n.**

(Figs. 3.9-16, 3.43-44)

Diagnosis: Large mites with the characteristics of the genus *Ptilonyssus*, with podosomal and pygidial shields. Characters that distinguish this species from closely related species include eight pairs of setae on podosomal shield with a distinctly trilobed posterior margin, five pairs of mesolateral setae which are approximately equal length, paranal and postanal setae of unequal length, cribrum does not extend to posterior end of anal shield, and relatively large hyp1 setae with rounded tips.

Female (based on holotype and four paratypes): LB 880 (730 – 875, 825). WID 300 (258 – 268, 271). LPS 190 (178 – 193, 188). WPS 158 (143 – 155, 152). LpS 50 (43 – 53, 49). WpS 83 (85 – 95, 89). LSS 120 (113 – 123, 118). WSS 80 (65 – 75, 73). LGS 103 (103 – 120, 111). WGS 63 (55, 57). LAS 105 (95 – 103, 101). WAS 63 (60 – 63, 62). LG 135 (140 – 145, 141). WG 95 (90 – 105, 97). LCH 170 (165 – 183, 174). WCH 35 (34 – 36, 35). LLeg I 268 (263 – 300, 278). LLeg II 208 (188 – 213, 201). LLeg III 200 (170 – 203, 190). LLeg IV 238 (238 – 265, 246).

Dorsum: Podosomal and pygidial shields sclerotized with areas of muscle insertions as illustrated (Fig. 3.9). Podosomal shield bearing eight pairs of minute sharp-tipped setae (j2-5, z2-5). Pygidial shield bearing one pair of short sharp-tipped setae (J4) and one pair of pores. Podosomal shield anterior margin slightly invaginated medially, anterolateral corners rounded, laterally excavated level with coxa III, widest posteriorly, distinctly trilobed posterior margin. Mesosomal shieldlets present. Pygidial shield small, wider than long, rounded anteriorly, slightly invaginated posteriorly. Five pairs of sharp-tipped setae (s5, s6, r3, r5, r6) in integument alongside podosomal shield, all approximately equal length. Subposterior setae (j6) just off posterior margin of podosomal shield half as long as the longest mesolateral setae (s5-6). Eight pairs short sharp-tipped setae (J1-3, Z1-3, R1, R2) in dorsal opisthosoma. Stigmata dorsolateral, at level of coxa III.

Venter: Sternal shield lightly sclerotized with distinct margins, one pair of sharp-tipped setae (st1) on shield, two pairs of sharp-tipped setae (st2, st3) off shield. Genital shield bearing one pair of short sharp-tipped setae (gen1), pair of pores in integument off shield. Anal shield distinct, distally tapering sharp-tipped paranal and postanal setae, paranal setae level with anal opening, paranal and postanal setae unequal length. Cribrum in narrow band, not extending to posterior of anal shield. Seven pairs of sharp-tipped setae (JV1-4, ZV2, ZV3, UR1) in ventral opisthosoma, and pair of pores lateral of anal shield.

Gnathosoma: Relatively long sharp-tipped subcapitular setae, three pairs hypostomal setae (hyp1 relatively long blunt-tipped, hyp2 short blunt-tipped, hyp3 relatively long sharp-tipped), nine deutosternal teeth. Chaetotaxy of palps: 1-2-4-13.

Tibia-tarsus sensory area with nine short setae. Chelicerae strongly inflated proximally, marked constriction distally, with small sharp-tipped curved moveable digit and blunt-tipped fixed digit (Fig. 3.43).

Legs: Claws of legs I-IV strongly curved. Chaetotaxy of legs: Coxa 2-2-2-1. Trochanter 4-4-4-5. Femur 9-7-4-5. Genu 5-5-5-3. Tibia 7-7-6-5. Tarsus 25-19-16-17. Tarsus II-IV ventral subapical setae long strong spikes.

Male (based on allotype and one paratype): LB 665 (675, 670). WID 233 (273, 253). LPS 178. WPS 155 (170, 163). LOS 183 (200, 191). WOS 140 (143, 141). LSGS 180 (188, 184). WSGS 64 (75, 69). LAS 88 (81, 84). WAS 56 (55, 56). LG 106 (105, 106). WG 95. LCH 90 (91, 91). WCH 29. LLeg I 220 (230, 225). LLeg II 169 (188, 178). LLeg III 163 (175, 169). LLeg IV 205 (203, 204).

Dorsum: Podosomal and opisthosomal shields lightly sclerotized, areas of muscle insertions were not observed (Fig. 3.15). Podosomal shield bearing eight pairs of minute sharp-tipped setae (j2-5, z2-5). Opisthosomal shield bearing six pairs of short sharp-tipped setae (J1-4, Z1, Z2). Podosomal shield anterior margin slightly invaginated medially, anterolateral corners rounded, widest anteriorly, laterally excavated level with coxa III, distinctly trilobed posterior margin. Opisthosomal shield anterior margin straight, widest medially, posterior margin slightly invaginated. Five pairs of sharp-tipped setae (s5, s6, r3, r5, r6) in integument alongside podosomal shield. Subposterior setae (j6) just off posterior margin of podosomal shield. Three pairs of short sharp-tipped setae in integument alongside opisthosomal shield. Stigmata dorsolateral, at level of coxa III.

Venter: Sternogenital shield with distinct margins, bearing four pairs of sharp-tipped setae (st1-3, gen1), pair of pores in integument posterior of shield. Anal shield distinct, bearing sharp-tipped paranal and postanal setae, paranal setae level with anal opening, paranal and postanal setae unequal length. Cribrum in narrow band, not extending to posterior of anal shield. Five pairs of sharp-tipped setae (JV1-4, ZV2) on ventral opisthosoma.

Gnathosoma: Sharp-tipped subcapitular setae, two pairs sharp-tipped hypostomal setae (hyp1, hyp3), eight deutosternal teeth. Chaetotaxy of palps: 1-2-4-12. Tibia-tarsus sensory area with seven short setae. Chelicerae widest proximally, tapering slightly to relatively large digits, with short and slender spermadactyl attached (Fig. 3.44).

Legs: Claws of legs I-IV strongly curved. Chaetotaxy of legs: Coxa 2-2-2-1. Trochanter 4-4-4-5. Femur 9-7-4-5. Genu 5-5-6-3. Tibia 7-7-6-6. Tarsus 22-17-17-17. Tarsus II-IV ventral subapical setal pair long strong spikes.

Deutonymph (based on one deutonymph): LB 700. WID 288. LPS 173. WPS 133. LOS 268. WOS 135. LAS 88. WAS 63. LG 100. WG 100. LCH 66. WCH 23. LLeg I 233. LLeg II 168. LLeg III 153. LLeg IV 190.

Dorsum: Podosomal and opisthosomal shield lightly sclerotized, areas of muscle insertions were not observed. Podosomal shield bearing eight pairs of minute sharp-tipped setae (j2-5, z2-5). Opisthosomal shield bearing four pairs of sharp-tipped setae (three pairs short sharp-tipped setae (J1-J3), one pair very long sharp-tipped barbed setae (J4) 30 long). Podosomal shield anterior margin slightly invaginated medially, anterolateral corners rounded, laterally excavated level with coxa III, widest posteriorly, distinctly trilobed posterior margin. Opisthosomal shield variable, anterior margin straight, sides parallel, posterior margin inverted. Five pairs of sharp-tipped setae (s5,s6, r3, r5, r6) in integument alongside podosomal shield. Subposterior setae (j6) just off posterior margin of podosomal shield. Five pairs of sharp-tipped setae (Z1-3, R1, R2) on dorsal opisthosoma. Stigmata dorsolateral, at level of coxa III.

Venter: Sternal shield absent. Three pairs of short sharp-tipped sternal setae (st1-3) present. Genital shield absent, very small sharp-tipped genital setae (gen1) present. Anal shield lightly sclerotized, bearing sharp-tipped paranal and postanal setae, paranal setae level with anal opening, paranal and postanal unequal length. Cribrum in narrow band, does not extend to posterior of anal shield. Ventral opisthosoma bearing six pairs of sharp-tipped setae (JV1-4, ZV2, ZV3).

Gnathosoma: Sharp-tipped subcapitular setae, three pairs hypostomal setae (hyp1 relatively long blunt-tipped, hyp2 short blunt-tipped, hyp3 relatively long sharp-tipped), nine deutosternal teeth. Chaetotaxy of palps: 1-2-4-12. Tibia-tarsus sensory pit with seven pairs of short setae. Chelicerae widest proximally, tapering slightly to short blunt-tipped moveable and fixed digits.

Legs: Claws of legs I-IV relatively small and curved. Chaetotaxy of legs: Coxa 2-2-2-1. Trochanter 4-4-4-5. Femur 9-7-4-5. Genu 6-6-6-3. Tibia 7-7-6-6. Tarsus 22-17-17-17. Tarsus II-IV ventral subapical setal pair sharp-tipped setae.

Protonymph (based on one protonymph): LB 595. WID 265. LPS 170. WPS 138. LpS 20. WpS 73. LAS 75. WAS 45. LG 115. WG 98. LCH 133. WCH 20. LLeg I 203. LLeg II 165. LLeg III 160. LLeg IV 183.

Dorsum: Podosomal and pygidial shields lightly sclerotized, areas of muscle insertions were not observed. Podosomal shield bearing eight pairs of minute sharp-tipped setae (j2-5, z2-5). Pygidial shield of variable shape, always wider than long, bearing one pair of very long barbed sharp-tipped setae (J4) 27 long. Podosomal shield anterior margin slightly invaginated medially, anterolateral corners rounded, laterally excavated level with coxa III, widest posteriorly, distinctly trilobed posterior margin. Mesosomal shieldlets present. Five pairs of short blunt-tipped setae (s5, s6, r3, r5, r6) in integument alongside podosomal shield. Subposterior setae (j6) just off posterior margin of podosomal shield. Eight pairs of short blunt-tipped setae (J1-3, Z1-3, R1, R2) on dorsal opisthosoma. Stigmata dorsolateral, at level of coxa III.

Venter: Sternal shield absent. Three pairs of short blunt-tipped sternal setae (st1-3) present. Pair of genital pores located in similar location as in adult females. Anal shield lightly sclerotized, bearing very short blunt-tipped paranal and postanal setae, paranal setae level with anal opening, postanal and paranal setae equal length. Cribrum extends to posterior of anal shield. Five pairs of blunt-tipped setae (JV1-4, ZV2) on ventral opisthosoma.

Gnathosoma: Short blunt-tipped subcapitular setae, two pairs short blunt-tipped hypostomal setae (hyp1, hyp3), ten deutosternal teeth. Chaetotaxy of palps: 1-2-4-14. Tibia-tarsus sensory pit with six pairs of short setae. Chelicerae strongly inflated proximally, marked constriction distally with small sharp-tipped curved moveable digit and blunt-tipped fixed digit.

Legs: Claws of legs I-IV are strongly curved. Chaetotaxy of legs: Coxa 2-2-2-1. Trochanter 4-4-4-4. Femur 8-7-5-4. Genu 6-6-6-3. Tibia 7-7-7-6. Tarsus 22-17-17-17. Tarsus II-IV ventral subapical setal pair short blunt-tipped setae.

Larva: Unknown.

Taxonomic summary

Type host: Spizella passerina Bechstein, 1798, Chipping Sparrow.

Type locality and collection date: Seven mites from Winnipeg, Manitoba (49°54'N, 97°08'W), 19th May 2004, coll. T. Galloway and D. Holder.

Additional localities and collection dates: Five mites from Winnipeg, Manitoba (49°54'N, 97°08'W), 26th May 2005, coll. T. Galloway and D. Holder. One mite from Manitoba, 3rd September 2004, same collectors. Six mites from Millet, Alberta (53°05'52"N, 113°28'22"W), 21st May 1999, coll. PMA.

Types: ♀ holotype, ♀ paratype CNCI&A Nos. 23513, 23514. Two ♀ paratypes JBWME Nos. 0003053, 0003054. Two ♀ paratypes ZIN No. 9988. Two ♀ paratypes, allotype ♂ UASM Nos. 80561 – 80563. Remaining vouchers in possession of author.

Etymology: calvaria (Latin feminine noun) means 'skull'. The shortened cribrum gives the anal shield a skull-like appearance.

Remarks

Ptilonyssus calvaria sp. n. is most similar to *P. sairae* Castro, 1948, described from *Tangara seledon* from Brazil, *P. japuibensis* Castro, 1948, described from *Ramphocelus carbo centralis* from Brazil, and *P. ludovicianus* Cerny, 1969, described from *Pheucticus ludovicianus* from Cuba. *Ptilonyssus sairae*, *P. japuibensis*, and *P. ludovicianus* are all members of the "*sairae*" species complex, and the morphological differences among them are minimal. As a result of the tenuous species boundaries between these species I performed the differential diagnosis based upon the original species descriptions. *Ptilonyssus calvaria* sp. n. is distinguished from these species by the following. Eight pairs of setae on podosomal shield; *P. japuibensis* and *P. ludovicianus* have seven pairs of setae. Podosomal shield posterior margin distinctly trilobed; *P. sairae* and *P. ludovicianus* podosomal shield posterior margin is not distinctly trilobed, it is straight. Five pairs of mesolateral setae of which are approximately equal length; *P. sairae* and *P. ludovicianus* have five pairs of mesolateral setae, and at least two pairs are twice as long as other mesolateral setae, *P. japuibensis* has four pairs of mesolateral setae, and at least two pairs are twice as long as other mesolateral setae. Paranal and postanal setae unequal length; *P. sairae*, *P. japuibensis*, and *P. ludovicianus* paranal and postanal setae approximately equal length. Cribrum in narrow band, not extending to posterior of anal shield; *P. sairae*, *P. japuibensis*, and *P. ludovicianus* cribrum does extend to posterior of anal shield. Pence and Casto (1976) reported that *P. sairae* from the White-throated Sparrow, *Zonotrichia albicollis*, had the cribrum restricted to a narrow band; however, in the "*sairae*" species complex mites that I examined from *Z. albicollis* from Manitoba the cribrum did extend to the posterior of the anal shield. Three pairs of hypostomal setae, hyp1 and hyp2 are blunt-tipped, and hyp3 are sharp-tipped; *P. sairae* and *P. japuibensis* have three pairs of sharp-tipped hypostomal setae, *P. ludovicianus* original species description does not mention the hypostomal setae or provide illustrations.

Ptilonyssus nivalis sp. n.

(Figs. 3.17-22, 3.45)

Diagnosis: Medium-sized mites with the characteristics of the genus *Ptilonyssus*, with podosomal and opisthosomal shields. Characters that distinguish this species from closely related species include three pairs of mesolateral setae, six pairs of dorsal opisthosomal setae, opisthosomal shield shape, two pairs of hypostomal setae, seven pairs of ventral opisthosomal setae, and sternal shield pattern.

Female (based on holotype and two paratypes): LB 650 (615 – 628, 631). WID 298 (275 – 295, 289). LPS 175 (178 – 183, 178). WPS 173 (175 – 180, 176). LOS 185 (183 – 188, 185). WOS 150. LSS 90 (85 – 88, 88). WSS 66 (63 – 65, 65). LGS 65 (68 – 70, 68). WGS 40. LAS 78. WAS 53 (53 – 58, 54). LG 100. WG 65. LCH 61 (63 – 65, 63). WCH 14. LLeg I 228 (208 – 213, 216). LLeg II 163 (163 – 178, 168). LLeg III 175 (163 – 175, 171). LLeg IV 225 (200 – 223, 216).

Dorsum: Podosomal and opisthosomal shields lightly sclerotized with areas of muscle insertions as illustrated (Fig. 3.17). Podosomal shield bearing nine pairs of setae (eight pairs very short sharp-tipped, one pair short blunt-tipped). Subposterior setae on posterior margin of podosomal shield much shorter than mesolateral setae. Opisthosomal shield bearing four pairs of setae (three pairs very short sharp-tipped (J1-3), one pair short blunt-tipped (J4)), three pairs of pores. Podosomal shield rounded anteriorly, widest medially, laterally excavated at level of coxa III, trilobed posterior margin. Mesosomal shieldlets present. Opisthosomal shield anterior margin straight, widest anteriorly, laterally excavated posteriorly, tapering to bilobed invaginated posterior margin. Three pairs of short setae in integument alongside podosomal shield, all approximately equal length. Six pairs of short blunt-tipped setae (Z1-4, R1, R2) in integument alongside opisthosomal shield. Dorsal opisthosomal setae R2 unpaired in holotype (left R2 absent), and one paratype (right R2 absent). Setae R1 and R2 unpaired in one paratype (left R1, and right R2 absent). Stigmata dorsolateral, at level of coxa III.

Venter: Sternal shield with distinct margins and scaling pattern resulting from horizontal striations. Three pairs of short blunt-tipped setae (st1-3) on shield, short blunt-tipped metasternal setae (st4) in integument posterior of shield. Genital shield narrow, lightly sclerotized bearing pair of short blunt-tipped setae (gen1), pair of pores in integument off shield. Anal shield with moderately sclerotized lateral margins, distally tapering blunt-tipped paranal and postanal setae, paranal setae anterior to anal opening, paranal and postanal setae unequal length. Seven pairs of short blunt-tipped setae (JV1-4, ZV1-3) on ventral opisthosoma. Ventral opisthosomal setae ZV1 unpaired in holotype, paired in paratypes.

Gnathosoma: Very short blunt-tipped subcapitular setae, two pairs hypostomal setae (hyp2-3), six deutosternal teeth. Chaetotaxy of palps: 0-1-2-11. Tibia-tarsus sensory area with four very short setae. Chelicerae widest proximally, tapering distally, with small sharp-tipped moveable and fixed digits (Fig. 3.45).

Legs: Claws of legs I-IV strongly curved. Chaetotaxy of legs: Coxa 2-2-2-1. Trochanter 4-4-4-4. Femur 9-8-5-5. Genu 6-6-6-5. Tibia 6-6-5-6. Tarsus 19-15-15-16. Tarsus IV ventral subapical setal pair long with one as a strong spike and the other a filamentous spike; tarsus II-III subapical setal pair long strong spikes.

Male, nymphs, larva: Unknown.

Taxonomic summary

Type host: Plectrophenax nivalis Linnaeus, 1758, Snow Bunting.

Type locality and collection date: Three mites from Oak Hammock Marsh, Manitoba (50°11'N, 97°07'W), 1st December 2002.

Types: ♀ holotype, ♀ paratype CNCI&A Nos. 23516, 23517. One ♀ paratype JBWME No. 0003056.

Etymology: nivalis, derived from the specific epithet of the Snow Bunting, *Plectrophenax nivalis* (nix, nivis, a Latin feminine noun).

Remarks

Ptilonyssus nivalis sp. n. is most similar to *P. emberizae* Fain, 1956, described from *Emberiza flaviventris* from Ruanda-Urundi, and *P. fringillae* Fain and Sixl, 1971, described from *Fringilla coelebs* from Austria. *Ptilonyssus nivalis* sp. n. is distinguished from these species by the following. Three pairs of mesolateral setae; *P. emberizae* and *P. fringillae* have four pairs of mesolateral setae. Six pairs of dorsal opisthosomal setae; *P. emberizae* has four pairs of setae, *P. fringillae* has five pairs of setae. Opisthosomal shield laterally excavated posteriorly and posterior margin invaginated; *P. emberizae* opisthosomal shield lateral margins are less excavated and the posterior margin is rounded. Two pairs hypostomal setae; *P. fringillae* has three pairs of setae. Seven pairs of ventral opisthosomal setae; *P. emberizae* and *P. fringillae* have six pairs of setae. Sternal shield with distinct scaling pattern; *P. fringillae* has poorly developed scaling pattern.

Ptilonyssus pinicola sp. n.

(Figs. 3.23-30, 3.46-47)

Diagnosis: Large-sized mites with the characteristics of the genus *Ptilonyssus*, with podosomal and opisthosomal shields. Characters that distinguish this species from closely related species include, relatively long subposterior setae on posterior margin of podosomal shield, presence and form of a vestigial tritosternum, paranal and postanal setae of unequal length, seven pairs of ventral opisthosomal setae, form of hypostomal setae, and differences in leg chaetotaxy, distinguish this from closely related species.

Female (based on holotype and four paratypes): LB 920 (790 – 960, 886). WID 410 (375 – 430, 409). LPS 234 (230 – 245, 236). WPS 215 (215 – 230, 219). LOS 258 (260 – 293, 271). WOS 170 (166 – 193, 178). LSS 105 (113 – 118, 115). WSS 103 (78 – 98, 93). LGS 116 (118 – 123, 119). WGS 79 (75 – 79, 77). LAS 108 (98 – 109, 103). WAS 80 (68 – 83, 77). LG 125 (115 – 130, 124). WG 85 (70 – 88, 81). LCH 78 (75 – 80, 78). WCH 18 (15 – 18, 17). LLeg I 285 (293 – 325, 302). LLeg II 240 (213 – 243, 231). LLeg III 245 (225 – 253, 241). LLeg IV 310 (280 – 315, 300).

Dorsum: Podosomal and pygidial shields sclerotized with areas of muscle insertions as illustrated (Fig. 3.23). Podosomal shield bearing seven pairs of setae (four pairs short sharp-tipped, three pairs long filamentous tipped). Podosomal shield in holotype bearing 13 setae, one mesolateral setae unpaired; in paratypes all podosomal shield setae are paired. Setae on anterolateral and posterolateral corners of podosomal shield are much longer than other dorsal idiosomal setae. Subposterior setae on posterior margin of podosomal shield longer than mesolateral setae. Opisthosomal shield bearing four pairs of setae (three pairs short filamentous tipped (J1-3), one pair short conical pointed (J4)). Podosomal shield rounded anteriorly, widest medially, very slight lateral excavation level with coxa III, trilobed posterior margin. Opisthosomal shield anterior margin medially straight with anterolateral projections, widest medially tapering to rounded posterior. Four pairs of short blunt-tipped setae in integument alongside podosomal shield, all approximately equal length. Six pairs of short filamentous tipped setae (Z1-4, R1, R2) in integument alongside opisthosomal shield. Stigmata dorsolateral, at level of coxa III.

Venter: very short blunt-tipped vestigial tritosternum level with coxa I. Sternal shield with distinct margins, bearing three pairs of sharp-tipped setae (st1-3) and two pairs of pores. Short sharp-tipped metasternal setae (st4) in integument posterior of shield. Lightly sclerotized genital shield bearing short sharp-tipped setae (gen1), pair of pores in integument off shield. Anal shield with distally tapering sharp-tipped paranal and postanal setae, paranal setae level with anal opening, paranal and postanal setae unequal length. Seven pairs sharp-tipped setae (JV1-4, ZV1-3) on ventral opisthosoma. Ventral opisthosomal setae ZV1 unpaired in holotype, paired in paratypes.

Gnathosoma: Short blunt-tipped subcapitular setae, three pairs blunt-tipped hypostomal setae (hyp1-3), six deutosternal teeth. Chaetotaxy of palps: 0-3-3-14. Tibia-tarsus sensory area with eight short setae. Chelicerae widest proximally, tapering distally, with small sharp-tipped moveable and fixed digits (Fig. 3.46).

Legs: Claws of legs I-IV strongly curved. Chaetotaxy of legs: Coxa 2-2-2-1. Trochanter 4-4-4-5. Femur 10-8-5-5. Genu 6-4-5-3. Tibia 7-7-6-5. Tarsus 23-17-18-17. Tarsus II-IV ventral subapical setal pair long strong spikes.

Male (based on allotype and three paratypes): LB 585 (500 – 660, 598). WID 283 (263 – 288, 274). LPS 209 (178 – 215, 204). WPS 204 (205 – 220, 212). LOS 220 (203 – 235, 222). WOS 180 (178 – 183, 180). LSGS 203 (190 – 195, 195). WSGS 83 (78 – 88, 83). LVS 93 (93 – 103, 97). WVS 100 (83 – 103, 92). LAS 88 (80 – 91, 87). WAS 71 (60 – 65, 65). LG 108 (98 – 100, 101). WG 83 (81 – 88, 83). LCH 65 (63 – 68, 65). WCH 20. LLeg I 238 (235 – 258, 245). LLeg II 175 (175 – 196, 184). LLeg III 179 (193 – 200, 191). LLeg IV 218 (208 – 235, 223).

Dorsum: Podosomal and opisthosomal shields lightly sclerotized, areas of muscle insertions were not observed (Fig. 3.29). Podosomal shield bearing six pairs of sharp-tipped setae. Setae on anterolateral and posterolateral corners of shield much longer than other dorsal idiosomal setae. Opisthosomal shield bearing four pairs of setae (three pairs short filamentous tipped (J1-3), one pair short conical pointed (J4)). Podosomal shield rounded anteriorly, widest medially, without lateral excavations, trilobed posterior margin. Opisthosomal shield anterior margin medially straight with slight anterolateral projections, widest medially tapering to rounded posterior. Four pairs of short sharp-tipped setae in integument alongside podosomal shield. Four pairs of short filamentous tipped setae in integument alongside opisthosomal shield. Stigmata dorsolateral, at level of coxa III.

Venter: Sternogenital shield with distinct margins, bearing five pairs of sharp-tipped setae (st1-4, gen1), and two pairs of pores, pair of pores in integument posterior of shield. Ventral shield of irregular shape, widest anteriorly, bearing three pairs of sharp-tipped setae. Anal shield with filamentous tipped paranal and postanal setae, paranal setae level with anal opening, paranal and postanal setae unequal length. Four pairs of sharp-tipped setae on ventral opisthosoma.

Gnathosoma: Short blunt-tipped subcapitular setae, three pairs blunt-tipped hypostomal setae (hyp1-3, hyp1 larger distally inflated and bulb-like), six deutosternal teeth. Chaetotaxy of palps: 0-2-2-12. Tibia-tarsus sensory area with eight short setae. Chelicerae widest proximally, tapering slightly to relatively large digits, with short and slender spermadactyl attached (Fig. 3.47).

Legs: Claws of legs I-IV strongly curved. Chaetotaxy of legs: Coxa 2-2-2-1. Trochanter 4-4-4-5. Femur 9-8-5-5. Genu 6-4-5-3. Tibia 6-7-6-5. Tarsus 22-17-17-16. Tarsus II-IV ventral subapical setal pair long strong spikes.

Protonymph (based on two protonymphs): LB 675 and 585. WID 350 and 370. LPS 180 and 173. WPS 165 and 163. LpS 43. WpS 80. LSS 100 and 103. WSS 73 and 70. LAS 73. WAS 54 and 58. LG 88 and 85. WG 75 and 80. LCH 66. WCH 16 and 18. LLeg I 200 and 185. LLeg II 153 and 158. LLeg III 163 and 165. LLeg IV 188 and 190.

Dorsum: Podosomal and pygidial shields lightly sclerotized, areas of muscle insertions were not observed. Podosomal shield bearing six pairs of setae. Setae on anterolateral and posterolateral corners of shield are much longer than other dorsal idiosomal setae, except setae J4. Pygidial shield of variable shape, always wider than long, bearing one pair of very long, barbed, sharp-tipped setae (J4) 41 long. Podosomal shield anterior margin either rounded or bearing a short medial projection, widest medially, slightly trilobed posterior margin. Mesosomal shieldlets present. Five pairs of setae (two pairs sharp-tipped, three pairs blunt-tipped) and one pair of pores in integument alongside podosomal shield. Eight pairs of short filamentous-tipped setae (J1-3, Z1-3, R1, R2) on dorsal opisthosoma. Stigmata dorsolateral, at level of coxa III.

Venter: Sternal shield lightly sclerotized, bearing three pairs of setae (st1, st2 sharp-tipped, st3 filamentous tipped) and two pairs of pores. Pair of genital pores located in similar location as in adult females. Anal shield bearing filamentous-tipped paranal and postanal setae, paranal setae level to anal opening, paranal and postanal setae unequal length. Five pairs of short filamentous-tipped setae (JV1-4, ZV2) on ventral opisthosoma.

Gnathosoma: Short blunt-tipped subcapitular setae, three pairs blunt-tipped hypostomal setae (hyp1-3, where hyp1 larger distally inflated bulb-like setae), seven deutosternal teeth. Palp chaetotaxy could not be reliably determined due to specimen condition. Chelicerae widest proximally, tapering distally, with small sharp-tipped moveable and fixed digits.

Legs: Claws of legs I-IV strongly curved. Chaetotaxy of legs: Coxa 2-2-2-1. Trochanter 4-4-4-4. Femur 10-7-5-5. Genu 6-4-5-4. Tibia 7-7-6-5. Tarsus 24-17-17-17. Tarsus II and III ventral subapical setal pair spikes with short filamentous tips, tarsus IV subapical setal pair strong spikes.

Deutonymph, larva: Unknown.

Taxonomic summary

Type host: Pinicola enucleator Linnaeus, 1758, Pine Grosbeak.

Type locality and collection date: Four mites from Coyote Lake Nature Sanctuary, Alberta (53°16'06"N, 114°32'06"W), 5th December 2002, coll. PMA.

Additional localities and collection dates: One mite from Barrhead, Alberta (54°07'23"N, 114°24'07"W), 8th December 1996, coll. PMA. Nine mites from Millet, Alberta (53°05'52"N, 113°28'22"W), 14th February 1995, same collector. Eight mites from Barrhead, Alberta (54°07'23"N, 114°24'07"W), same collector. Five mites from Pinawa, Manitoba (50°09'N, 5°53'W), 12th February 2005, coll. T. Galloway and C. Dugal.

Types: ♀ holotype CNCI&A No. 23515. One ♀ paratype JBWME 0003055. One ♀ paratype ZIN No. 9989. One ♀ paratype, allotype ♂ UASM Nos. 80564, 80565. Remaining vouchers in possession of author.

Etymology: pinicola, derived from the generic name of the Pine Grosbeak, *Pinicola* (Latin feminine noun).

Remarks

Ptilonyssus pinicola sp. n. is most similar to *P. plesiotypicus* sp. n., described herein from *Carpodacus purpureus* from Alberta, and *P. carduelis* Fain, 1962, described from *Carduelis cannabina* from Belgium. *Ptilonyssus pinicola* sp. n. is distinguished from these species by the following. Body length ranging from 790–960; *P. plesiotypicus* body length ranges 590–775, and *P. carduelis* body length 643. Subposterior setae on posterior margin of podosomal shield much longer than mesolateral setae; *P. carduelis* subposterior setae are not longer than mesolateral setae. Very short blunt-tipped vestigial tritosternum level with coxa I; *P. plesiotypicus* vestigial tritosternum is short and sharply pointed, *P. carduelis* lacks a vestigial tritosternum. Paranal and postanal setae unequal in length and tapered distally; *P. plesiotypicus* paranal and postanal setae proximally constricted and unequal in length, *P.*

carduelis paranal and postanal setae taper distally and are equal length. Seven pairs of ventral opisthosomal setae; *P. plesiotypicus* has eight pairs, *P. carduelis* has six pairs. Blunt-tipped peg-like hypostomal setae; *P. plesiotypicus* has blunt-tipped setae, where hyp1 is bulb-like and distally inflated, and *P. carduelis* has blunt-tipped peg-like setae similar to *P. pinicola* except they are relatively shorter in *P. carduelis*. Coxa I setae are blunt-tipped pegs; *P. carduelis* has one blunt-tipped peg seta and one sharp-tipped spike seta on coxa I. Five setae on femur IV and three setae on genu IV; *P. plesiotypicus* has six setae on femur IV and two setae on genu IV.

Ptilonyssus plesiotypicus sp. n.

(Figs. 3.31-36, 3.48)

Diagnosis: Medium-sized mites with the characteristics of the genus *Ptilonyssus*, with podosomal and opisthosomal shields. Characters that distinguish this species from closely related species include, the relatively long setae on posterolateral corners of podosomal shield, relatively long subposterior setae on posterior margin of podosomal shield, six pairs of dorsal opisthosomal setae, the presence and form of a vestigial tritosternum, anal setae that constrict proximally with a long filamentous tip, paranal and postanal setae of unequal length, eight pairs of ventral opisthosomal setae, three pairs of large distally inflated hypostomal setae, and differences in leg chaetotaxy.

Female (based on holotype and four paratypes): LB 650 (590 – 775, 674). WID 300 (295 – 375, 327). LPS 190 (193 – 205, 195). WPS 183 (178 – 198, 187). LOS 225 (209 – 225, 218). WOS 170 (148 – 165, 160). LSS 105 (90 – 108, 102). WSS 100 (73 – 93, 89). LGS 88 (80 – 88, 86). WGS 63 (50 – 63, 58). LAS 85 (73 – 80, 79). WAS 63 (63 – 70, 65). LG 98 (83 – 95, 90). WG 73 (68 – 70, 69). LCH 63 (56 – 60, 59). WCH 13. LLeg I 230 (213 – 228, 223). LLeg II 188 (163 – 188, 178). LLeg III 180 (175 - 188, 179). LLeg IV 225 (208 – 220, 217).

Dorsum: Podosomal and opisthosomal shields lightly sclerotized, areas of muscle insertions were not observed (Fig. 3.31). Podosomal shield bearing seven pairs of setae (four pairs short sharp-tipped, three pairs long filamentous tipped) and three pairs of pores. Setae on anterolateral and posterolateral corners of podosomal shield much longer than other dorsal idiosomal setae. Subposterior setae on posterior margin of podosomal shield much longer than mesolateral setae. Opisthosomal shield bearing four pairs of setae (three pairs short filamentous tipped setae (J1-3), one pair short conical pointed setae (J4)). Podosomal shield rounded anteriorly, widest medially, without lateral excavation, trilobed posterior margin. Opisthosomal shield anterior margin medially straight with anterolateral projections, widest anteriorly, tapering to rounded posterior. Four pairs of short sharp-tipped setae in integument alongside podosomal shield, all approximately equal length. Six pairs of short filamentous tipped setae (Z1-4, R1, R2) in integument alongside opisthosomal shield. Stigmata dorsolateral, at level of coxa III.

Venter: Short sharply pointed vestigial tritosternum level with coxa I. Sternal shield with distinct margins, bearing three pairs of short setae (st1 and st2 sharp-tipped, st3 filamentous tipped), and two pairs of pores. Short sharp-tipped metasternal setae (st4) in integument posterior of shield. Lightly sclerotized genital shield bearing short filamentous tipped setae (gen1), pair of pores in integument off shield. Anal shield distinct, paranal and postanal setae constricted from 1/3 of length from base to form long filamentous tips, paranal setae level with anal opening, paranal and postanal setae unequal length. Eight pairs of filamentous tipped setae (JV1-4, ZV1-3, UR1), one pair of pores on ventral opisthosoma.

Gnathosoma: Short blunt-tipped subcapitular setae, three pairs blunt-tipped hypostomal setae (hyp1-3, hyp1 larger distally inflated and bulb-like), five deutosternal teeth. Chaetotaxy of palps: 0-2-3-12. Tibia-tarsus sensory area with seven short setae. Chelicerae widest proximally, tapering distally with small sharp-tipped moveable and fixed digits (Fig. 3.48).

Legs: Claws of leg I curved, of legs II-IV strongly curved. Chaetotaxy of legs: Coxa 2-2-2-1. Trochanter 4-4-4-5. Femur 10-8-5-6. Genu 6-4-5-2. Tibia 7-7-6-5. Tarsus 22-18-17-17. Tarsus II-IV ventral subapical setal pair long strong spikes.

Male, nymphs, larva: Unknown.

Taxonomic summary

Type host: Carpodacus purpureus Gmelin, 1789, Purple Finch.

Type locality and collection date: Five mites from Alberta, 4th May 1996, coll. PMA (Provincial Museum of Alberta).

Types: ♀ holotype CNCI&A No. 23512. Two ♀ paratypes UASM Nos. 80559, 80560. Two ♀ paratypes in possession of author.

Etymology: plesiotypic (latinized Greek masculine adjective), in the cladistic sense meaning 'primitive character'. Named for the presence of a plesiomorphic character, a vestigial tritosternum.

Remarks

Ptilonyssus plesiotypicus sp. n. is most similar to *Ptilonyssus pinicola* sp. n., described herein from *Pinicola enucleator* from Alberta, *P. carduelis* Fain, 1962, described from *Carduelis cannabina* from Belgium, and *P. melissae* Spicer, 1977, described from *Carpodacus purpureus* from Texas. *Ptilonyssus plesiotypicus* sp. n. is distinguished from these species by the following characters. Body length ranging from 590–775; *P. pinicola* body length ranges 790–960, and *P. melissae* body length ranges 561–668. Relatively long setae on posterolateral corners of podosomal shield; *P. melissae* has much shorter setae on the posterolateral corners. Subposterior setae on posterior margin of podosomal shield much longer than mesolateral setae; *P. carduelis* and *P. melissae* subposterior setae are not longer than mesolateral setae. Six pairs of setae in integument alongside opisthosomal shield; *P. melissae* has five pairs. Short sharply pointed vestigial tritosternum level with coxa I; *P. pinicola* vestigial tritosternum is very short and blunt-tipped, *P. carduelis* and *P. melissae* lack a vestigial tritosternum. Paranal and postanal setae constrict proximally (within 1/3 of length from base) forming long filamentous tips; *P. pinicola*, *P. carduelis* and *P. melissae* anal setae taper distally. Paranal setae level with anal opening, and longer than the postanal seta; *P. carduelis* paranal and postanal setae equal length, *P. melissae* paranal setae anterior to anal opening and no longer than the postanal seta. Eight pairs of ventral opisthosomal setae; *P. pinicola* and *P. melissae* have seven pairs, and *P. carduelis* has six pairs. Three pairs of blunt-tipped hypostomal setae, where hyp1 is bulb-like and distally inflated; *P. pinicola* and *P. carduelis* have three pairs of hypostomal setae, but hyp1 is not bulb-like or distally inflated, *P. melissae* has one pair of hypostomal setae, and does not appear to be distally inflated and bulb-like. Coxa I setae are blunt-tipped pegs; *P. carduelis* has one blunt-tipped peg seta and one sharp-tipped spike seta on coxa I, *P. melissae* coxa I setae are sharp-tipped spikes. Six setae on femur IV and two setae on genu IV; *P. pinicola* has five setae on femur IV and three setae on genu IV.

Family Rhinonyssidae Trouessart, 1895

Genus *Sternostoma* Berlese and Trouessart, 1889

Diagnosis: Peritreme absent, gnathosoma ventroterminal, anus terminal, one or two dorsal shields. Chelicerae distally attenuated and digits minute, less than $^1/_{10}$ the length of the chelicerae.

***Sternostoma setifer* sp. n.**

(Figs. 3.37-42, 3.49)

Diagnosis: Medium-sized mites with the characteristics of the genus *Sternostoma*, with podosomal and opisthosomal shields. Characters that distinguish this species from closely related species include, three pairs of setae on the opisthosomal shield, four pairs of dorsal opisthosomal setae, genital setal pair off the genital shield, paranal setae on the anal shield, comparatively long posterolateral palp genu seta, one pair of hypostomal setae, form of the apical ventral setal pair on tarsus I, form of the ventral, ventrolateral and apical setae on tarsus II-IV.

Female (based on holotype and one paratype): LB 535 (575, 555). WID 268 (325, 296). LPS 160 (165, 163). WPS 180. LOP 135. WOS 143 (145, 144). LSS 104 (105, 104). WSS 89 (84, 86). LGS 100. WGS 70 (73, 71). LAS 60 (58, 59). WAS 53 (45, 49). LG 78. WG 75 (65, 70). LCH 64 (60, 62). WCH 20 (19, 19). LLeg I 190 (205, 198). LLeg II 140 (158, 149). LLeg III 163 (175, 169). LLeg IV 200 (203, 201).

Dorsum: Podosomal and opisthosomal shields lightly sclerotized with areas of muscle insertions as illustrated (Fig. 3.37). Podosomal shield bearing eight pairs and opisthosomal shield with three pairs of short sharp-tipped setae. Podosomal shield triangular, rounded anteriorly, widest posteriorly, posterior margin straight.

Opisthosomal shield widest anteriorly, with slight lateral excavation. Four pairs of short sharp-tipped setae in integument alongside opisthosomal shield. Stigmata dorsolateral, at level to podosomal shield posterior margin.

Venter: Sternal shield lightly sclerotized with distinct margins and three pairs of blunt-tipped setae (st1-3) on shield. Genital shield broad, lightly sclerotized with pair of short sharp-tipped genital setae (gen1) in integument off shield. Anal shield with heavily sclerotized lateral margins; cribrum and blunt-tipped paranal setae on dorsum posterior to anal opening. Three pairs of short sharp-tipped setae on ventral opisthosoma.

Gnathosoma: One pair of minute blunt-tipped hypostomal setae present, gnathosoma positioned ventrally, deutosternal groove absent. Chaetotaxy of palps: 0-4-4-11. Tibia-tarsus sensory area with five minute setae. Posterolateral palp genu seta as long or longer than palp genu. Chelicerae widest proximally, tapering distally, with small sharp-tipped moveable and fixed digits (Fig. 3.49).

Legs: Claws leg I straight, slightly curved at tip, of legs II-IV strongly curved. Chaetotaxy of legs: Coxa 1-2-2-1. Trochanter 3-2-4-4. Femur 10-7-5-4. Genu 10-6-6-4. Tibia 8-6-5-5. Tarsus 22-19-19-19. Tarsus I apical ventral setal pair with truncate tip. Tarsus II-IV with ten pairs relatively long (9.4 μm) cylindrical blunt-tipped ventral and ventrolateral setae.

Male, nymphs, larva: Unknown.

Taxonomic summary

Type host: Empidonax minimus Baird & Baird, 1843, Least Flycatcher.

Type locality and collection date: Two mites from Delta Marsh, Manitoba (98°23'W, 50°11'N), 11th June 2001, coll. T. Galloway and D. Holder.

Types: ♀ holotype CNCI&A No. 23518. One ♀ paratype JBWME No. 0003057.

Etymology: setifer (Latin masculine adjective), meaning 'bearer of setae'.

Remarks

Sternostoma setifer sp. n. is most similar to *S. sayornis* Pence and Casto, 1975 described from *Sayornis nigricans* from Texas, *S. pencei* Spicer, 1984, described from *Empidonax flavescens* from Guatemala, *S. darlingi* Spicer, 1984, described from *Mitrephanes phaeocercus* from Guatemala, and *S. hedonophilum* Fain and Aitken, 1969 described from *Platyrinchus saturatus* from Brazil. *Sternostoma setifer* sp. n. is distinguished by the following. Three pairs of setae on the opisthosomal shield; *S. darlingi* has two pairs of setae on the shield. Four pairs of dorsal opisthosomal setae; *S. sayornis* has six pairs, *S. hedonophilum* has one pair. Stigmata not surrounded with sclerotized cuticle; *S. hedonophilum* stigmata surrounded with hardened cuticle. Genital setal pair off shield in integument; *S. sayornis* has no genital setae, *S. pencei, S. darlingi,* and *S. hedonophilum* genital setae on shield. Paranal setae on the anal shield; *S. sayornis, S. pencei,* and *S. darlingi* have no anal setae. Posterolateral palp genu seta as long or longer than palp genu; *S. sayornis, S. pencei, S. darlingi,* and *S. hedonophilum* posterolateral palp genu seta is clearly shorter than palp genu. One pair of hypostomal setae; *S. sayornis*, and *S. pencei* have no hypostomal setae, *S. darlingi* has two pairs, *S. hedonophilum* has three pairs. No subcapitular setae, while *S. hedonophilum* has subcapitular setae. Tarsus I apical ventral setal pair with truncate tip; *S. sayornis* setal pair with serrated tip and a single spine at one side, *S. hedonophilum* setal pair with bifurcate tip. Tarsus II-IV ventral and ventrolateral setae relatively long (9.4 µm) cylindrical blunt-tipped setae; *S. sayornis* and *S. hedonophilum* ventral and ventrolateral setae are relatively short and taper distally, *S. pencei* and *S. darlingi* ventral and ventrolateral setae are relatively short, but have the same cylindrical form.

Literature cited

Andrew, P., and I. McAllan. 1998. Nomina: Global Bird Dictionary, Relational Taxonomies. CSIRO Publishing, Collingwood, Australia.

Baker, E.W., T.M. Evans, D.J. Gould, W.B. Hull, and H.L. Keegan. 1956. A Manual of Parasitic Mites of Medical or Economic Importance. National Pest Control Association, New York.

Ballard, J.T., and R.A. Ring. 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.

Castro, M.P. 1948. Reestruturacao generica da familia Rhinonyssidae Vitzthum 1935 (Acari: Mesostigmata: Gamasides) e descraicao de algumas especies novas. Arquivos do Instituto Biologico **18**: 253-284.

Cerny, V. 1969. Six new nasal mites (Mesostigmata, Ptilonyssidae) from Cuban birds. Folia Parasitologica **16**: 227-235.

Clements, J.F. 1991. Birds of the World: A Checklist, 4th ed. Ibis Publishing, Vista, California.

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.

Evans, G.O. 1963. Observations on the chaetotaxy of the legs in the free-living Gamasina (Acari: Mesostigmata). Bulletin of the British Museum of Natural History Zoology **10**: 277-303.

Evans, G.O., and W.M. Till. 1965. Studies on the British Dermanyssidae (Acari: Mesostigmata). Pt. I external morphology. Bulletin of the British Museum (Natural History) Zoology **13**: 249-294.

Ewing, H.E. 1936. A short synopsis of the North American species of the mites genus *Dermanyssus*. Proceedings of the Entomological Society of Washington **38**: 47-54.

Fain, A. 1956. Les acariens de la famille Rhinonyssidae Vitzthum 1935 parasites des fosses nasales des oiseaux au Ruanda-Urundi (note preliminaire). Revue de Zoologie et de Botanique Africaines **53**: 131-157.

Fain, A. 1962. Les acariens parasites nasicoles des oiseaux de Belgique. I. Deux especes nouvelles de Rhinonyssidae (Mesostigmata) avec une liste des especes connues de Belgique. Bulletin and Annales de la Societe Royale d'Entomologie de Belgique **98**: 252-270.

Fain, A., and T.H.G. Aitken. 1969. Acariens nasicoles d'oiseaux et de mammiferes du Bresil III. Nouvelles especes de Rhinonyssidae de la region de Belem (Nord Bresil). Bulletin and Annales de la Societe Royale d'Entomologie de Belgique **105**: 342-415.

Fain, A., and K.E. Hyland. 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.

Fain, A., and W. Sixl. 1971. Two new rhinonyssids from Austrian birds (Acarina: Mesostigmata). Bulletin and Annales de la Societe Royale d'Entomologie de Belgique **107**: 89-93.

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

Hood, D.E., and H.E. Welch. 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. 1963. Current trends in the systematics of acarines endoparasitic in vertebrates. *In* Advances in acarology, J.A. Naegele (ed.). Comstock Publishing Associates, Ithaca, New York, p. 365-373.

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

Lindquist, E.E. and G.O. Evans. 1965. Taxonomic concepts in the Ascidae with a modified setal nomenclature for the idiosoma of the Gamasina (Acari: Mesostigmata). Memoirs of the Entomological Society of Canada **47**: 1-64.

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

Moss, W.W. 1978. The mite genus *Dermanyssus*: a survey, with description of *Dermanyssus trochilinis*, n.sp., and a revised key to the species (Acari: Mesostigmata: Dermanyssidae). Journal of Medical Entomology **14**: 627-640.

Moss, W.W., and F.J. Radovsky. 1967. *Dermanyssus hirsutus*, a new name for *Dermanyssus scutatus* Ewing (Acari: Mesostigmata: Dermanyssidae). Journal of the Kansas Entomological Society **40**: 277.

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 Texas Tech University **8**: 1-148.

Pence, D.B., and S. Casto. 1975. Two new species and new records of nasal mites of the genus *Sternostoma* (Acarina: Rhinonyssinae) from birds in Texas. The Journal of Parasitology **61**: 360-368.

Pence, D.B., and S. Casto. 1976. 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 R.W. Strandtmann. 1952. Nasal mites of the English sparrow. Texas Journal of Science **4**: 393-399.

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

Radovsky, F.J. 1994. The evolution of parasitism and the distribution of some dermanyssoid mites (Mesostigmata) on vertebrate hosts. *In* Mites: ecological and evolutionary analyses of life-history patterns, M.A. Houck (ed.). Chapman & Hall, New York, New York, p. 186–217.

Schrank, F.P. 1781. *Enumeratio Insectorum Austriae Indigenorum*. Klett : August Vindelicor. p. 548.

Spicer, G.S. 1977. Two new nasal mites of the genus *Ptilonyssus* (Mesostigmata: Rhinonyssidae) from Texas. Acarologia **18**: 594-601.

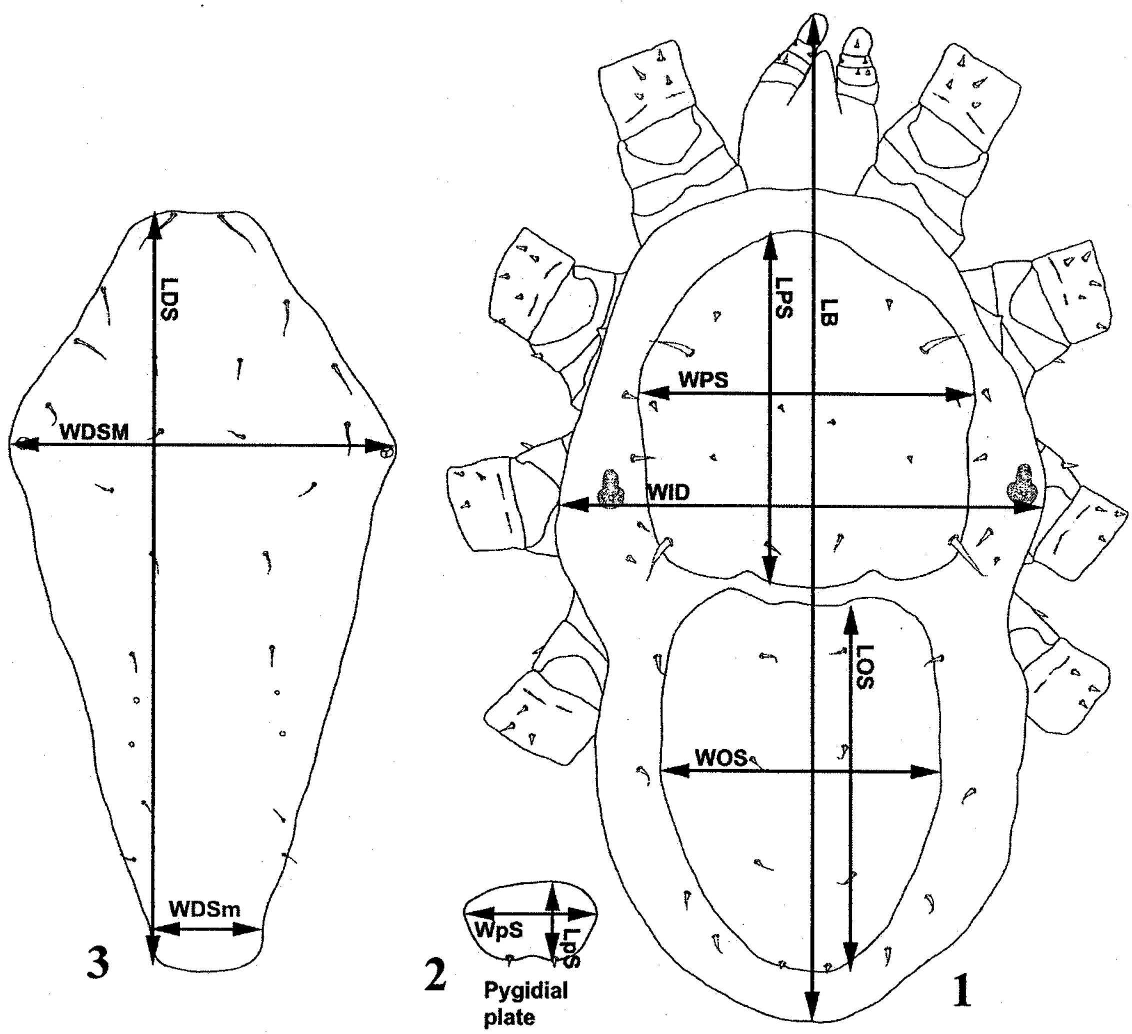
Spicer, G.S. 1984. Nasal mites from birds of a Guatemalan cloud forest (Acarina: Rhinonyssidae). Journal of Parasitology **70**: 794-802.

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

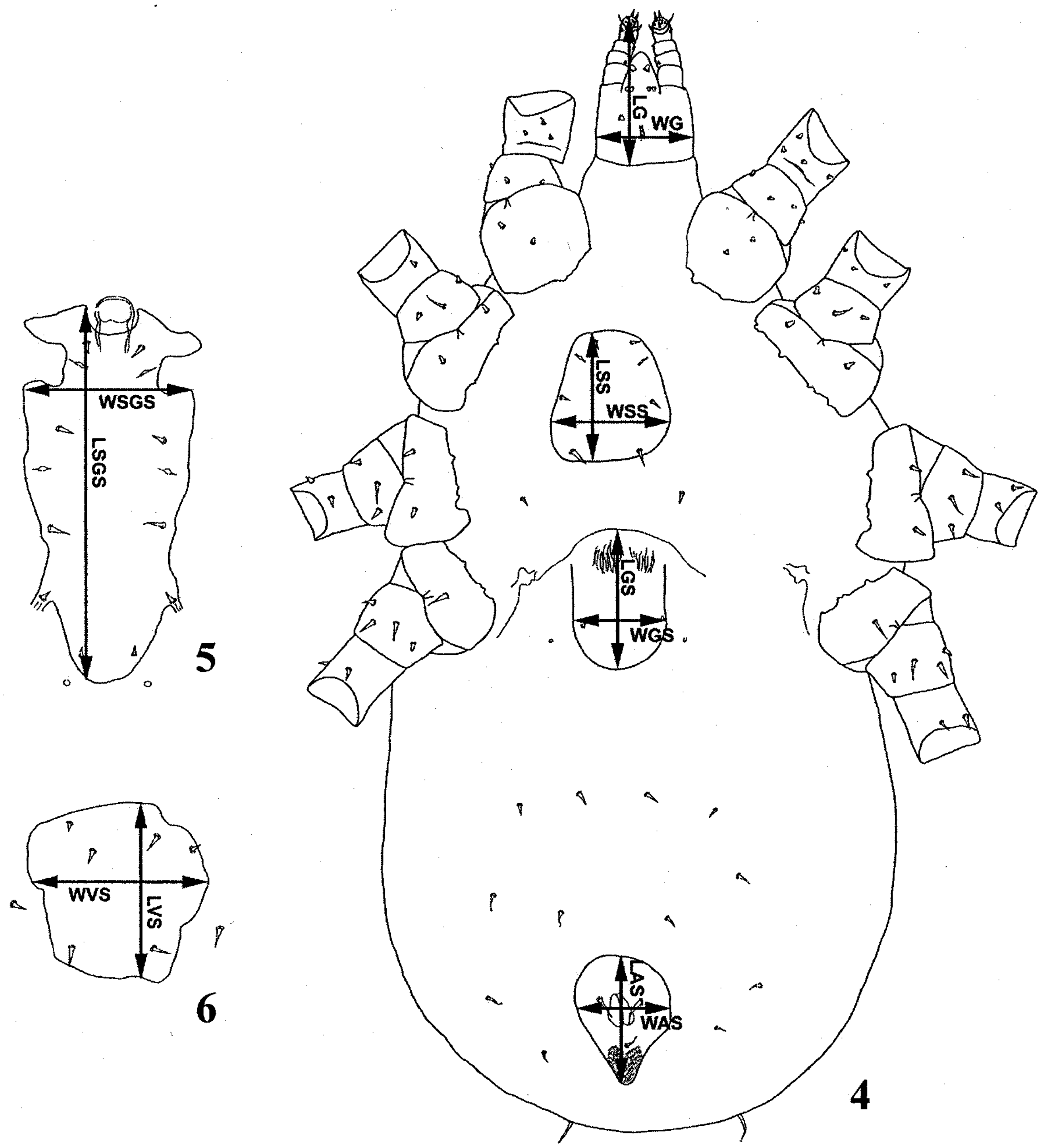
Stephan, S.A.R., V.R. Kaschula, and F.S. Canham. 1950. Respiratory acariasis of canaries. Journal of the South African Veterinary Medical Association **21**: 103-107.

Table 3.1. *Dermanyssus diphyes* sp. n. female leg chaetotaxy.

Leg segment	Leg number I	II	III	IV
coxa	2	2	2	1
trochanter	$0-\frac{0}{1},\frac{1}{2}-1$	$0-\frac{0}{1},\frac{1}{2}-1$	$1-\frac{0}{1},\frac{0}{1}-1$	$1-\frac{0}{2},\frac{0}{1}-1$
femur	$3-\frac{2}{2},\frac{2}{1}-1$	$3-\frac{2}{1},\frac{1}{1}-2$	$2-\frac{1}{1},\frac{0}{1}-0$	$0-\frac{2}{1},\frac{1}{1}-1$
genu	$2-\frac{2}{2},\frac{2}{1}-1$	$2-\frac{2}{1},\frac{1}{0}-0$	$2-\frac{2}{1},\frac{1}{0}-0$	$0-\frac{2}{1},\frac{2}{1}-1$
tibia	$2-\frac{2}{1},\frac{1}{1}-1$	$1-\frac{2}{1},\frac{1}{1}-1$	$1-\frac{2}{1},\frac{1}{1}-1$	$1-\frac{2}{1},\frac{1}{1}-1$



Figures 3.1-3.3. Dorsum measurements **1.** Rhinonyssid dorsum. **2.** Rhinonyssid pygidial shield. **3.** Dermanyssid dorsal shield.



Figures 3.4-3.6. Venter measurements **4.** Rhinonyssid venter. **5.** Rhinonyssid sternogenital shield. **6.** Rhinonyssid ventral shield.

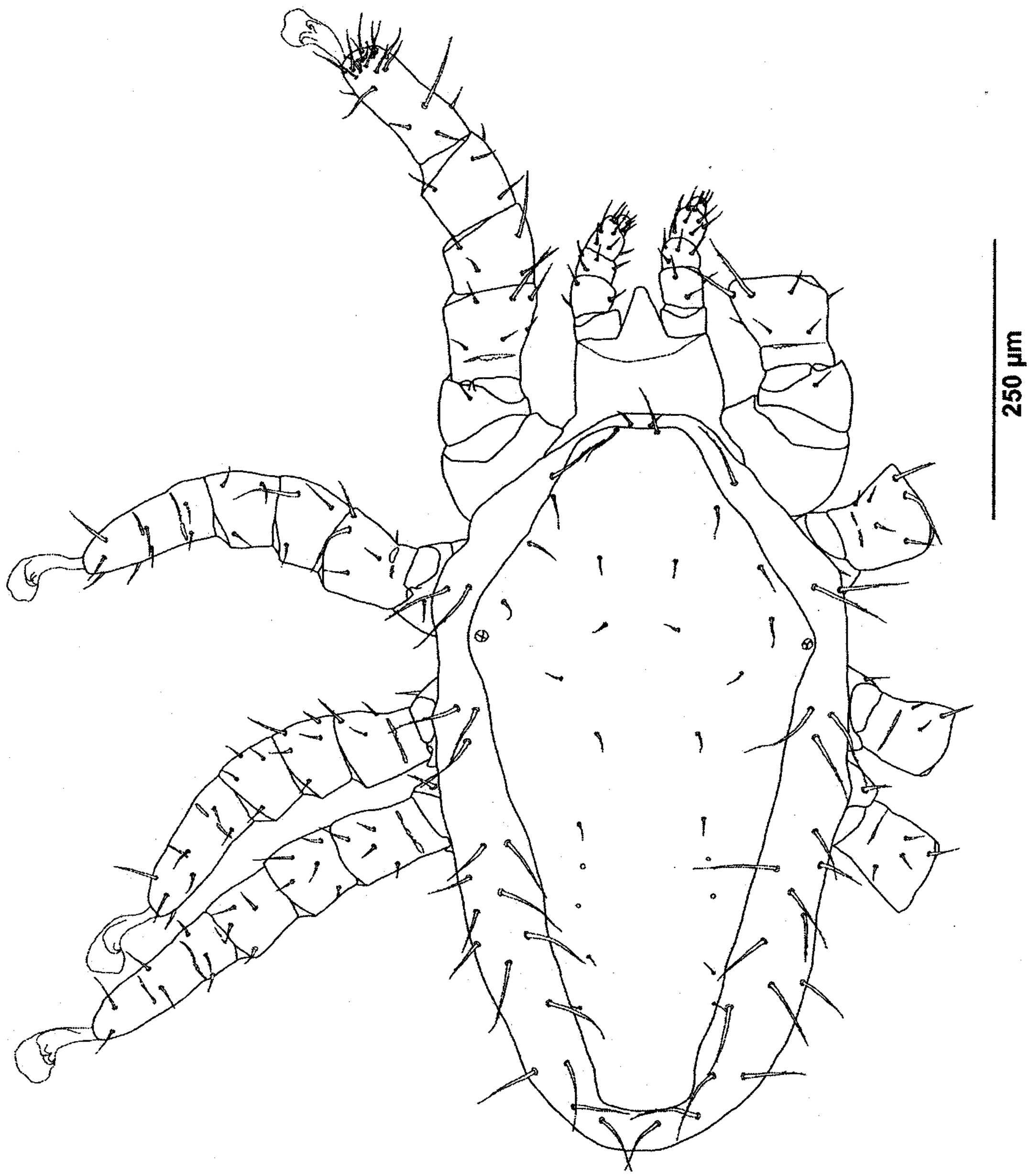


Figure 3.7. *Dermanyssus diphyes* sp. n. female dorsum.

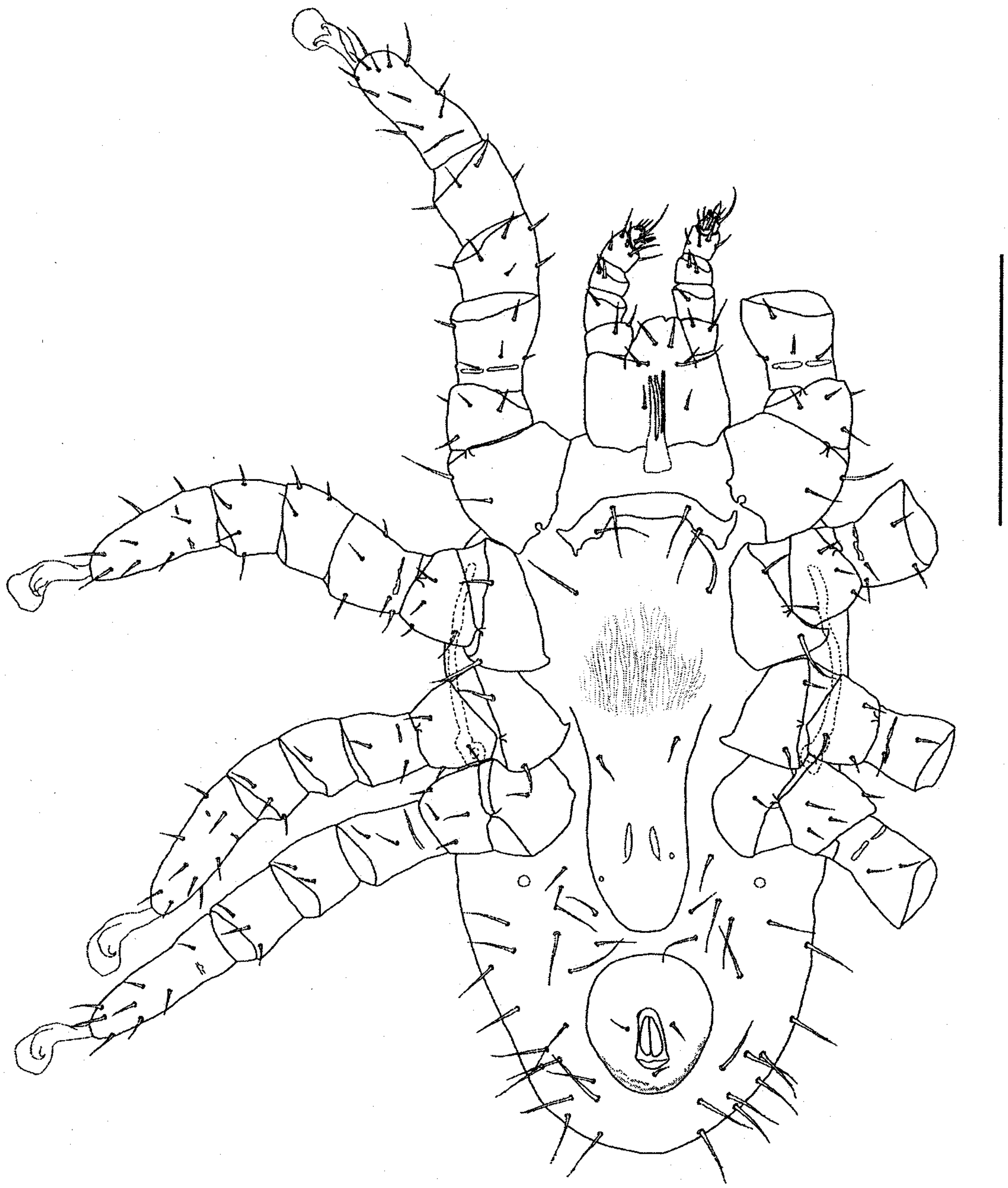
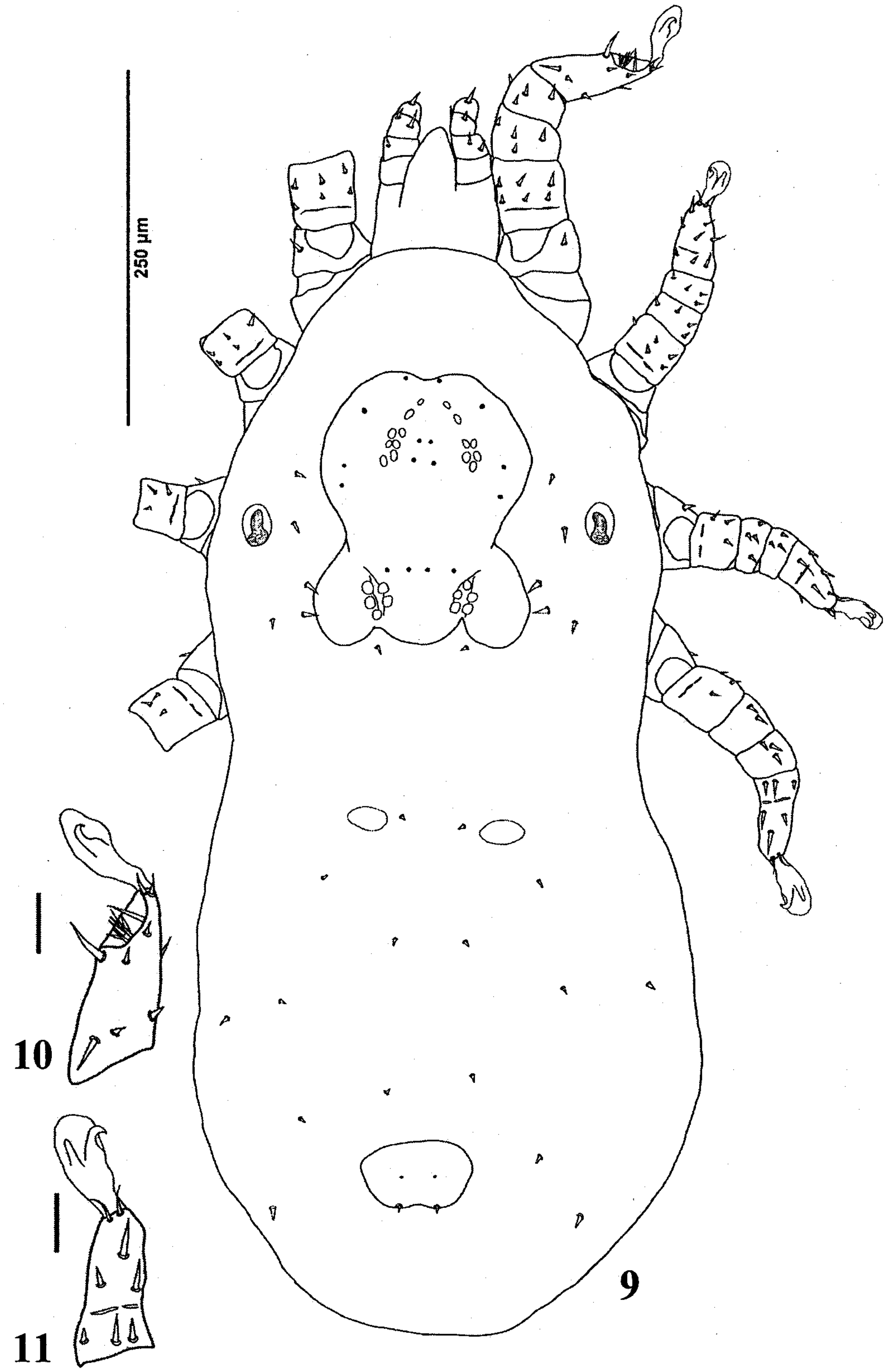
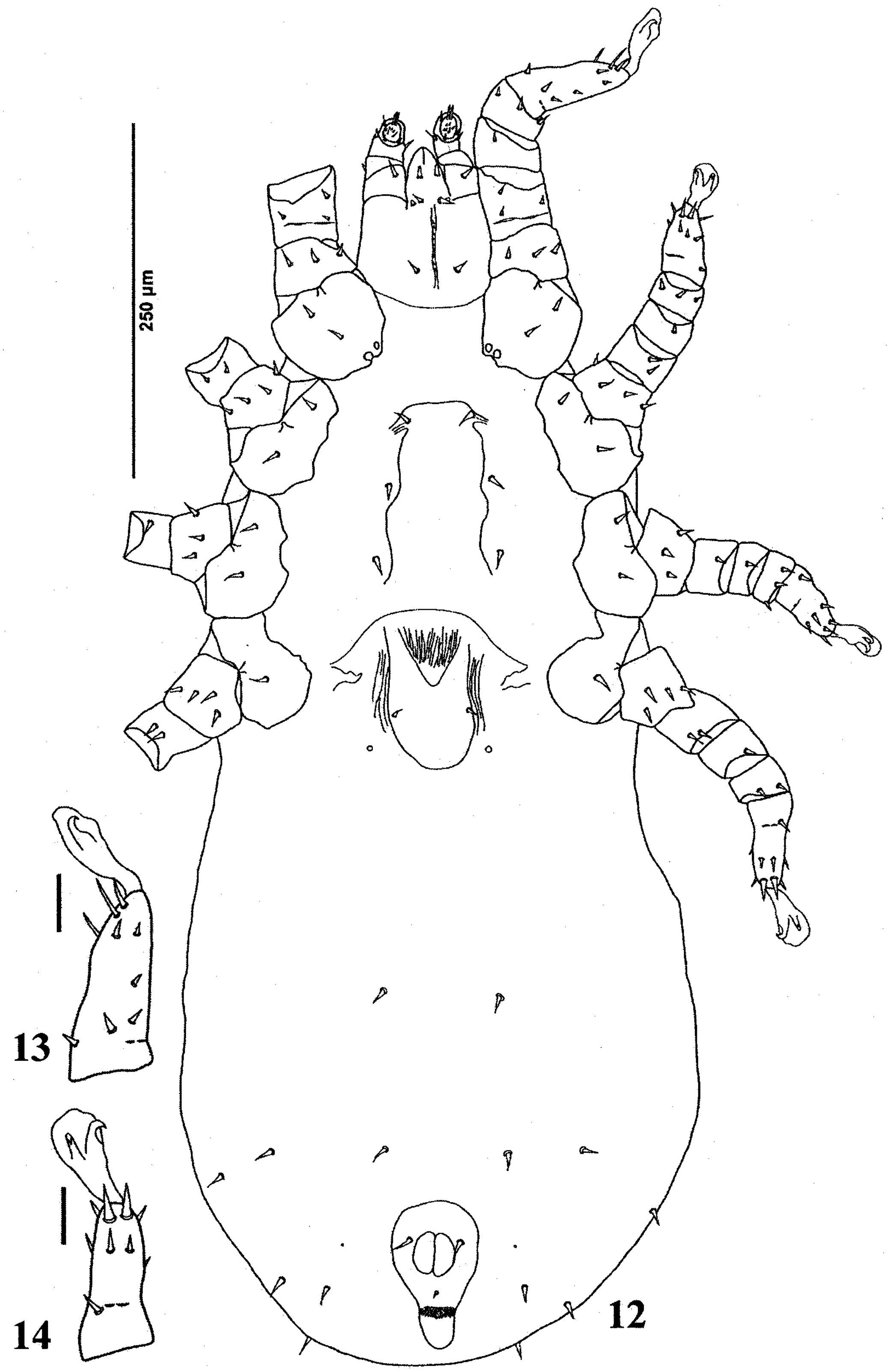


Figure 3.8. *Dermanyssus diphyes* sp. n. female venter.



Figures 3.9-3.11. *Ptilonyssus calvaria* sp. n. female. **9.** Dorsum. **10.** Dorsum of tarsus I. **11.** Dorsum of tarsus IV. Unlabelled scale bars 25 µm.



Figures 3.12-3.14. *Ptilonyssus calvaria* sp. n. female. **12.** Venter. **13.** Venter of tarsus I. **14.** Venter of tarsus IV. Unlabelled scale bars 25 µm.

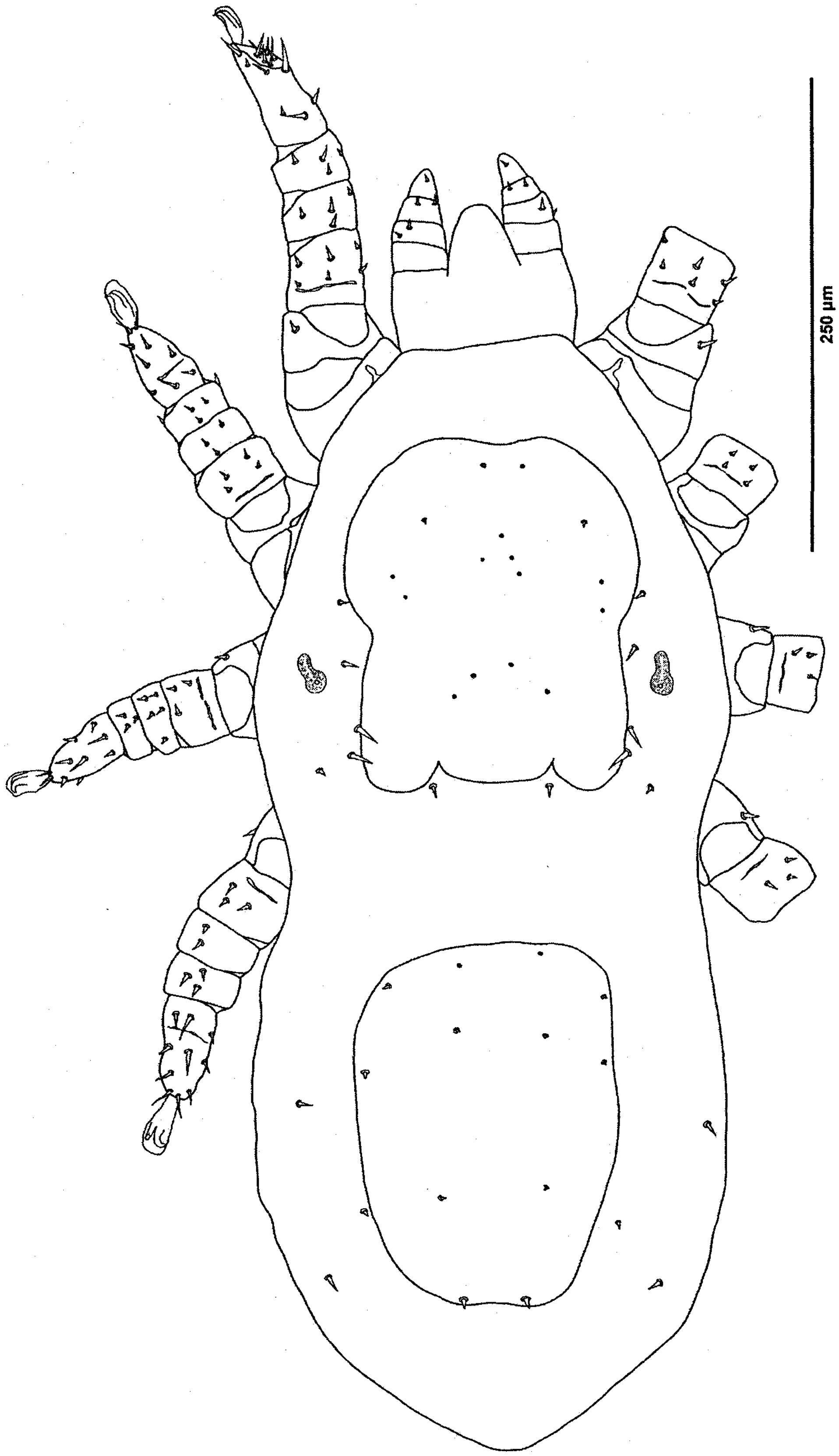


Figure 3.15. *Ptilonyssus calvaria* sp. n. male dorsum.

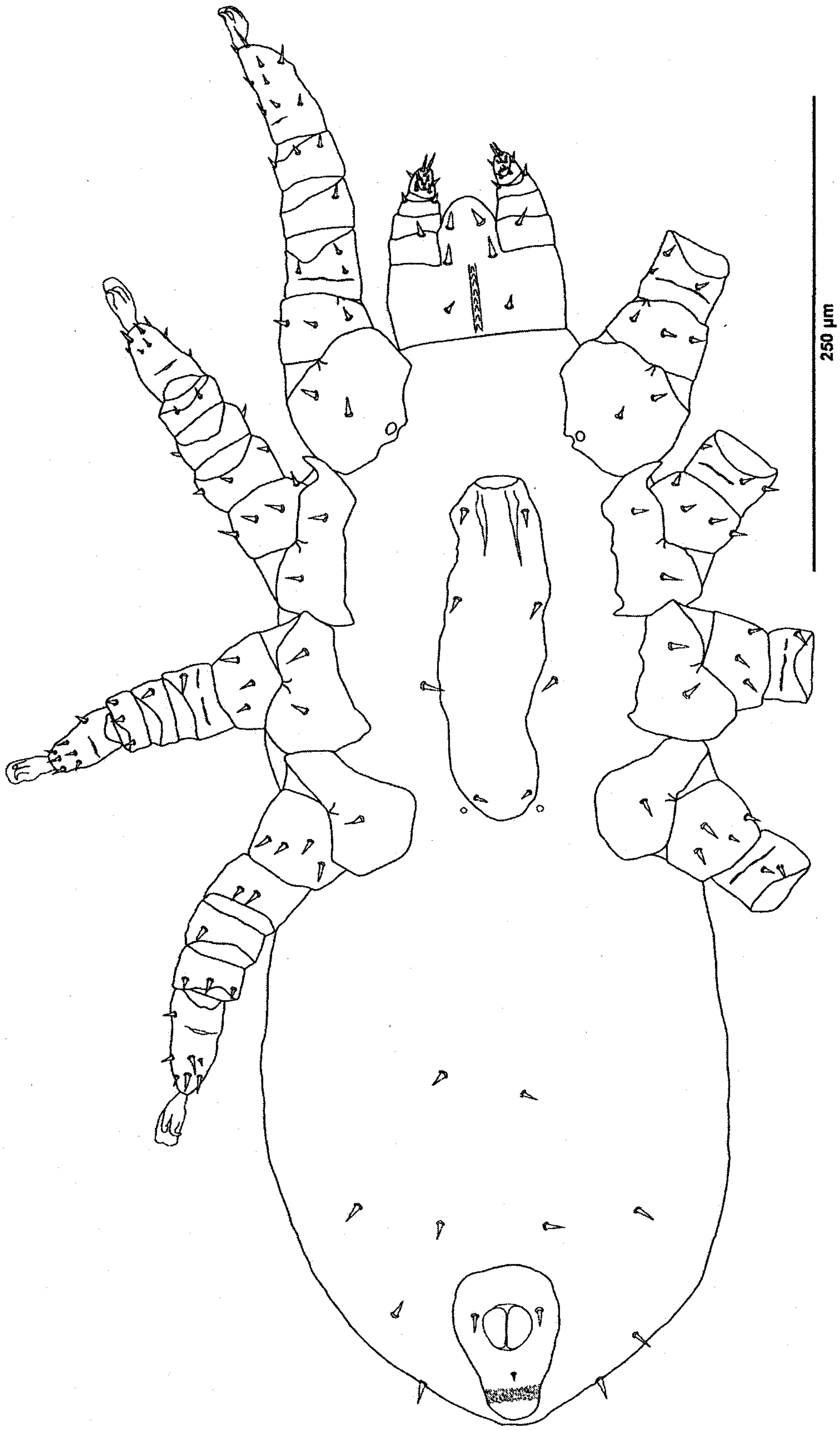
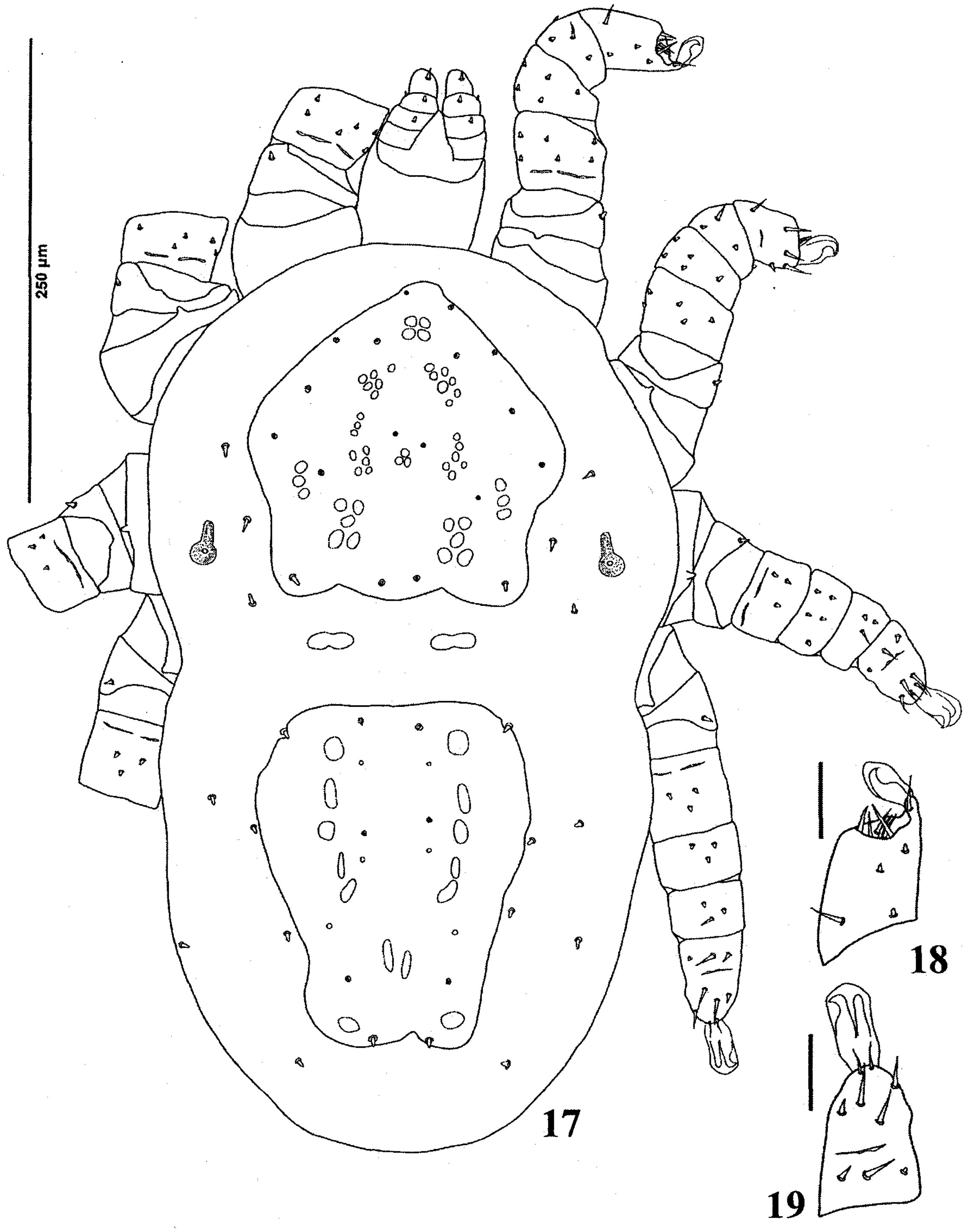
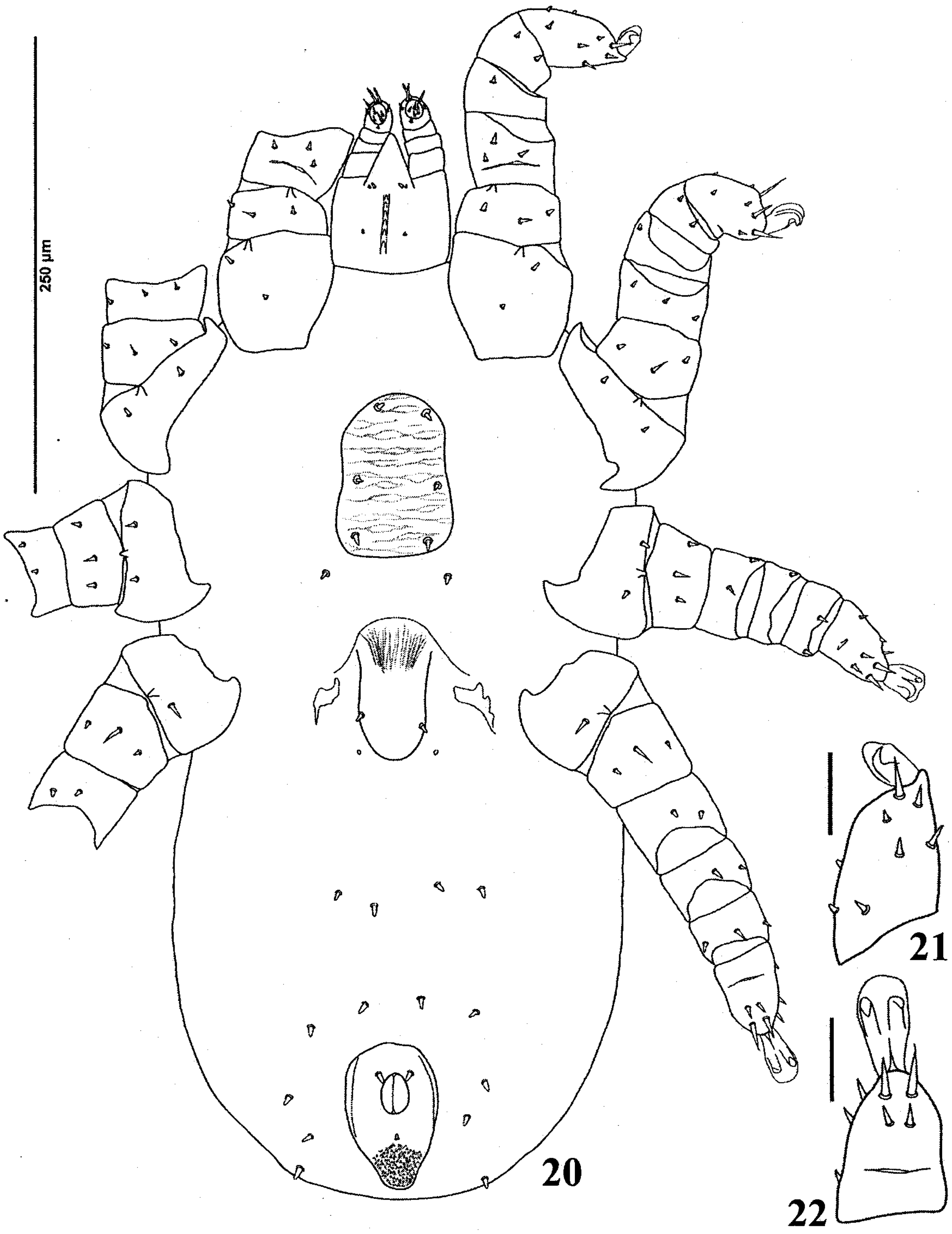


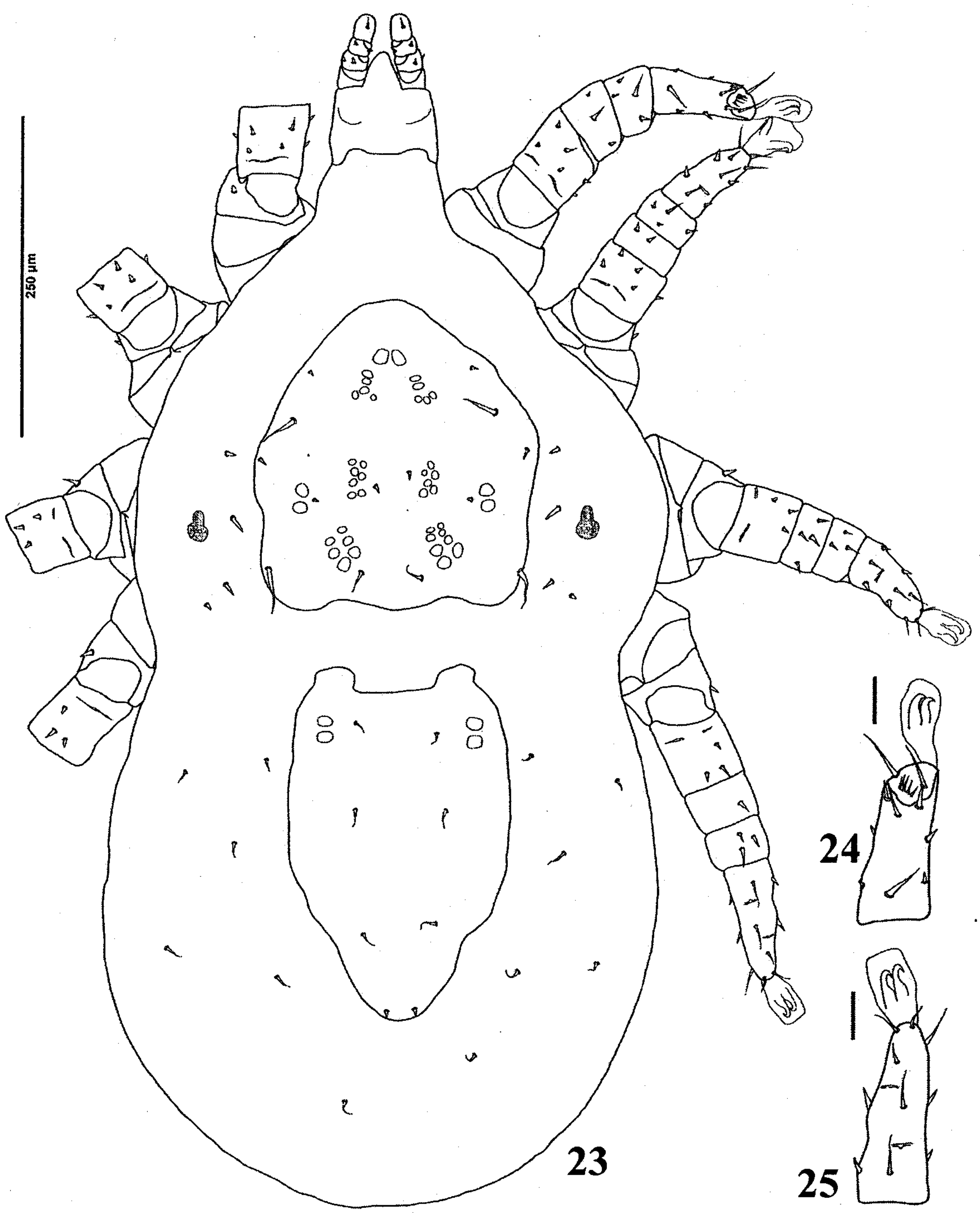
Figure 3.16. *Ptilonyssus calvaria* sp. n. male venter.



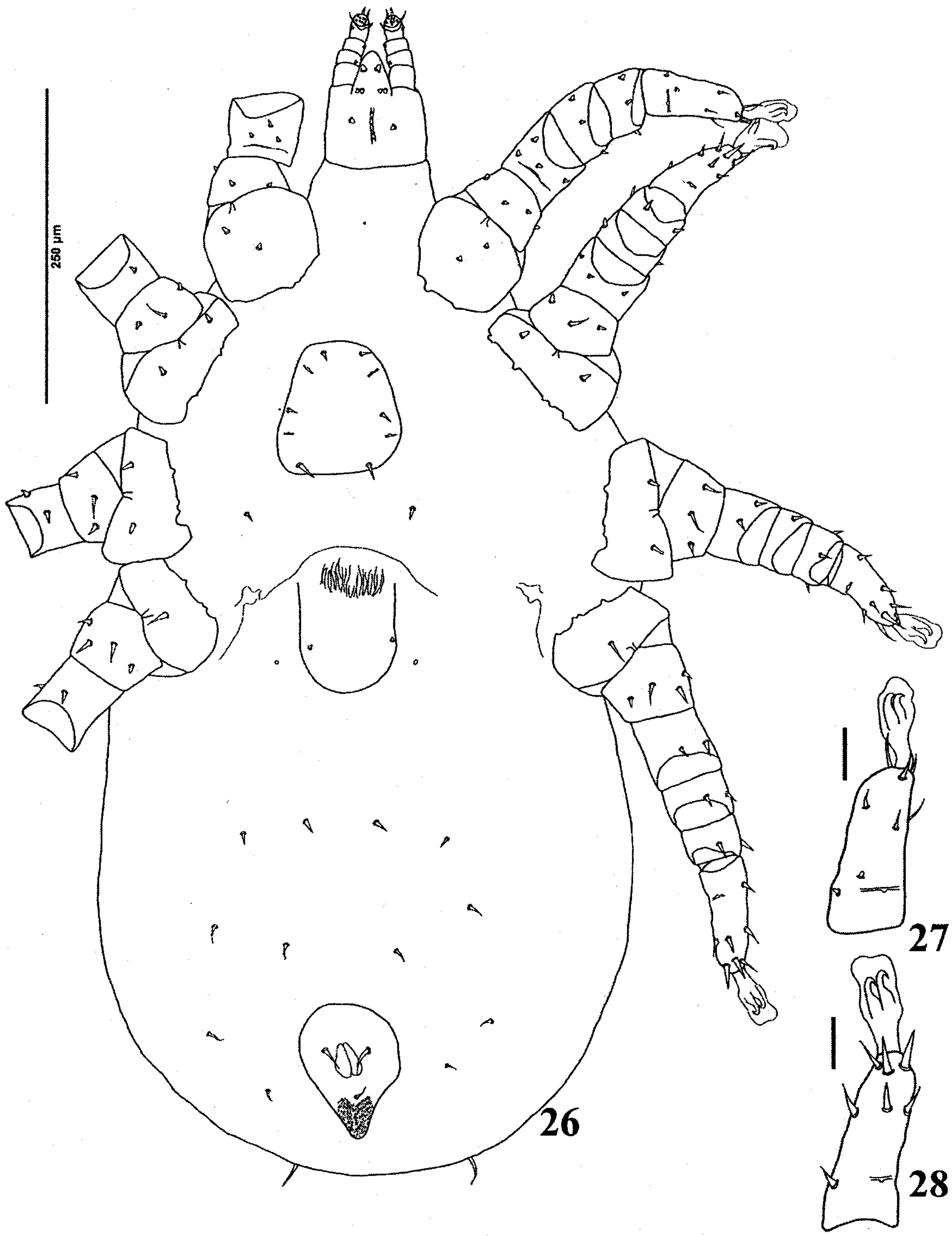
Figures 3.17-3.19. *Ptilonyssus nivalis* sp. n. female. **17.** Dorsum. **18.** Dorsum of tarsus I. **19.** Dorsum of tarsus IV. Unlabelled scale bars 25 µm.



Figures 3.20-3.22. *Ptilonyssus nivalis* sp. n. female. **20.** Venter. **21.** Venter of tarsus I. **22.** Venter of tarsus IV. Unlabelled scale bars 25 μm.



Figures 3.23-3.25. *Ptilonyssus pinicola* sp. n. female. **23.** Dorsum. **24.** Dorsum of tarsus I. **25.** Dorsum of tarsus IV. Unlabelled scale bars 25 μm.



Figures 3.26-3.28. *Ptilonyssus pinicola* sp. n. female. **26.** Venter. **27.** Venter of tarsus I. **28.** Venter of tarsus IV. Unlabelled scale bars 25 µm.

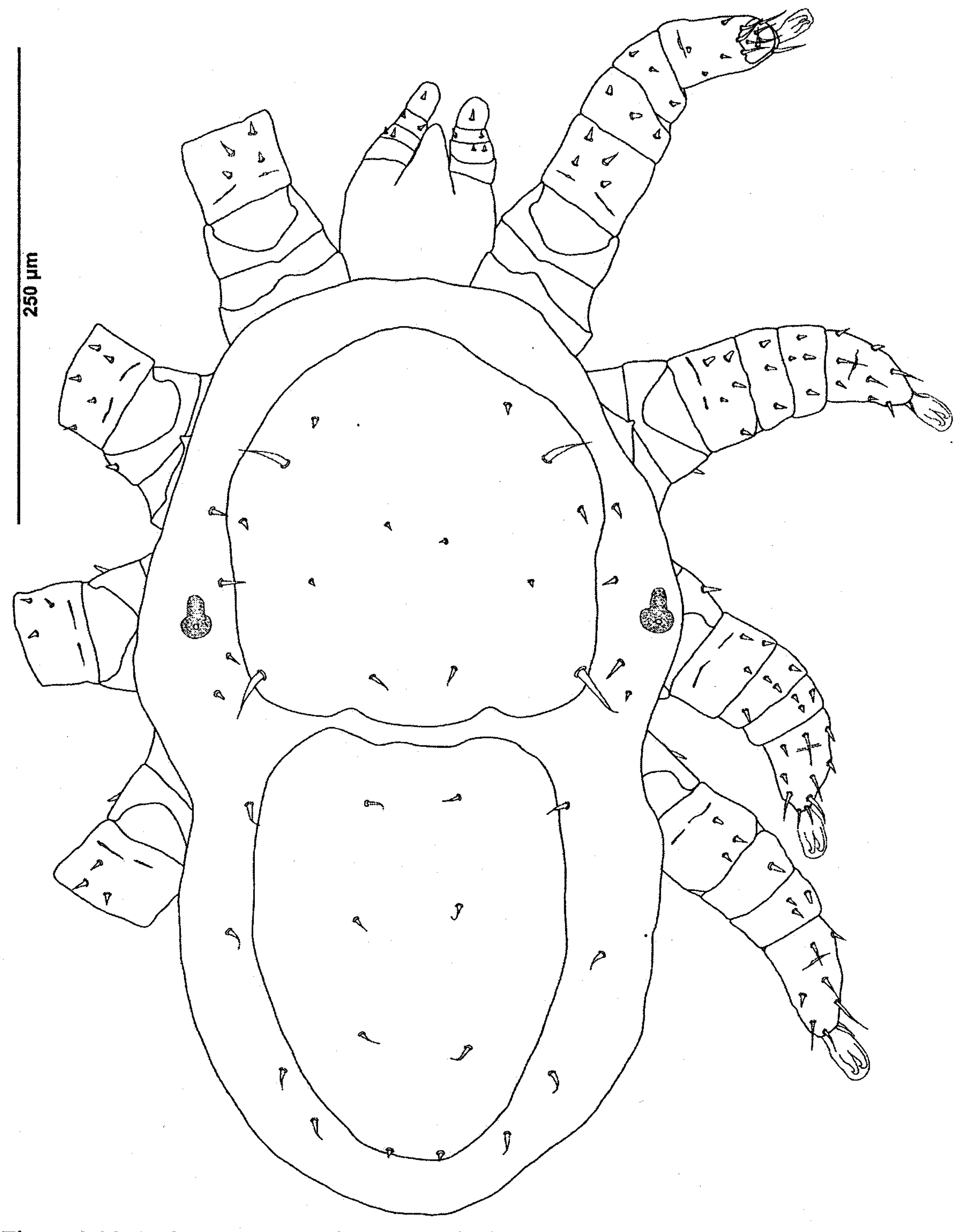


Figure 3.29. *Ptilonyssus pinicola* sp. n. male dorsum.

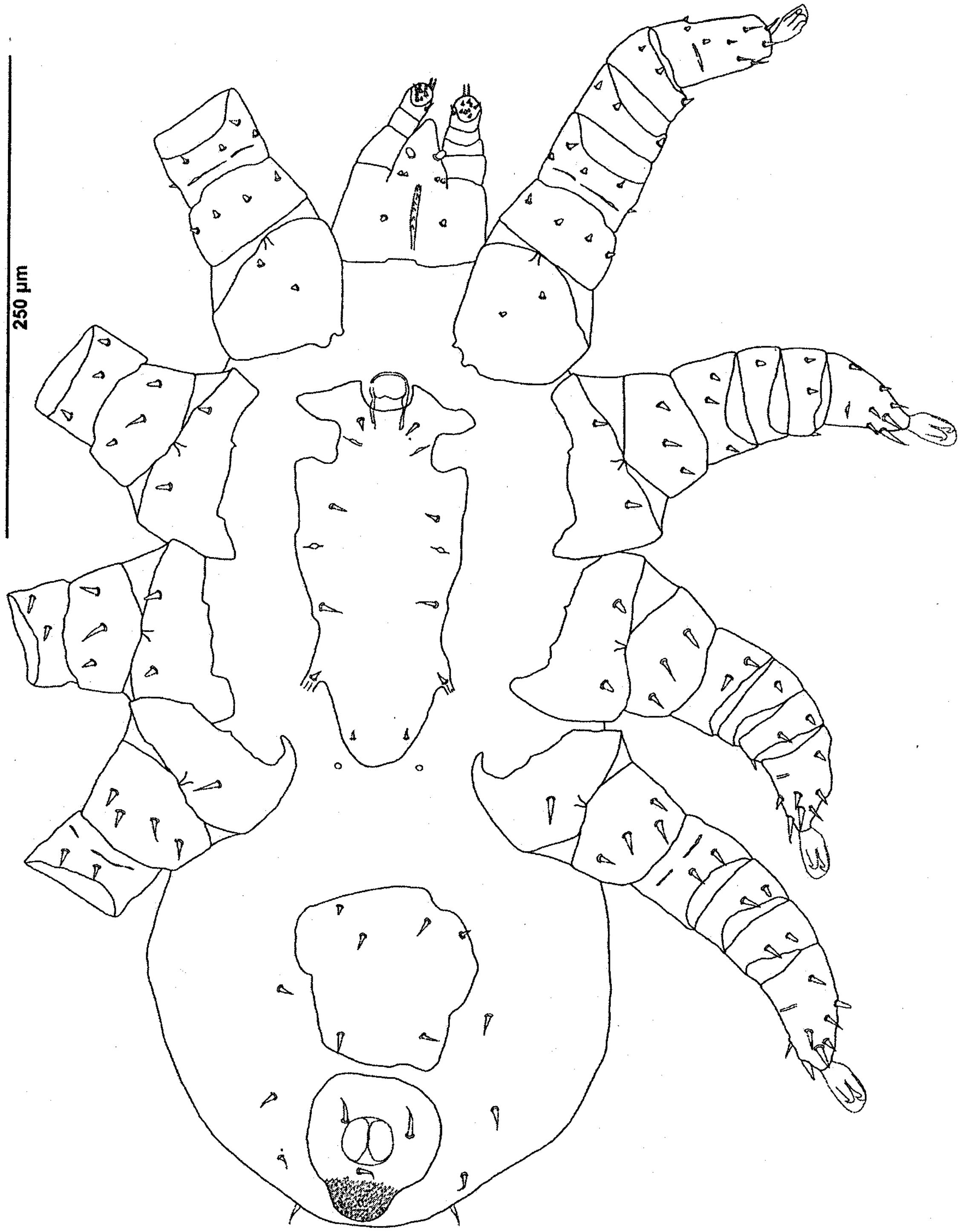
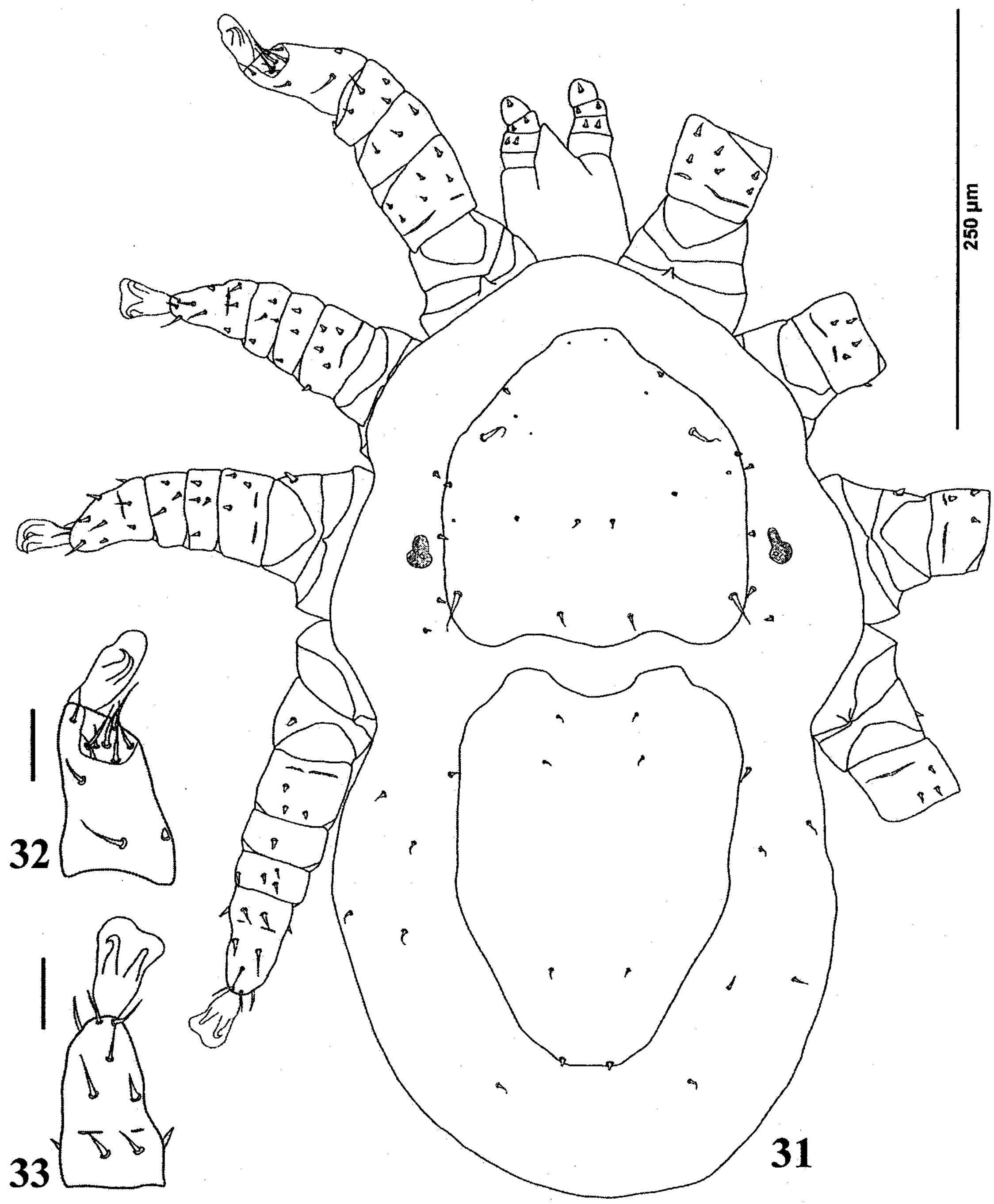
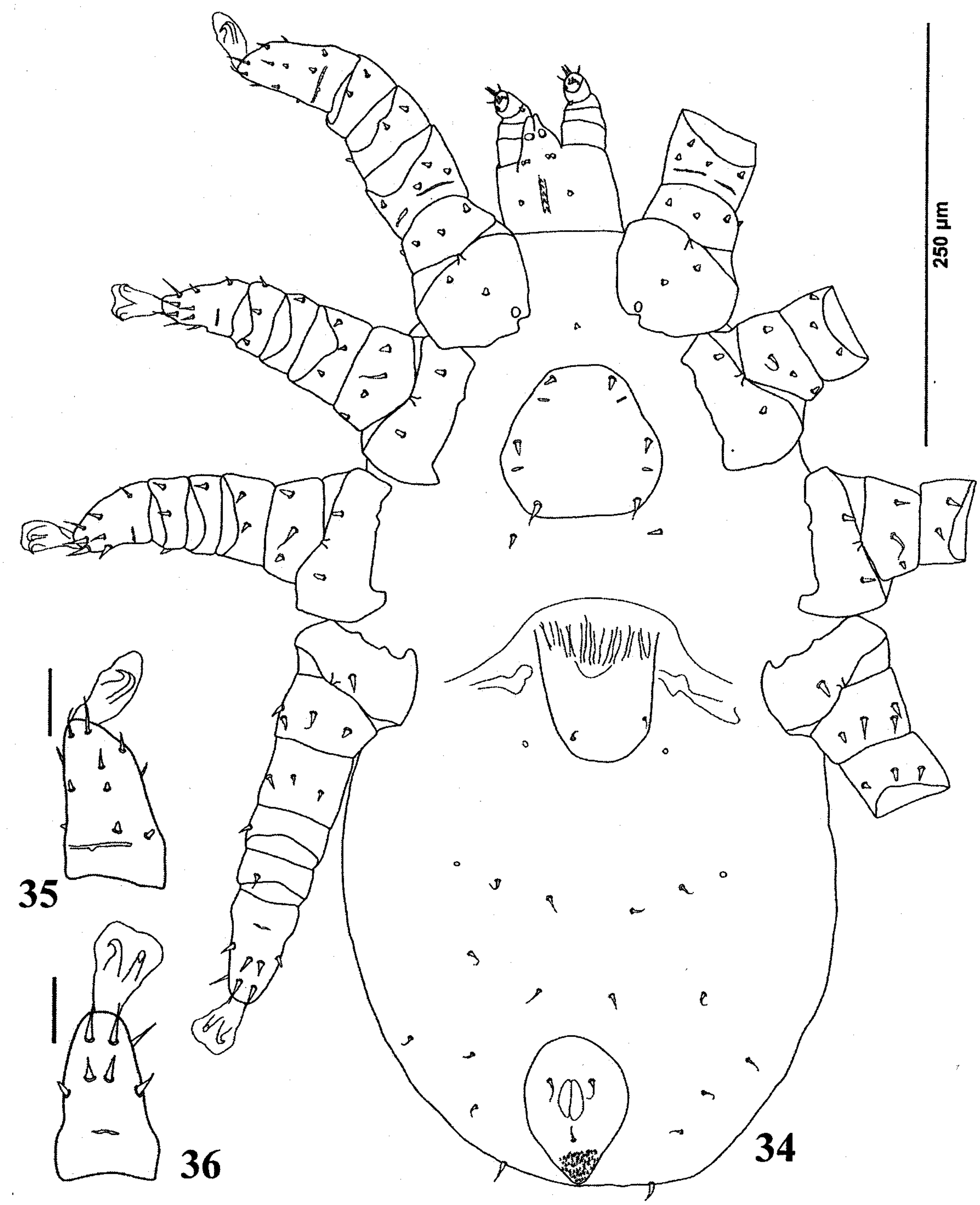


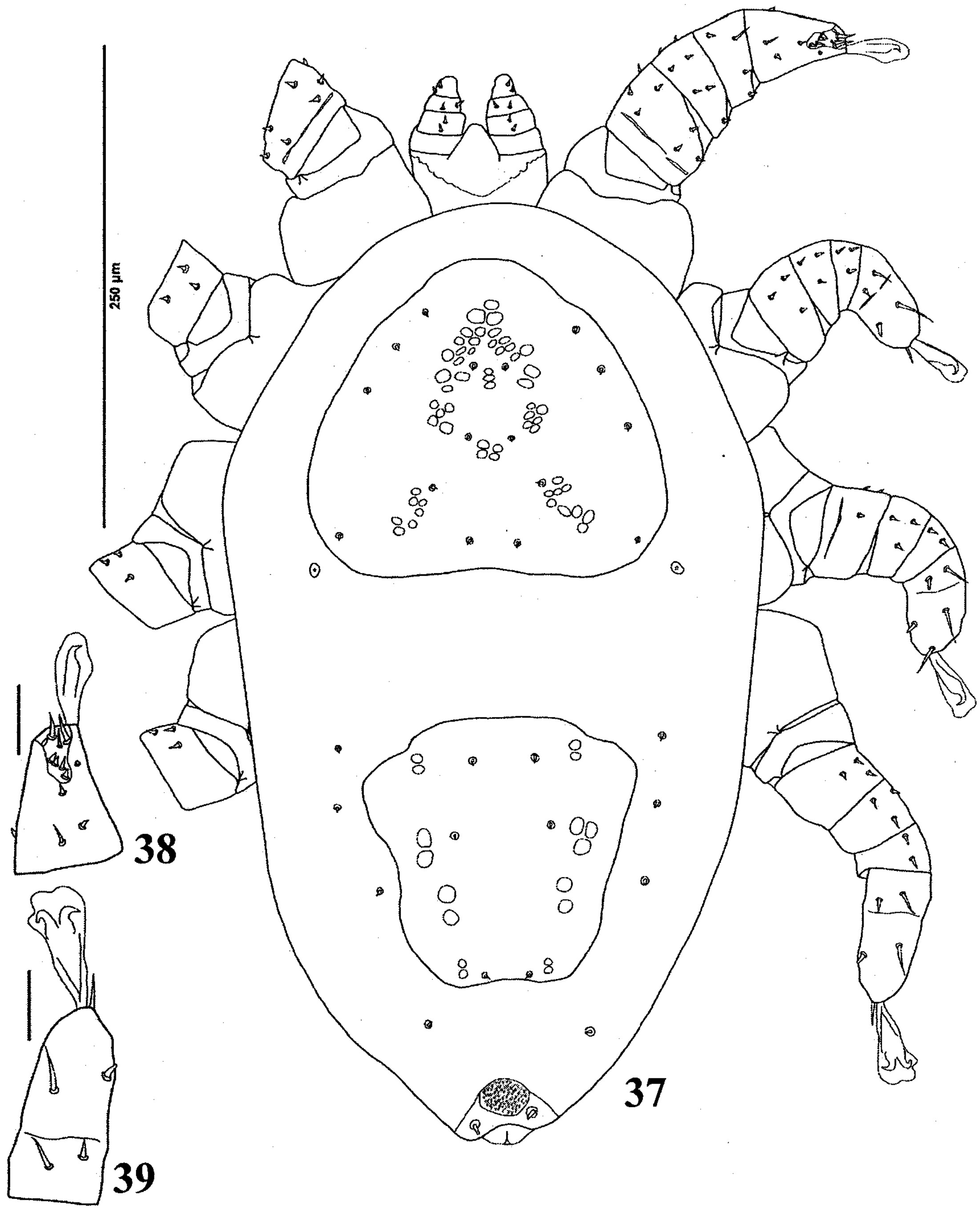
Figure 3.30. *Ptilonyssus pinicola* sp. n. male venter.



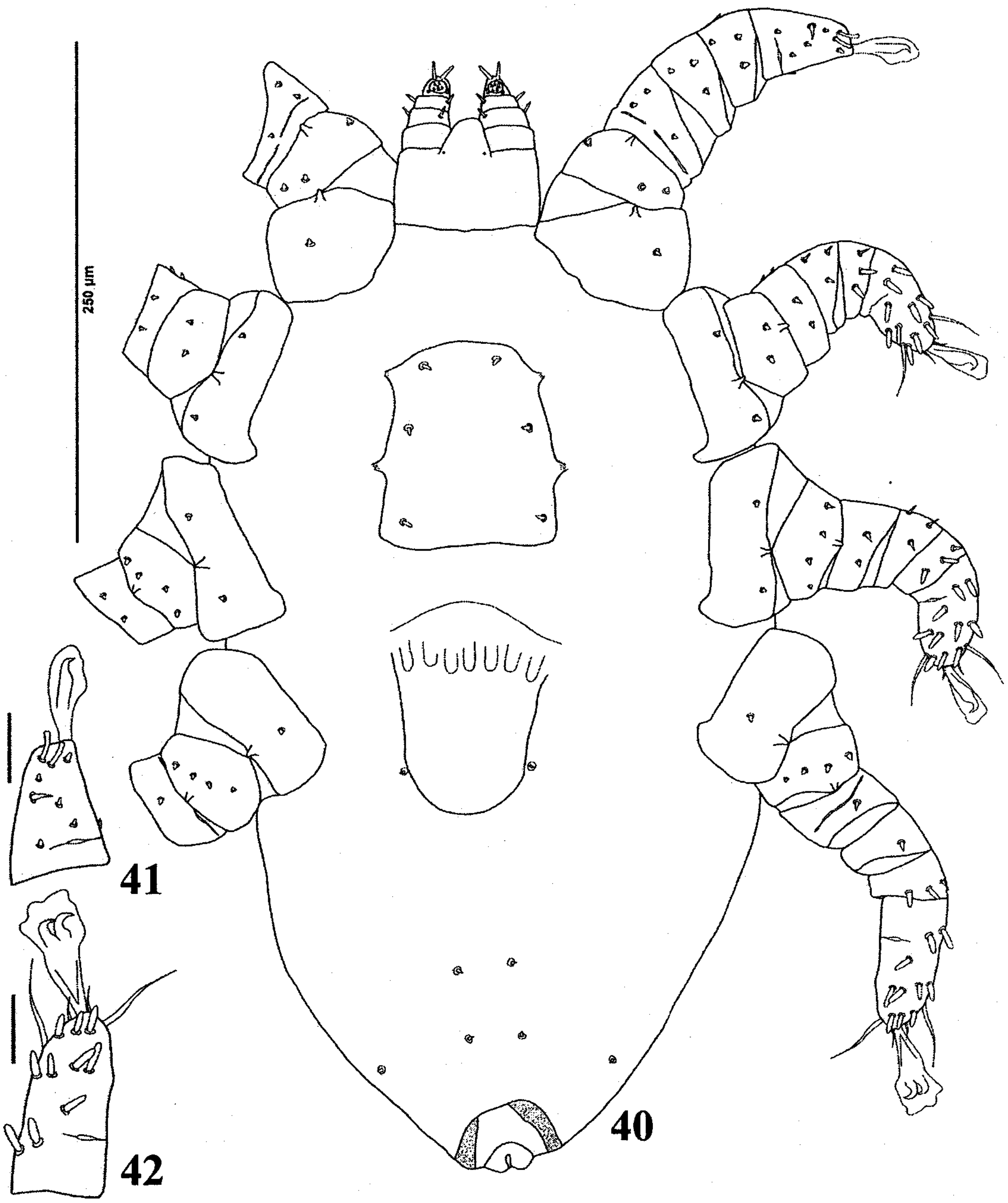
Figures 3.31-3.33. *Ptilonyssus plesiotypicus* sp. n. female. **31.** Dorsum. **32.** Dorsum of tarsus I. **33.** Dorsum of tarsus IV. Unlabelled scale bars 25 µm.



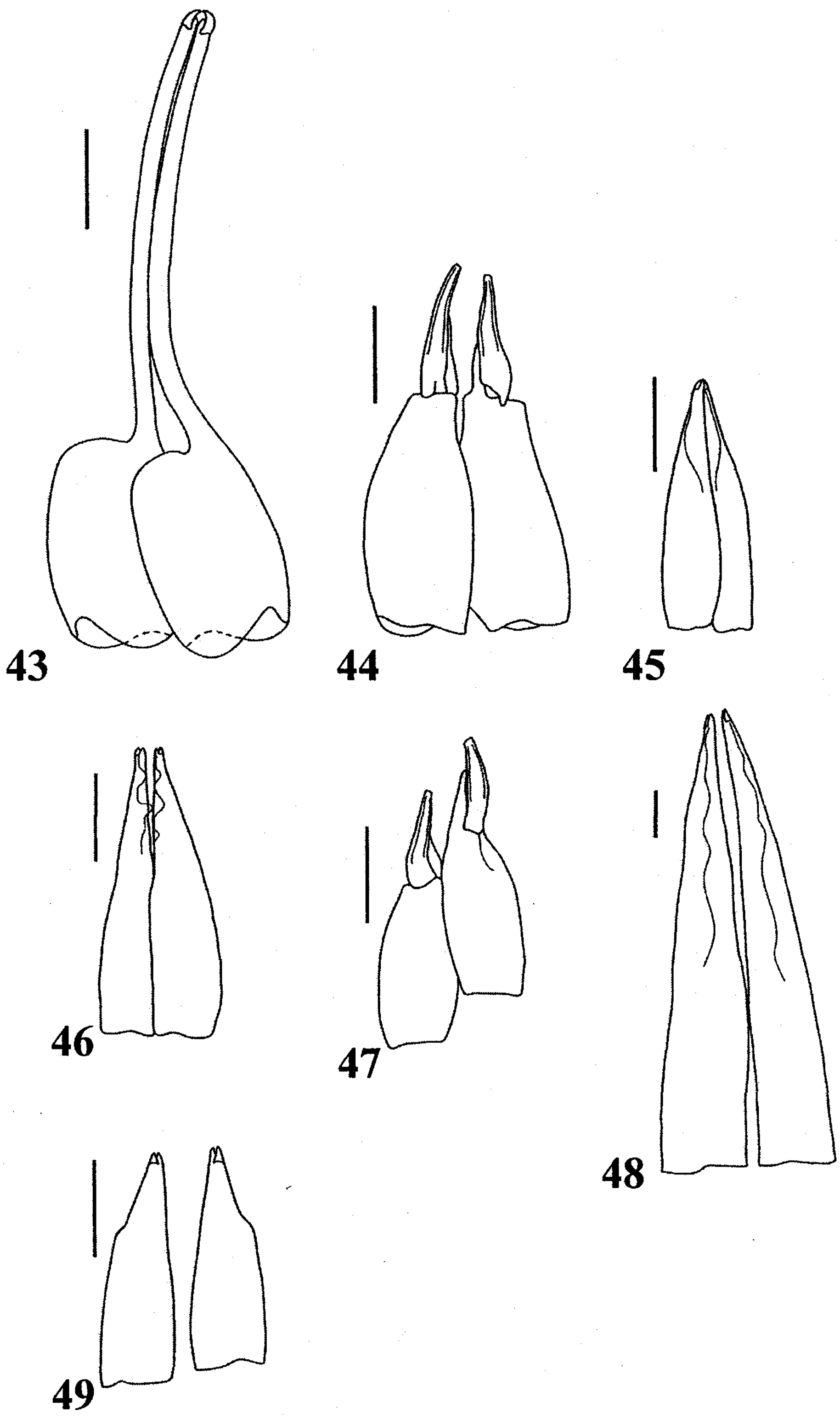
Figures 3.34-3.36. *Ptilonyssus plesiotypicus* sp. n. female. **34.** Venter. **35.** Venter of tarsus I. **36.** Venter of tarsus IV. Unlabelled scale bars 25 μm.



Figures 3.37-3.39. *Sternostoma setifer* sp. n. female. **37.** Dorsum. **38.** Dorsum of tarsus I. **39.** Dorsum of tarsus IV. Unlabelled scale bars 25 µm.



Figures 3.40-3.42. *Sternostoma setifer* sp. n. female. **40.** Venter. **41.** Venter of tarsus I. **42.** Venter of tarsus IV. Unlabelled scale bars 25 µm.



Figures 3.43-3.49. Chelicerae **43.** *Ptilonyssus calvaria* sp. n. female. **44.** *P. calvaria* sp. n. male. **45.** *P. nivalis* sp. n. female. **46.** *P. pinicola* sp. n. female. **47.** *P. pinicola* sp. n. male. **48.** *P. plesiotypicus* sp. n. female. **49.** *Sternostoma setifer* sp. n. female. Unlabelled scale bars 25 μm.

Chapter 4

Interactive and Dichotomous Keys to Female Rhinonyssidae (Mesostigmata) of Canada.

Introduction

Birds are host to a broad diversity of symbiotic animals. Mites are among the most diverse groups of these symbionts, with at least 40 families and approximately 3,000 described species known from avian hosts (Proctor and Owens 2000). Some species are highly detrimental parasites such as the nasal mite *Sternostoma tracheacolum* Lawrence, 1948 (Mesostigmata: Rhinonyssidae), while others are relatively benign such as most feather mites (Astigmata: Analgoidea, Pterolichoidea, Freyanoidea) (Proctor and Owens 2000). The superfamily Dermanyssoidea contains most of the bird-associated Mesostigmata (Radovsky 1994). Within the Dermanyssoidea, species of the families Rhinonyssidae, Dermanyssidae, Laelapidae, and Macronyssidae parasitize birds of Canada.

Rhinonyssids are obligate hematophagous endoparasites in the nasal passages of non-ratite birds worldwide. They are distributed among eight genera, believed to have descended from ectoparasitic ancestors related to the Macronyssidae (Strandtmann 1948). Rhinonyssid genera vary in their degree of host specificity, with some genera being restricted to single host families, and others found in hosts from different orders (Pence 1973). In North America, passeriform, caprimulgiform, falconiform, and apodiform host species are parasitized by *Ptilonyssus* species. *Sternostoma* species parasitize passeriform, piciform, and charadriiform birds. *Rhinonyssus* species parasitize anseriform, podicipediform, and charadriiform birds. Ciconiiform and columbiform birds are parasitized by *Tinaminyssus* species. Owls (Strigiformes) are parasitized by *Rhinoecius* species; generally each *Rhinoecius* species occurs in a different species of owl. Birds of the family Rallidae are parasitized by *Rallinyssus* species. *Larinyssus* species parasitize gulls and terns (Laridae). Rhinonyssids are slow moving sluggish mites which occur predominately 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). Generally rhinonyssids are not considered to cause significant pathology to a host individual, with the exception of *Sternostoma tracheacolum,* which invades the lower respiratory tract, lungs, and air sacs of a host (Stephan et al. 1950). Including captive and wild records this mite has been reported from 37 species, 32 genera and 11 families of birds (Bell 1996). Captive birds are reported to experience more severe pathology than wild birds (Fain and Hyland 1962). These mites have been reported to cause inflammation leading to aerocystitis, tracheitis, pneumonia, and occasionally death of the host (Stephan et al. 1950). The decline of the endangered Gouldian Finch, *Erythrura gouldiae* (Gould, 1844), has been linked (Tidemann et al. 1992) to infestation by *S. tracheacolum.*

An interactive key to rhinonyssids could potentially enable ornithologists, acarologists, and veterinarians to make species identifications without having to involve a nasal mite specialist. An interactive key is a computer-based interactive program, such as Lucid (http://www.lucidcentral.org) and Delta-Intkey (http://delta-intkey.com), which allows a user to select character states for a specimen from a list of characters. The program eliminates taxa which do not share the same attributes as the specimen until a single taxon remains. While a dichotomous key has a single starting point and a single path to a correct identification, an interactive key has multiple starting points and multiple paths. Interactive key programs allow for an extensive number of images, illustrations, and support material to be added to a key. Because they are matrix-based, these keys can be readily expanded with new taxa or characters, and are easily accessible if uploaded onto the internet (Walter and Winterton 2006). With the appropriate support material, interactive keys can be much more user friendly and effective than dichotomous keys. Interactive keys provide a way to alleviate the pressure of the taxonomic impediment, the global shortage of taxonomists and reduction in funding for taxonomic research, by putting effective identification tools in the hands of those who need them (Godfray 2002). Numerous interactive key programs are available, all with varying strengths and weaknesses, Lucid and Delta-Intkey are two of the most widespread programs used today. At least 124 keys are available on the lucidcentral.org website for taxa ranging from fungi and *Euglena* to insects and mammals.

While surveying the parasitic nasal mites associated with birds of Alberta and Manitoba, I became aware of the need for an interactive key to rhinonyssids of Canada. There has never been an interactive key to rhinonyssids, and there has never been a key specifically for Canadian rhinonyssids. The best previously published key for nasal mites of North American birds is a dichotomous key by Pence (1975), but Pence's key lacks a number of rhinonyssid species known to occur in Canada. Most bird species in western Canada migrate annually (Kaufman 2000); thus, an interactive key to rhinonyssids of Canada will be useful to acarologists, wildlife biologists, and veterinarians in Canada and other parts of North America.

Materials and Methods

The laboratory of Heather Proctor at the University of Alberta had a collection of approximately 700 bird carcasses from Alberta, largely from the contributions of the Alberta Fish & 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, and for some I can only say that the birds were collected somewhere in Alberta. Host taxonomy and authorities follow Clements (1991) provided by Andrew and McAllan (1998), selecting the 'Clements 1991-1996' taxonomy option in Nomina version 1.0. Bird bodies were maintained at -20°C until processing. Frozen birds were first thawed and then washed using the following method. The bird was placed in a suitably sized container, ranging from 4-18 L, with a drop of dish detergent, enough 95% ethanol to soak the plumage of the bird, and enough water to submerge it. The sealed container was then shaken vigorously for five minutes. 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 filter; 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 filter. The material remaining in the filter was stored in 30 ml snap cap and scintillation vials in 95% ethanol.

Mites were also collected from some individual 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 table top drill press vice. Depending on bird size, I used a scalpel, molybdenum steel scissors, or molybdenum steel bone shears to sagittally section the head and expose the nasal cavities. The dissected halves were placed in appropriately sized vials and stored at -20°C until inspection. For inspection I placed the dissected heads were placed in a glass dish with 80% ethanol and examined the tissues using a dissecting stereomicroscope.

I also received many nasal mite samples from Dr. Terry Galloway's lab at the University of Manitoba. Galloway's lab performed nasal flushings on Manitoban birds 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 in the Manitoba lab 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 filter.

I examined washings and dissections using Leica MZ16 and MZ6 dissecting microscopes at 20-25x magnification. Mites were removed from ethanol and cleared in 85% lactic acid for 1-24 hours depending on the degree of original opacity. Mites were mounted in a polyvinyl alcohol medium (6371A, BioQuip Products, Rancho Dominguez, CA). Slides were cured on a slide warmer at about 40°C for 3-4 days. I examined slide mounted specimens on a Leica DMLB compound microscope with differential interference contrast (DIC) at 400x magnification. Species level identifications were made using keys (Pence 1975) and species descriptions from the primary literature.

I made a key to the female Rhinonyssidae species of Canada using the Lucid version 3.3 builder (http://www.lucidcentral.org). Rhinonyssid species were scored for various character states in a matrix in Excel (Appendix 4.1-6). The matrix was then used to score species for various character states in the Lucid builder. The ventral opisthosomal setae were scored as they would appear to a naive user, since the posterior pair of "ventral" opisthosomal setae (JV4) are sometimes shifted dorsally or terminally, making them difficult to interpret, in which case I excluded them from the total count for ventral opisthosomal setae. The character states were organized and scored to first provide genus-level features, and then display species-level features once a single genus remains.

Illustrations were made on paper using camera lucida, merged in Adobe Photoshop CS version 8.0, and redrawn in Adobe Illustrator CS version 11.0 using an Intuos 2 Graphics Tablet from WACOM Co., Ltd. I used the program FrontPage to create an HTML page for each species. Each of these species pages includes North American host records, diagnostic characteristics, relevant references, and scaled habitus images. The *Sternostoma lanorium* Fain, 1956 habitus image was redrawn with permission from Pence (1975), due to the poor condition of the single specimen in my possession. Most character states are accompanied by a labeled image indicating the structures of interest. I also included illustrations of the dorsum and venter of a generalized rhinonyssid female. Photos of slide-mounted mites were taken with a Canon Powershot S40 digital camera mounted on a Leica DMLB compound microscope with differential interference contrast (DIC), at 200-400x magnification. Images were captured in the Canon Utilities Remote Capture program, version 2.2.0.11, and edited using Adobe Photoshop CS version 8.0.

I also made two types of dichotomous keys to females of the Rhinonyssidae species of Canada: one is a HTML-based key with hyperlinks to labeled images of the characters of interest and to the HTML species pages; the other is a hard copy dichotomous key with the same support material made in Microsoft Word 2002.

Results and Discussion

The interactive and dichotomous keys provide species level identifications for 47 species and six genera of rhinonyssids collected from birds of Canada (Table 4.1), imaged in 116 figures. The keys include all of the known rhinonyssid species from Canada, with 45 species collected from birds of Alberta and Manitoba and two species from birds of the Northwest Territories. The interactive and HTML-based keys are located on CD, and the hard copy dichotomous key is located prior to the appendix. The interactive key includes 151 character states distributed among 51 characters. In the interactive key the illustrations of the dorsum and venter of a generalized rhinonyssid female can be accessed by selecting 'about key' under the help tab. The labeled images indicating the structures of interest and HTML species pages can be accessed by clicking on them in the key. Additional keys to species of nasal mites collected from North American birds can be found in Pence (1975). Keys to blood- and tissue-feeding mites associated with birds of Alberta can be found in Knee and Proctor (2006).

Literature cited

Andrew, P., and I. McAllan. 1998. Nomina: Global Bird Dictionary, Relational Taxonomies. CSIRO Publishing, Collingwood, Australia.

Bell, P.J. 1996. 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.

Clements, J.F. 1991. Birds of the World: A Checklist, 4th ed. Ibis Publishing, Vista, California.

De-Rojas, M., M.D. Mora, J.M. Ubeda, C. Cutillas, M. Navajas, and D.C. Guevara. 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.

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.

Godfray, H.C.J. 2002. Challenges for taxonomy. Nature **417**: 17-19.

Kaufman, K. 2000. Birds of North America. Houghton Mifflin Company, New York, New York, 384 p.

Knee, W., and H. Proctor. 2006. Keys to the families and genera of blood and tissue feeding mites associated with Albertan birds. Canadian Journal of Arthropod Identification No. 2, 28 June 2006, available online at http://www.biology.ualberta.ca/bsc/ejournal/kp02/kp_02.html

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

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 Texas Tech University **8**: 1-148.

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

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

Radovsky, F.J. 1994. The evolution of parasitism and the distribution of some dermanyssoid mites (Mesostigmata) on vertebrate hosts. *In* Mites: ecological and evolutionary analyses of life-history patterns, M.A. Houck (ed.). Chapman & Hall, New York, New York, p. 186–217.

Stephan, S.A.R., V.R. Kaschula, and F.S. Canham. 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.

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

Walter, D.E., and S. Winterton. 2006. Keys and the crisis in taxonomy: extinction or reinvention? Annual Review of Entomology **21**: 193-208.

Table 4.1. Rhinonyssid species associated with Canadian birds.

Mite species	Authority
Ptilonyssus acrocephali	Fain, 1964
Ptilonyssus angrensis	(Castro, 1948)
Ptilonyssus bombycillae	Fain, 1972
Ptilonyssus callinectoides	(Brooks and Strandtmann, 1969)
Ptilonyssus calvaria sp. n.	described in Chapter 3
Ptilonyssus carduelis	Fain, 1962
Ptilonyssus cerchneis	Fain, 1957
Ptilonyssus coccothraustis	Fain and Bafort, 1963
Ptilonyssus echinatus	Berlese & Trouessart, 1889
Ptilonyssus euroturdi	Fain & Hyland, 1963
Ptilonyssus hirsti	(Castro & Periera, 1947)
Ptilonyssus icteridius	(Strandtmann and Furman, 1956)
Ptilonyssus japuibensis	Castro, 1948
Ptilonyssus morofskyi	Hyland, 1962
Ptilonyssus nivalis sp. n.	described in Chapter 3
Ptilonyssus nudus	Berlese & Trouessart, 1889
Ptilonyssus perisorei	George, 1961
Ptilonyssus pinicola sp. n.	described in Chapter 3
Ptilonyssus pirangae	(Cerny, 1969)
Ptilonyssus plesiotypicus sp. n.	described in Chapter 3
Ptilonyssus sairae	Castro, 1948
Ptilonyssus troglodytis	Fain, 1964
Ptilonyssus tyrannus	(Brooks and Strandtmann, 1960)
Ptilonyssus vireonis	(Dusbabek, 1969)
Rallinyssus caudistigmus	Strandtmann, 1948
Rhinoecius aegolii	Butenko, 1971
Rhinoecius alifanovi	Butenko, 1976
Rhinoecius brikinboricus	Butenko, 1976
Rhinoecius cooremani	Strandtmann, 1952
Rhinoecius grandis	Strandtmann, 1952
Rhinoecius nycteae	Butenko, 1976
Rhinonyssus coniventris	Trouessart, 1894
Rhinonyssus rhinolethrum	(Trouessart, 1895)
Sternostoma boydi	Strandtmann, 1951
Sternostoma cryptorhynchum	Berlese and Trouessart, 1889
Sternostoma hylandi	Fain and Johnston, 1966
Sternostoma lanorium	Fain 1956
Sternostoma longisetosae	Hyland, 1961
Sternostoma loxiae	Fain, 1965
Sternostoma porteri	Hyland, 1962
Sternostoma sialiphilus	Hyland and Ford, 1961
Sternostoma technaui	Vitzthum, 1935
Sternostoma tracheacolum	Lawrence, 1948
Sternostoma setifer sp. n.	described in Chapter 3
Tinaminyssus columbae	(Crossley, 1950)
Tinaminyssus melloi	(Castro, 1948)
Tinaminyssus zenaidurae	(Crossley, 1952)

Dichotomous key to females of the Rhinonyssidae known from Canada.

Labeled diagrams:
- Generalized rhinonyssid female, dorsal aspect, showing major body regions (Fig. 4.1)
- Generalized rhinonyssid female, dorsal aspect, details of shields and setation (Fig. 4.2)
- Generalized rhinonyssid female, ventral aspect (Fig. 4.3)

Key to Rhinonyssidae genera of Canada:

1(a). Female genital shield present between coxa IV (Fig. 4.4).....2 (Female)

1(b). Sternogenital shield with male gonopore anteromedially (Fig. 4.5) ......Male

2(a). Chelicerae distally attenuated, digits minute (Fig. 4.6).......6

2(b). Chelicerae approximately uniform diameter, digits robust (Fig. 4.7).......3

3(a). Posterior adhesive disk present (Fig. 4.8)..... *Rallinyssus* (refer to species key)

3(b). Posterior adhesive disk absent......4

4(a). Chelicerae with one digit (Fig. 4.9)..... *Rhinoecius* (refer to species key)

4(b). Chelicerae with two digits (Fig. 4.10)......5

5(a). Peritreme absent (Fig. 4.11)...... *Rhinonyssus* (refer to species key)

5(b). Peritreme present (Fig. 4.12)........ *Tinaminyssus* (refer to species key)

6(a). Peritreme present (Fig. 4.12), gnathosoma terminal, anus ventroterminal .... *Ptilonyssus* (refer to species key)

6(b). Peritreme absent (Fig. 4.11), gnathosoma ventroterminal, anus terminal .... *Sternostoma* (refer to species key)

***Rallinyssus*:**

- Only *Rallinyssus caudistigmus* (Fig. 4.70) has so far been found in Canada. Two other species, *R. sorae* Pence and Young, 1979, and *R. verheyeni* Fain, 1963 have been recorded from North American birds. *Rallinyssus verheyeni* and *R. sorae* differ from *R. caudistigmus* by having an extensively fragmented podosomal shield, as well as different chaetotaxy.

Key to females of *Rhinonyssus* species known from Canada:

1 a) Podosomal shield complete (Fig. 4.13), without medial erosion. Nine or more pairs of ventral opisthosomal setae..... *Rhinonyssus rhinolethrum* (Fig. 4.71)

1 b) Podosomal shield medially eroded (Fig. 4.14), often divided medially. Five or fewer pairs of ventral opisthosomal setae..... *Rhinonyssus coniventris* (Fig. 4.72)

Key to females of *Tinaminyssus* species known from Canada:

1 a) Poststigmatal platelet absent, five or fewer pairs of ventral opisthosomal setae...... *Tinaminyssus columbae* (Fig. 4.73)

1 b) Poststigmatal platelet present (Fig. 4.15), ten or more pairs of ventral opisthosomal setae.....2

2 a) Paranal setae anterior to anus, opisthosomal shield widest anteriorly (Fig. 4.16), posterior portion is less than 1/2 the width of the anterior portion..... *Tinaminyssus melloi* (Fig. 4.74)

2 b) Paranal setae level with anus, opisthosomal shield occupying most of the dorsal opisthosoma (Fig. 4.17), widest posteriorly....... *Tinaminyssus zenaidurae* (Fig. 4.75)

Key to females of *Rhinoecius* species known from Canada:

1 a) Subposterior pair of dorsal podosomal setae on posterior margin of podosomal shield and very long (at least 70 µm long) (Fig. 4.18). Host species *Aegolius funereus and A. acadicus* ......*Rhinoecius aegolii* (Fig. 4.76)

1 b) Subposterior pair of dorsal podosomal setae on or off posterior margin of podosomal shield and short (less than 70 µm long) (Fig. 4.19)......2

2 a) Sternal shield highly reduced, sternal setae off shield. Host species *Strix nebulosa* ......*Rhinoecius cooremani* (Fig. 4.77)

2 b) Sternal shield more complete (Fig. 4.20), st1 and st2 on shield and st3 off shield 3

3 a) Postanal seta absent. Host species *Asio otus* .....*Rhinoecius brikinboricus* (Fig. 4.78)

3 b) Postanal seta present......4

4 a) Posterior margin of sternal shield with posteromedial projection (Fig. 4.21). Host species *Bubo virginianus* ....*Rhinoecius grandis* (Fig. 4.79)

4 b) Posterior margin of sternal shield straight without projection (Fig. 4.22).....5

5 a) Anterior margin of sternal shield does not extend far beyond st1. Host species *Asio flammeus* ......*Rhinoecius alifanovi* (Fig. 4.80)

5 b) Anterior margin of sternal shield extends anteriorly beyond st1 (Fig. 4.23). Host species *Nyctea scandiaca* ......*Rhinoecius nycteae* (Fig. 4.81)

Key to females of *Sternostoma* species known from Canada:

1 a) One dorsal shield, sternal setae large, proximally inflated blunt-tipped spines (Fig. 4.24) .... *Sternostoma technaui* (Fig. 4.82)

1 b) Two dorsal shields, sternal setae minute spines (Fig. 4.25)........2

2 a) Apical setal pair on palp tarsus proximally inflated, medially constricted and distally flattened, in form of a T with an inflated base (Fig. 4.26). Tarsi II – IV subapical ventral and ventrolateral setae relatively long spines (Fig. 4.27) .... *Sternostoma longisetosae* (Fig. 4.83)

2 b) Apical setal pair on palp tarsus long spines (Fig. 4.28), short spines, or short bulbs (Fig. 4.29), not T-like. Tarsi II – IV subapical ventral and ventrolateral setae either relatively long spines or otherwise........3

3 a) Tarsus IV anterodorsal apical seta long prominently swollen spike with flexible tip (Fig. 4.30). Tarsi II - IV subapical ventral setal pair short blunt-tipped stout spines (Fig. 4.31), especially noticeable on tarsus IV....*Sternostoma porteri* (Fig. 4.84)

3 b) Tarsus IV anterodorsal apical seta not swollen, long hair-like (Fig. 4.32). Tarsi II – IV subapical ventral setal pair either short blunt-tipped stout spines or otherwise 4

4 a) Tarsi II – IV subapical ventral setal pair short blunt-tipped stout spines (Fig. 4.31), especially noticeable on tarsus IV. Postanal seta present....... *Sternostoma hylandi* (Fig. 4.85)

4 b) Tarsi II – IV subapical ventral setal pair otherwise. Postanal seta absent.....5

5 a) Tarsi II – IV subapical ventral setal pair short flattened setae with rounded tips (Fig. 4.33). No setae in dorsal opisthosomal unsclerotized integument…… *Sternostoma boydi* (Fig. 4.86)

5 b) Tarsi II – IV subapical ventral setal pair otherwise. One or more pairs of setae in dorsal opisthosomal unsclerotized integument………6

6 a) Tarsi II – IV subapical ventral and ventrolateral setae relatively long spines (Fig. 4.27). More than three pairs of setae in dorsal opisthosomal unsclerotized integument……. *Sternostoma setifer* sp. n. (Fig. 4.87)

6 b) Tarsi II – IV subapical ventral and ventrolateral setae otherwise. Fewer than three pairs of setae in dorsal opisthosomal unsclerotized integument……7

7 a) Tarsi II – IV subapical ventral and ventrolateral setae minute spines (Fig. 4.34), barely visible. Two pairs of setae in dorsal opisthosomal unsclerotized integument……. *Sternostoma tracheacolum* (Fig. 4.88)

7 b) Tarsi II – IV subapical ventral and ventrolateral setae variously modified, not minute spines. One or two pairs of setae in dorsal opisthosomal unsclerotized integument…..8

8 a) Tarsi II – IV subapical ventral and ventrolateral setae hook-like short spines (Fig. 4.35). Two pairs of setae in dorsal opisthosomal unsclerotized integument…… *Sternostoma lanorium* (Fig. 4.89)

8 b) Tarsi II – IV subapical ventral and ventrolateral setae distally inflated setae (Fig. 4.36). One or two pairs of setae in dorsal opisthosomal unsclerotized integument……9

9 a) Tarsi II – IV subapical ventral and ventrolateral setae distally inflated symmetrical setae (Fig. 4.36). Two pairs of setae in dorsal opisthosomal unsclerotized integument. Paranal setae at level with anal opening……. *Sternostoma cryptorhynchum* (Fig. 4.90)

9 b) Tarsi II – IV subapical ventral and ventrolateral setae distally inflated asymmetrical setae (Fig. 4.37). One or two pairs of setae in dorsal opisthosomal unsclerotized integument. Paranal setae posterior to anal opening……10

10 a) Two pairs of setae in dorsal opisthosomal unsclerotized integument …….*Sternostoma loxiae* (Fig. 4.91)

10 b) One pair of setae in dorsal opisthosomal unsclerotized integument …….*Sternostoma sialiphilus* (Fig. 4.92)

Key to females of *Ptilonyssus* species known from Canada:

1 a) Second cheliceral segment prominently inflated proximally with marked constriction distally (Fig. 4.38)……14

1 b) Second cheliceral segment without marked inflation and constriction (Fig. 4.39) ……2

2 a) One dorsal shield present (podosomal), sternal shield absent, peritreme absent (Fig. 4.11), and cribrum absent or unnoticeable (Fig. 4.40) ……*Ptilonyssus angrensis* (Fig. 4.93)

2 b) Three dorsal shields present (podosomal, opisthosomal and pygidial, usually pygidial and opisthosomal fused), sternal shield present, peritreme present (Fig. 4.12) or absent, and cribrum present (Fig. 4.41).……3

3 a) Ventral hypostomal setae large distally inflated bulb setae (Fig. 4.42) …….4

3 b) Ventral hypostomal setae not distally inflated bulb setae (Fig. 4.43)……..5

4 a) Six pairs of ventral opisthosomal setae, anal setae tapered distally (Fig. 4.44) with filamentous, spike, or rounded tip. Tarsus IV subapical ventral setal pair relatively long, one strong spike and one filamentous spike (Fig. 4.47). Subposterior pair of dorsal podosomal setae as long or almost as long as longest mesolateral setae…… *Ptilonyssus coccothraustis* (Fig. 4.94)

4 b) Seven pairs of ventral opisthosomal setae, anal setae constricted proximally (within 1/3 of length from base) with long filamentous tip (Fig. 4.45). Tarsus IV subapical ventral setal pair relatively long strong spikes (Fig. 4.46). Subposterior pair of dorsal podosomal setae longer than mesolateral setae …… *Ptilonyssus plesiotypicus* sp. n. (Fig. 4.95)

5 a) Podosomal shield with lateral wing-like processes (Fig. 4.48), posterior margin of podosomal shield rounded (Fig. 4.49), two pairs of mesolateral setae……. *Ptilonyssus callinectoides* (Fig. 4.96)

5 b) Podosomal shield without lateral wing-like processes, posterior margin of podosomal shield otherwise, more than two pairs of mesolateral setae…….6

6 a) Peritreme absent. Opisthosomal shield laterally excavated medially with excavation extending posteriorly (Fig. 4.50), anterior margin of shield bearing medial lobe without lateral lobes (Fig. 4.51). ……*Ptilonyssus vireonis* (Fig. 4.97)

6 b) Peritreme present. Opisthosomal shield either laterally excavated (Fig. 4.52) along posterior portion or no lateral excavation (Fig. 4.53), anterior margin of shield either straight (Fig. 4.54) or medially straight with anterolateral projections (Fig. 4.55) ……..7

7 a) Sternal setae st1, st2, and st3 off shield in unsclerotized integument.......8

7 b) Sternal setae st1, st2, and st3 on shield (Fig. 4.56)......10

8 a) Six pairs of ventral opisthosomal setae, four pairs of mesolateral setae, opisthosomal shield without lateral excavation (Fig. 4.53), subapical ventral setal pair on tarsus IV with pointed terminus (Fig. 4.46)......9

8 b) Four pairs of ventral opisthosomal setae, three pairs of mesolateral setae, opisthosomal shield laterally excavated along the posterior portion (Fig. 4.52), subapical ventral setal pair on tarsus IV relatively long strong spikes with a rounded terminus (Fig. 4.57) ......*Ptilonyssus tyrannus* (Fig. 4.98)

9 a) Opisthosomal shield twice as long as wide. Subapical ventral setal pair on tarsus IV relatively long filamentous spikes, long flexible tip (Fig. 4.58). Paranal setae posterior to anus, paranal and postanal setae unequal length (Fig. 4.45)...... *Ptilonyssus hirsti* (Fig. 4.99)

9 b) Opisthosomal shield less than twice as long as wide. Subapical ventral setal pair on tarsus IV long heavyset inflated spikes (Fig. 4.59). Paranal setae anterior to anus, paranal and postanal setae equal or almost equal length........ *Ptilonyssus icteridius* (Fig. 4.100)

10 a) Subapical ventral setal pair on tarsus IV one short filamentous spike and one short partially inflated bulb (Fig. 4.60). Sternal shield wider than long, four pairs of ventral opisthosomal setae .....*Ptilonyssus morofskyi* (Fig. 4.101)

10 b) Subapical ventral setal pair on tarsus IV either relatively long strong spikes (Fig. 4.46), or one strong spike and one filamentous spike (Fig. 4.47). Sternal shield longer than wide, five or six pairs of ventral opisthosomal setae......11

11 a) Subapical ventral setal pair on tarsus IV relatively long, one strong spike and one filamentous spike (Fig. 4.47). Three pairs of mesolateral setae ..... *Ptilonyssus nivalis* sp. n. (Fig. 4.102)

11 b) Subapical ventral setal pair on tarsus IV relatively long strong spikes (Fig. 4.46). Four pairs of mesolateral setae 12

12 a) Mesosomal shieldlets absent, anterior margin of opisthosomal shield medially straight with anterolateral projections (Fig. 4.55), podosomal shield posterior margin trilobed (Fig. 4.61), subposterior pair of dorsal podosomal setae as long or longer than the longest mesolateral setae...... 13

12 b) Mesosomal shieldlets present, anterior margin of opisthosomal shield straight (Fig. 4.54), podosomal shield posterior margin straight (Fig. 4.62), subposterior pair of dorsal podosomal setae less than half the length of longest mesolateral setae....... *Ptilonyssus pirangae* (Fig. 4.103)

13 a) Five pairs of ventral opisthosomal setae, subposterior pair of dorsal podosomal setae as long or almost as long as longest mesolateral setae, paranal and postanal setae equal or almost equal length .... *Ptilonyssus carduelis* (Fig. 4.104)

13 b) Six pairs of ventral opisthosomal setae, subposterior pair of dorsal podosomal setae longer than mesolateral setae, paranal and postanal setae unequal length (Fig. 4.45) ......*Ptilonyssus pinicola* sp. n. (Fig. 4.105)

14 a) Subapical ventral setal pair on tarsus IV relatively long strong spikes with rounded terminus (Fig. 4.57), four pairs of ventral opisthosomal setae, three pairs of mesolateral setae, postanal seta absent......... *Ptilonyssus perisorei* (Fig. 4.106)

14 b) Subapical ventral setal pair on tarsus IV relatively long strong spikes (Fig. 4.46), more than four pairs of ventral opisthosomal setae, three or more pairs of mesolateral setae, postanal seta present or absent........15

15 a) Pygidial shield in two fragments (Fig. 4.63), subposterior setal pair either on or off fragments 16

15 b) Pygidial shield entire (Fig. 4.64).......18

16 a) Genital shield arrow-shaped, pointed terminus, 10 times longer than wide (Fig. 4.65). Sternal shield absent, seven or more pairs of ventral opisthosomal setae.......... *Ptilonyssus echinatus* (Fig. 4.107)

16 b) Genital shield thumb-shaped, rounded terminus (Fig. 4.66). Sternal shield present, six pairs of ventral opisthosomal setae.......17

17 a) Paranal setae posterior to anal opening, postanal setae absent. Pygidial shield in two fragments without subposterior setal pair on fragments, subposterior pair of dorsal podosomal setae longer than longest mesolateral setae, three pairs of mesolateral setae........*Ptilonyssus cerchneis* (Fig. 4.108)

17 b) Paranal setae level with anal opening, postanal seta present. Pygidial shield in two fragments with subposterior setal pair on fragments, subposterior pair of dorsal podosomal setae half as long as longest mesolateral setae, six pairs of mesolateral setae........*Ptilonyssus troglodytis* (Fig. 4.109)

18 a) No two pairs of mesolateral setae are twice as long as other mesolateral setae.....19

18 b) At least two pairs of mesolateral setae are twice as long as other mesolateral setae.......21

19 a) Posterior margin of podosomal shield trilobed (Fig. 4.61), subposterior setal pair off podosomal shield and as long or almost as long as longest mesolateral setae, five pairs of mesolateral setae. Sternal setae st1 on shield, st2 and st3 off shield (Fig. 4.67)........20

19 b) Posterior margin of podosomal shield rounded (Fig. 4.49), subposterior setal pair on podosomal shield and less than half the length of longest mesolateral setae, four pairs of mesolateral setae. Sternal setae st1, st2, and st3 on shield (Fig. 4.56) ......*Ptilonyssus nudus* (Fig. 4.110)

20 a) Cribrum extends to anal shield terminus (Fig. 4.41), paranal setae posterior to anal opening, paranal and postanal setae equal or almost equal in length......*Ptilonyssus bombycillae* (Fig. 4.111)

20 b) Cribrum does not extend to anal shield terminus (Fig. 4.68), paranal setae level with anal opening, paranal and postanal setae of unequal length (Fig. 4.45)..... *Ptilonyssus calvaria* sp. n. (Fig. 4.112)

21 a) Six pairs of mesolateral setae, paranal and postanal setae of unequal length (Fig. 4.45) .....*Ptilonyssus euroturdi* (Fig. 4.113)

21 b) Fewer than six pairs of mesolateral setae, paranal and postanal setae equal or almost equal in length 22

22 a) Posterior margin of podosomal shield medially straight with lateral lobes (Fig. 4.69), subposterior setal pair on podosomal shield and as long or almost as long as longest mesolateral setae….. *Ptilonyssus acrocephali* (Fig. 4.114)

22 b) Posterior margin of podosomal shield either trilobed (Fig. 4.61) or straight (Fig. 4.62), subposterior setal pair off podosomal shield and less than half the length of longest mesolateral setae…..23

23 a) Posterior margin of podosomal shield trilobed (Fig. 4.61), four pairs of mesolateral setae …… *Ptilonyssus japuibensis* (Fig. 4.115)

23 b) Posterior margin of podosomal shield straight (Fig. 4.62), five pairs of mesolateral setae ……*Ptilonyssus sairae* (Fig. 4.116)

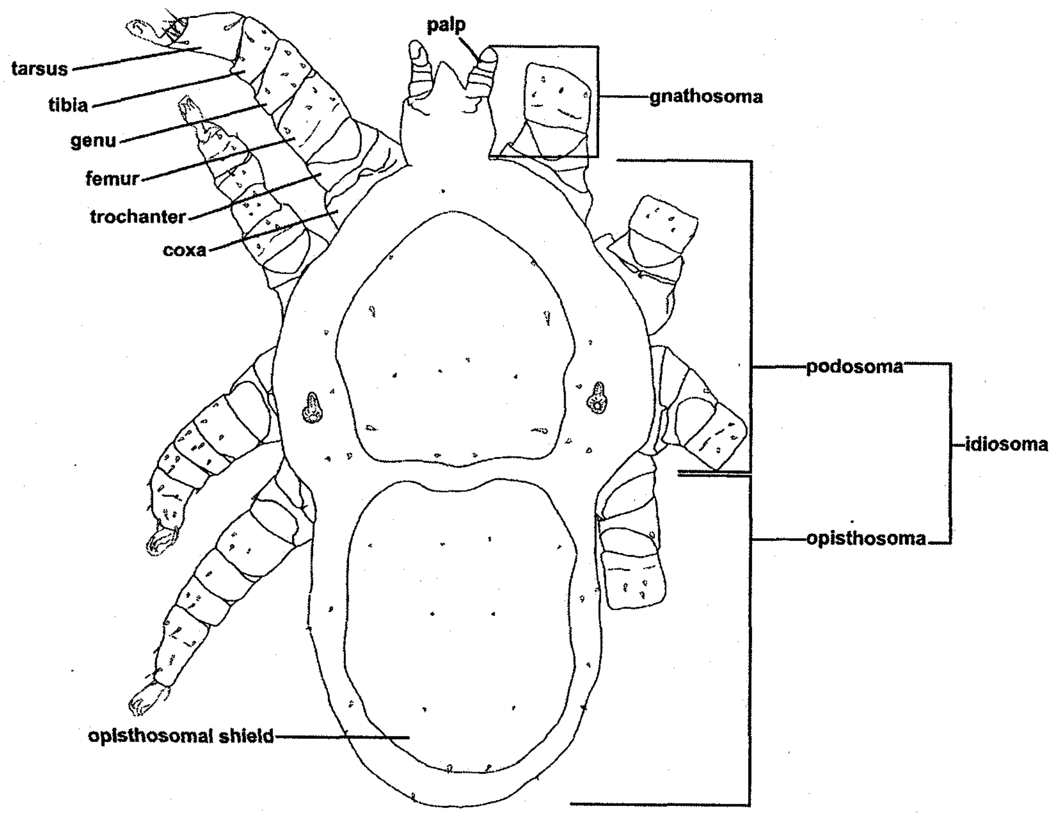


Figure 4.1. Generalized rhinonyssid female, dorsal aspect, showing major body regions.

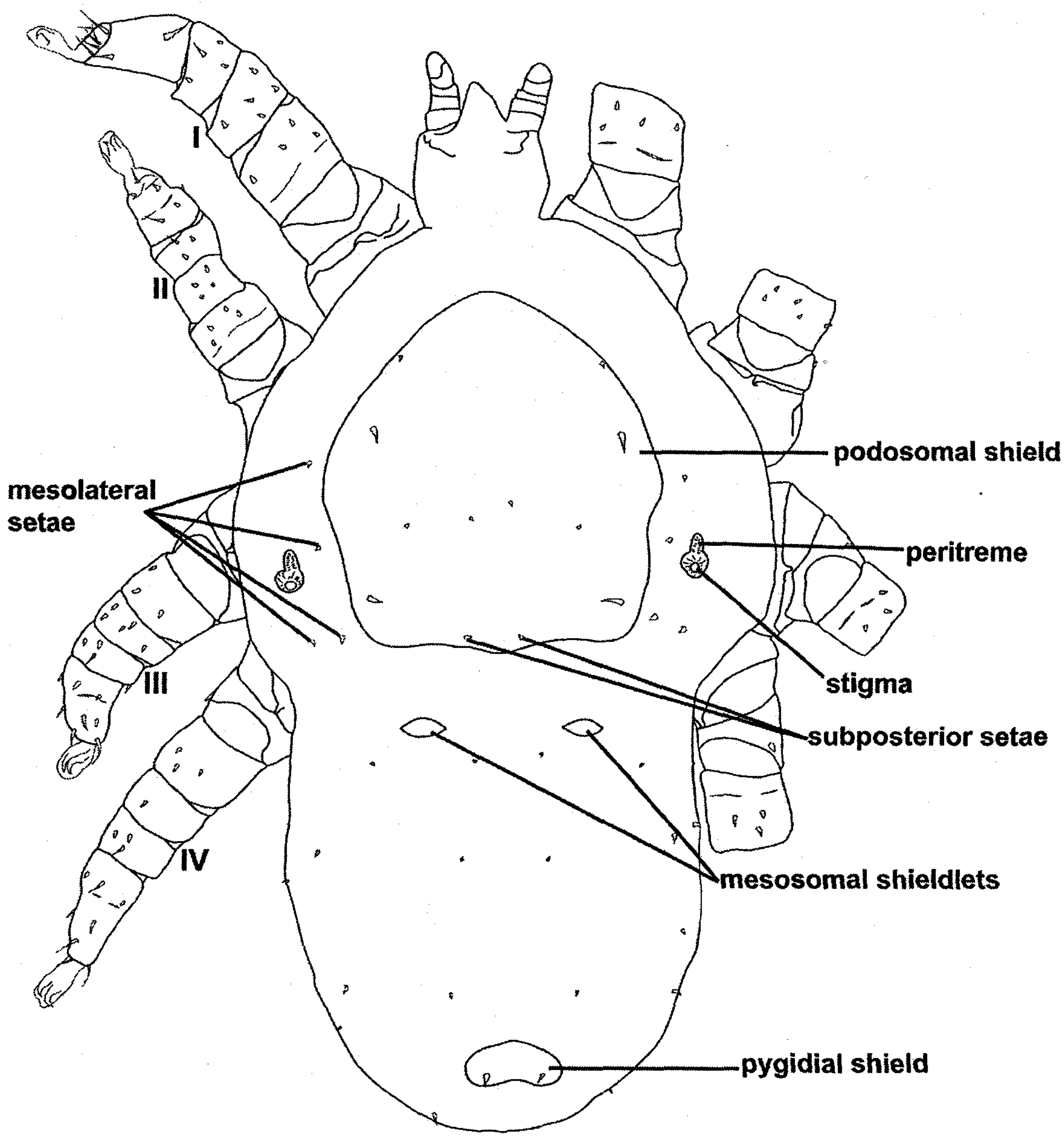


Figure 4.2. Generalized rhinonyssid female, dorsal aspect, details of shields and setation.

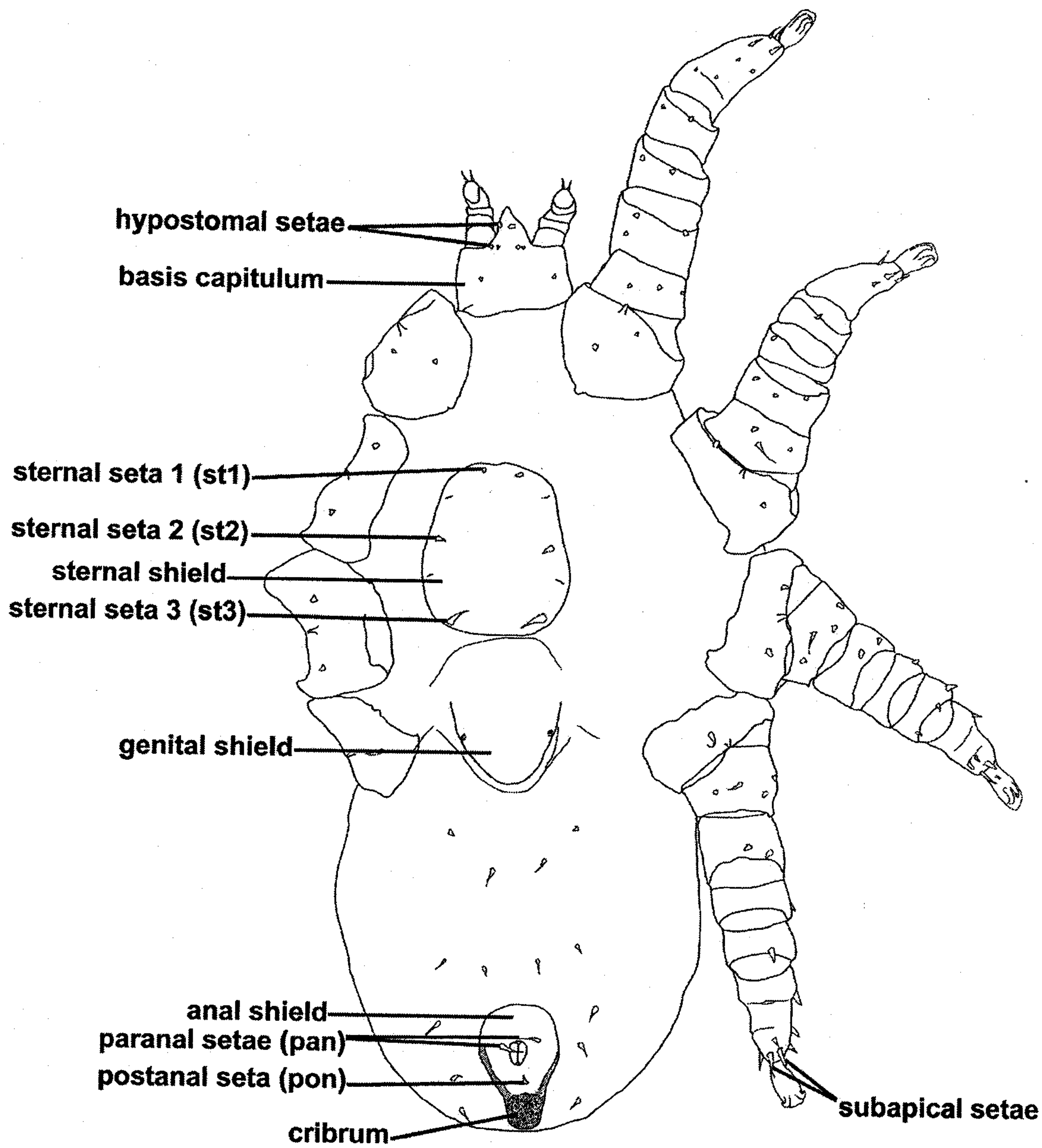


Figure 4.3. Generalized rhinonyssid female ventral aspect.

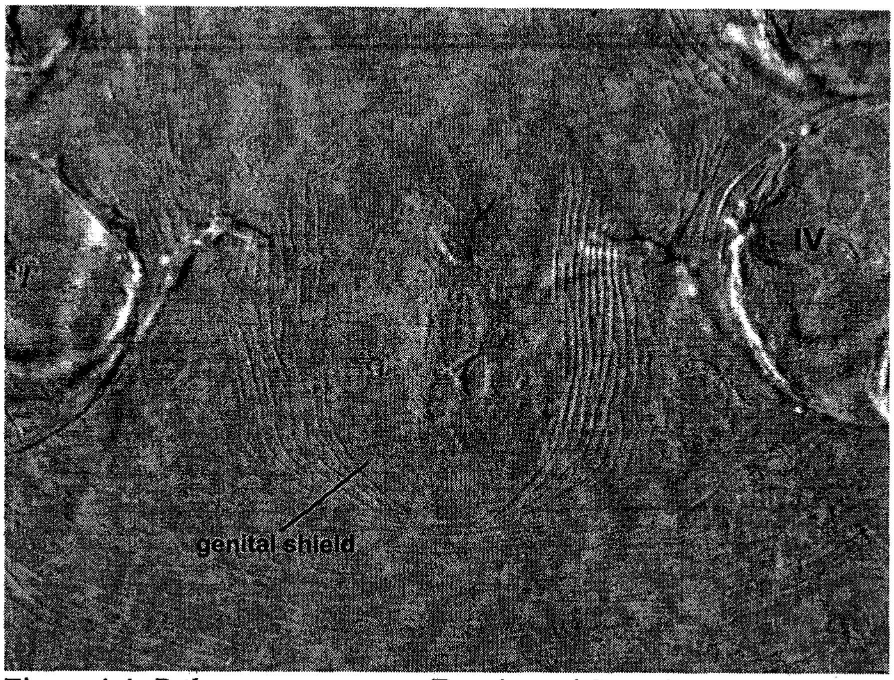


Figure 4.4. *Ptilonyssus tyrannus* (Brooks and Strandtmann, 1960) female genital shield.

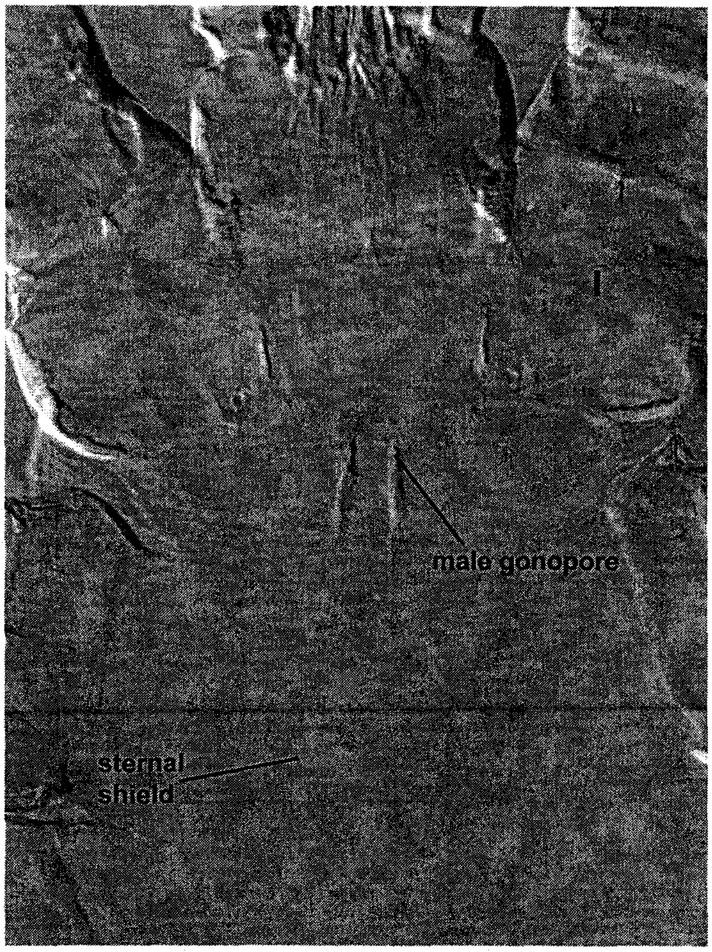


Figure 4.5. *Ptilonyssus icteridius* (Strandtmann and Furman, 1956) male gonopore.

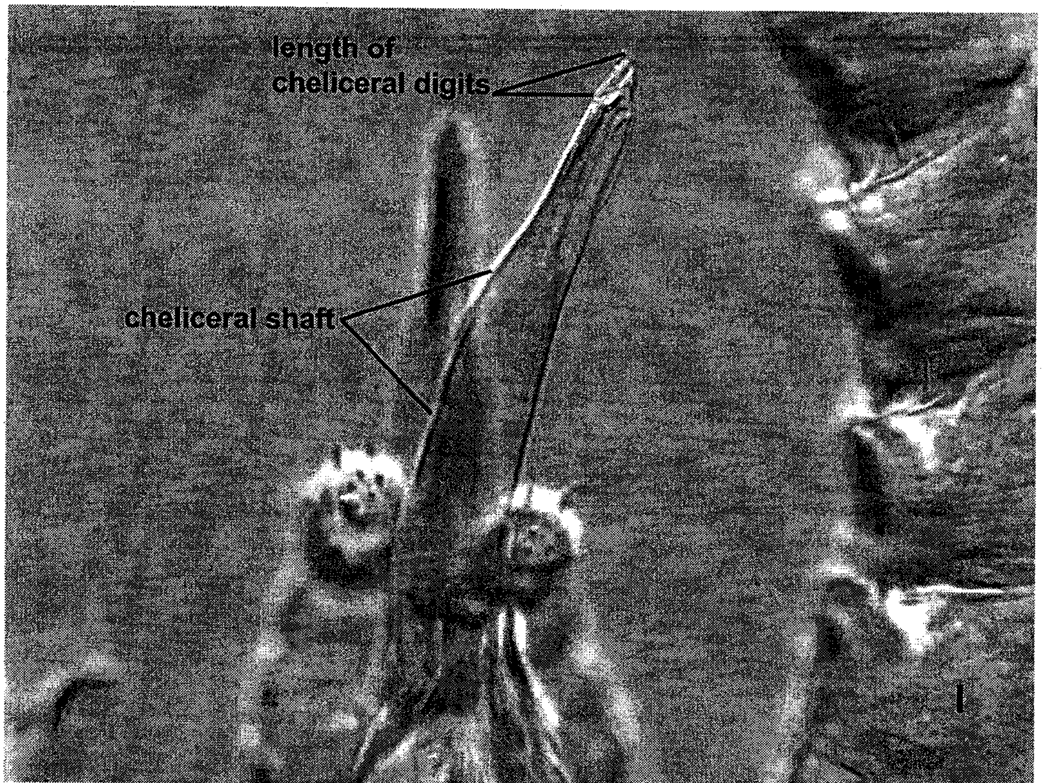


Figure 4.6. *Ptilonyssus tyrannus* (Brooks and Strandtmann, 1960) distally attenuated chelicera.

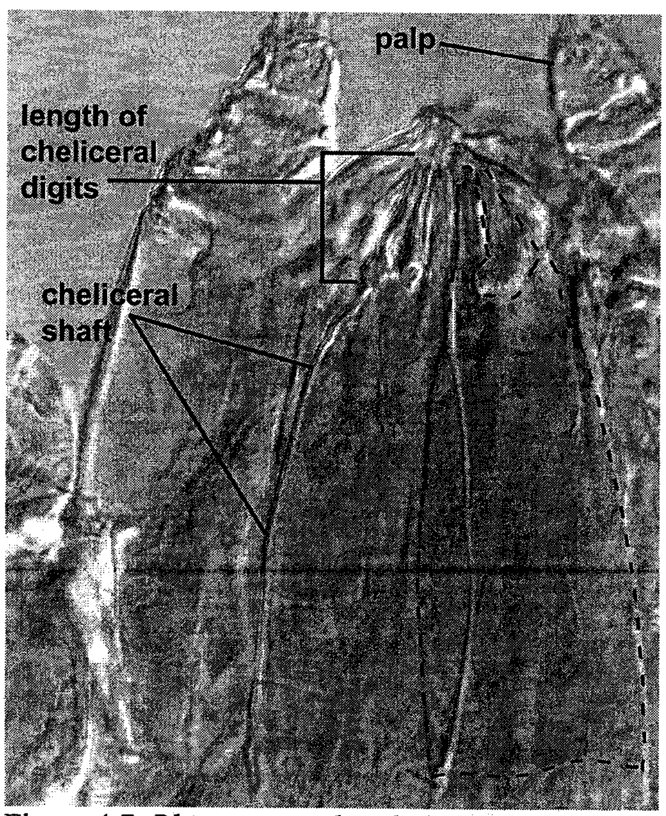


Figure 4.7. *Rhinonyssus rhinolethrum* (Trouessart, 1895) chelicerae.

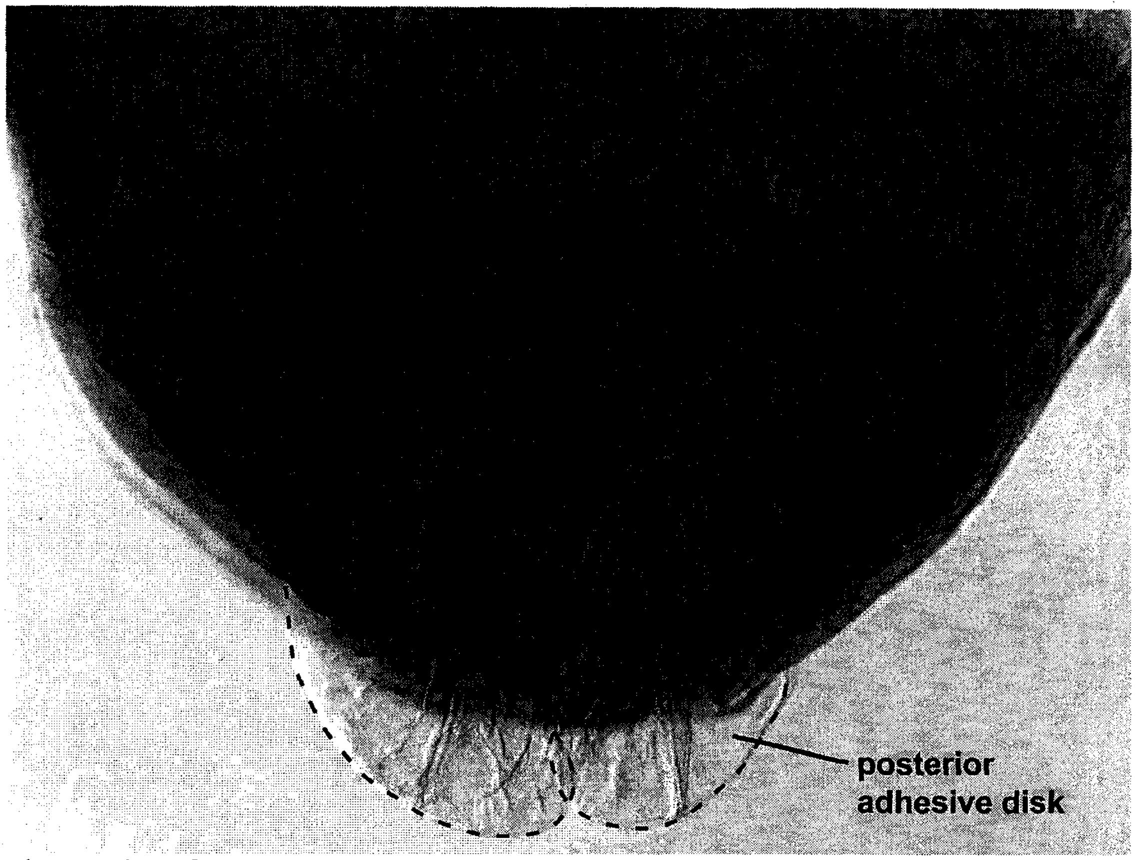


Figure 4.8. *Rallinyssus caudistigmus* Strandtmann, 1948 posterior adhesive disk.

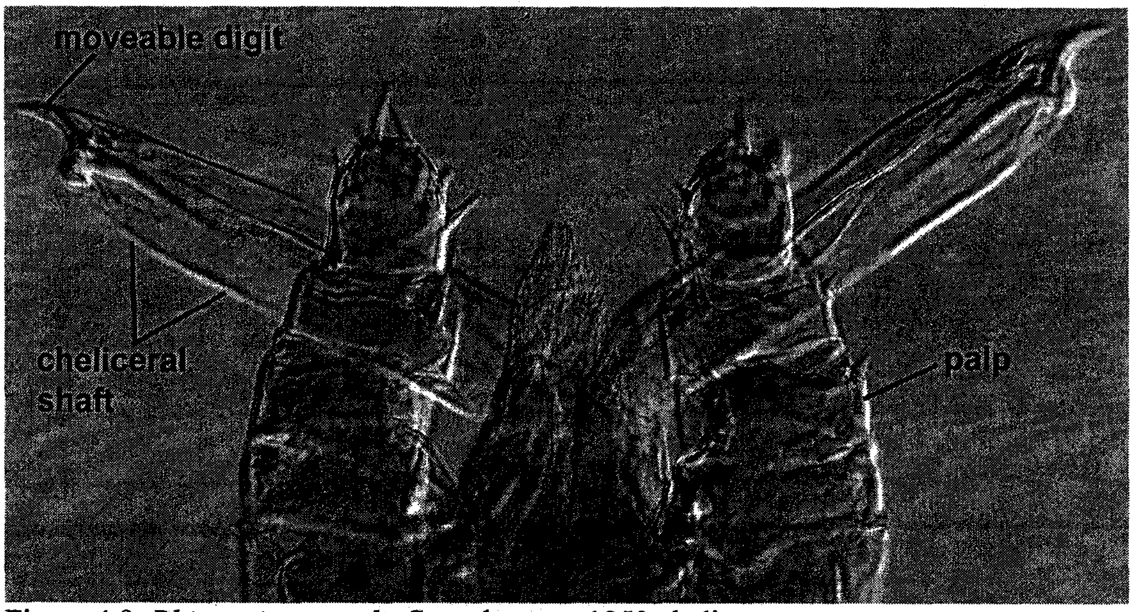


Figure 4.9. *Rhinoecius grandis* Strandtmann, 1952 chelicerae.

Figure 4.10. *Ptilonyssus tyrannus* (Brooks and Strandtmann, 1960) chelicera.

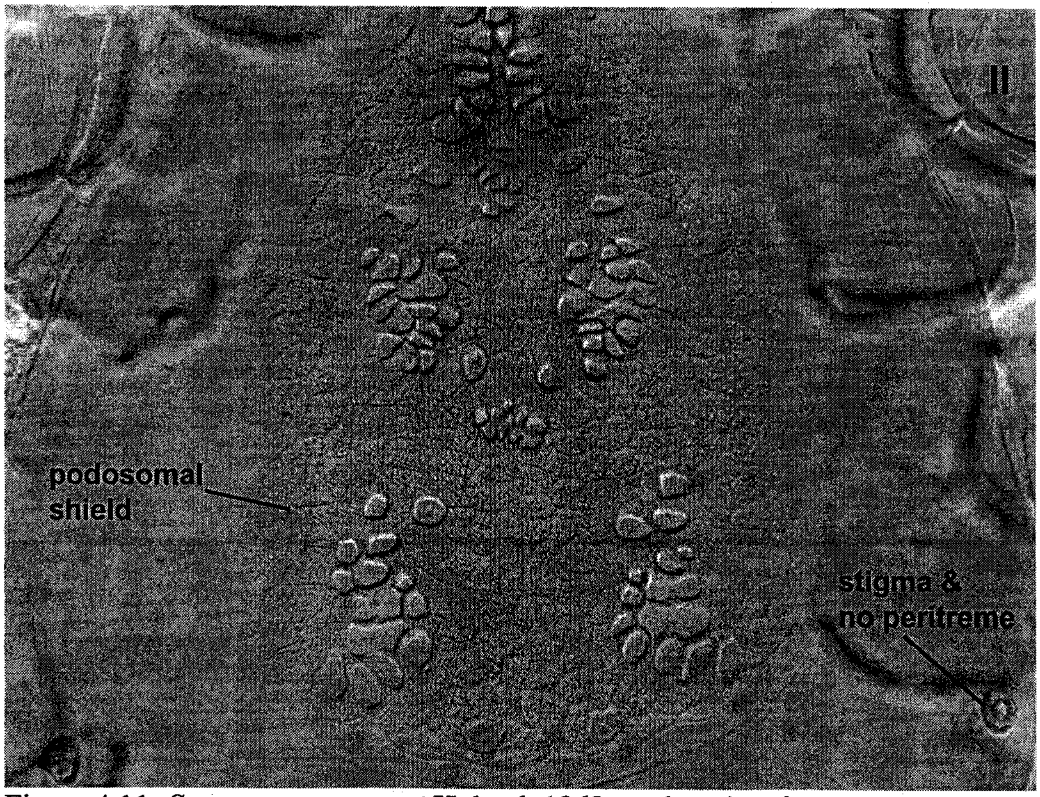


Figure 4.11. *Sternostoma porteri* Hyland, 1962 prodorsal region.

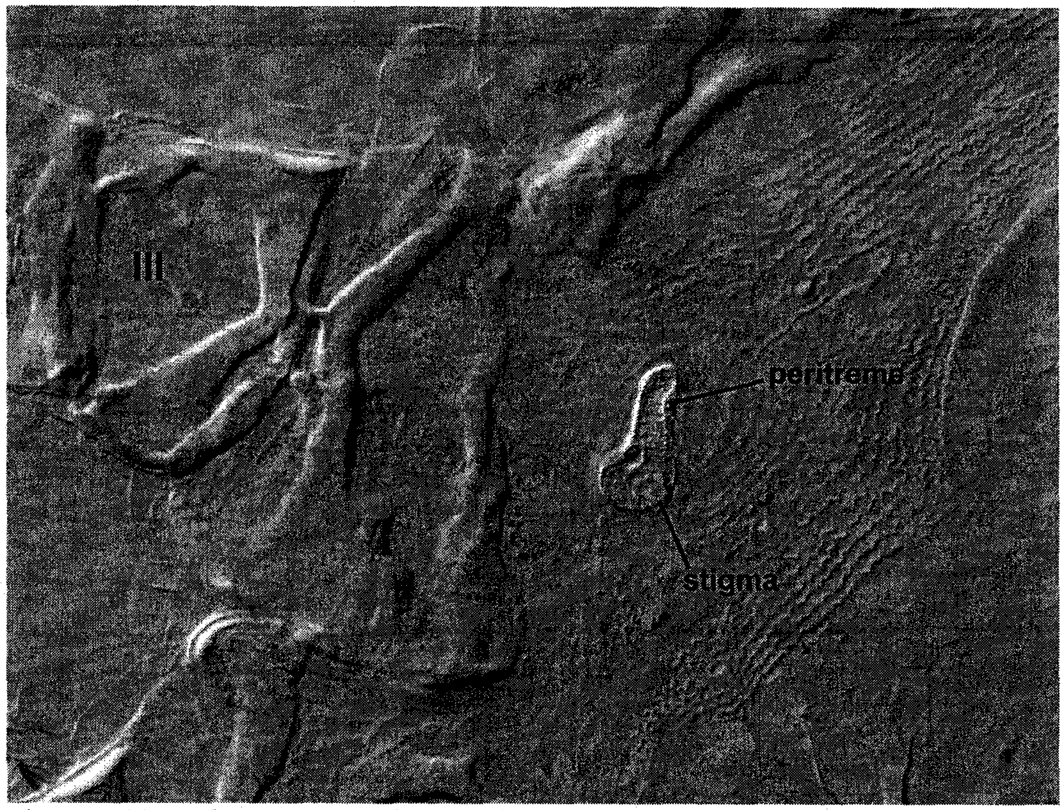


Figure 4.12. *Ptilonyssus japuibensis* Castro, 1948 stigma.

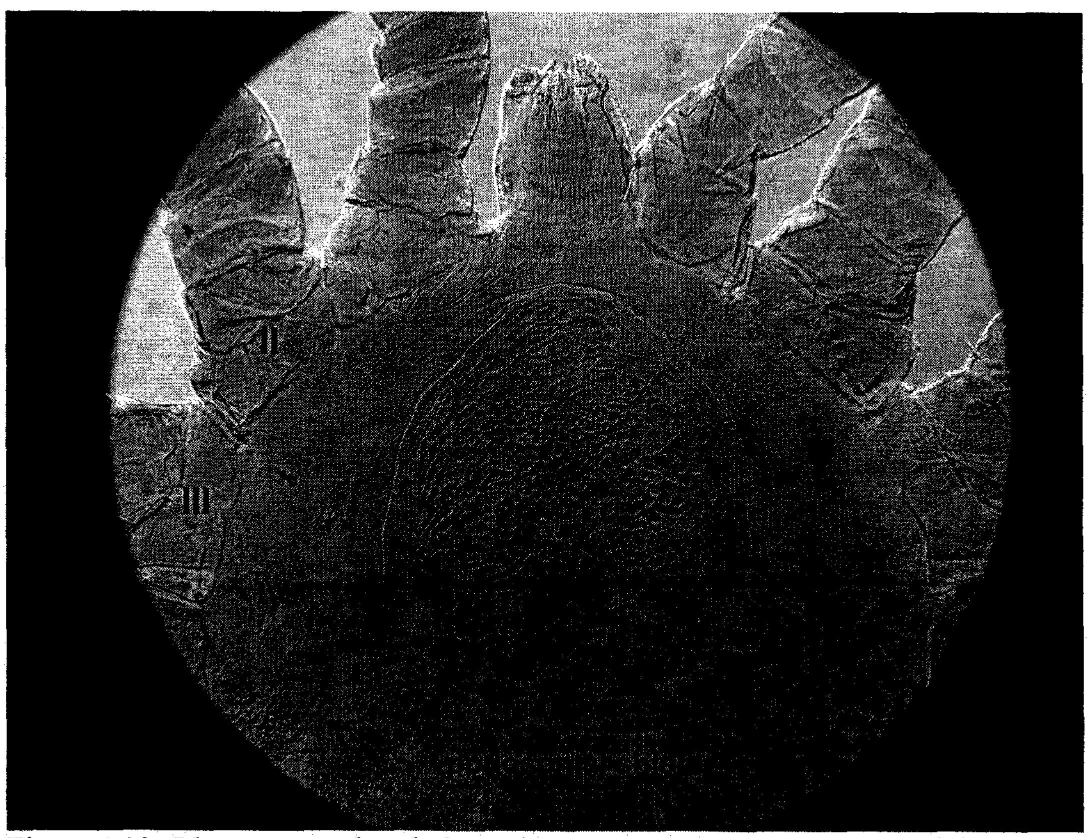


Figure 4.13. *Rhinonyssus rhinolethrum* (Trouessart, 1895) podosomal shield.

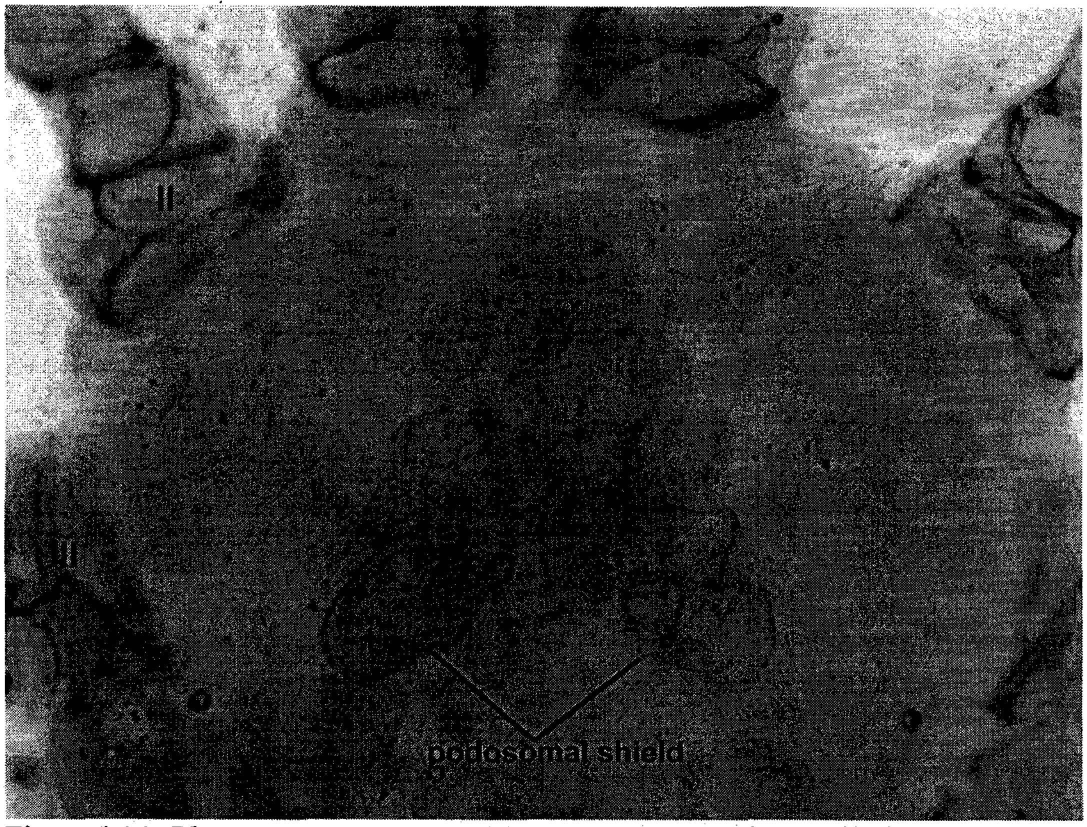


Figure 4.14. *Rhinonyssus coniventris* Trouessart, 1894 podosomal shield.

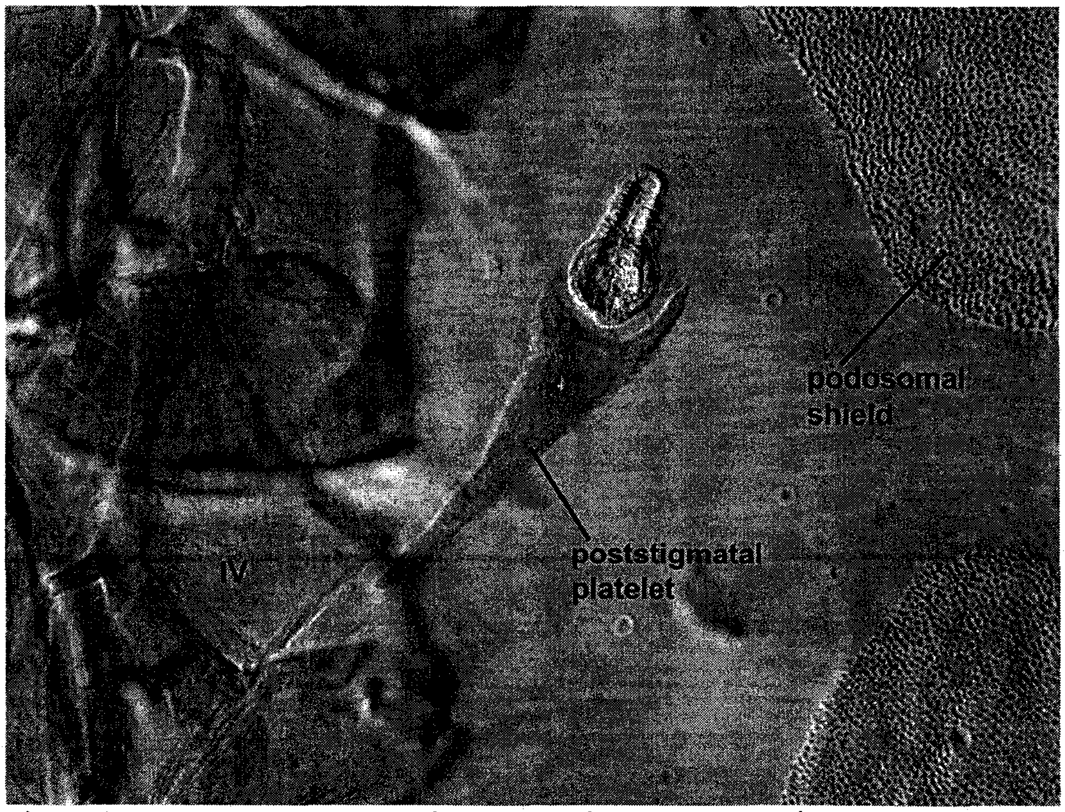


Figure 4.15. *Tinaminyssus zenaidurae* (Crossley, 1952) poststigmatal platelet.

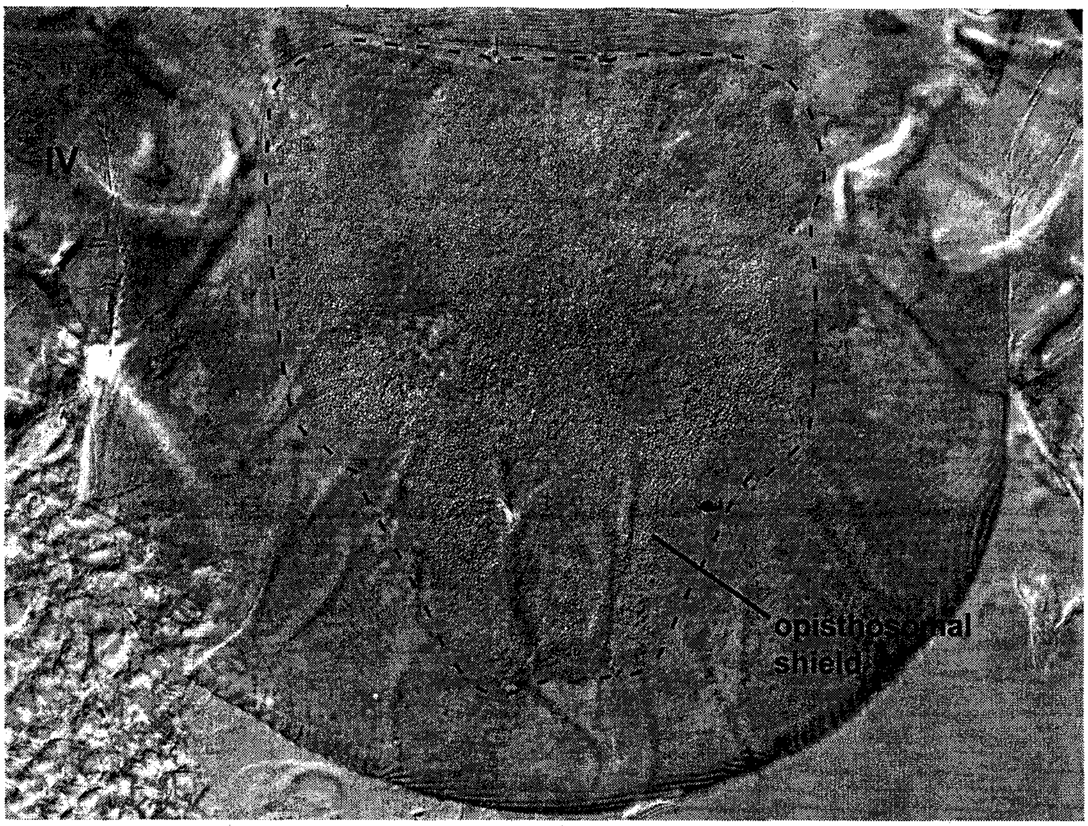


Figure 4.16. *Tinaminyssus melloi* (Castro, 1948) dorsal opisthosomal shield.

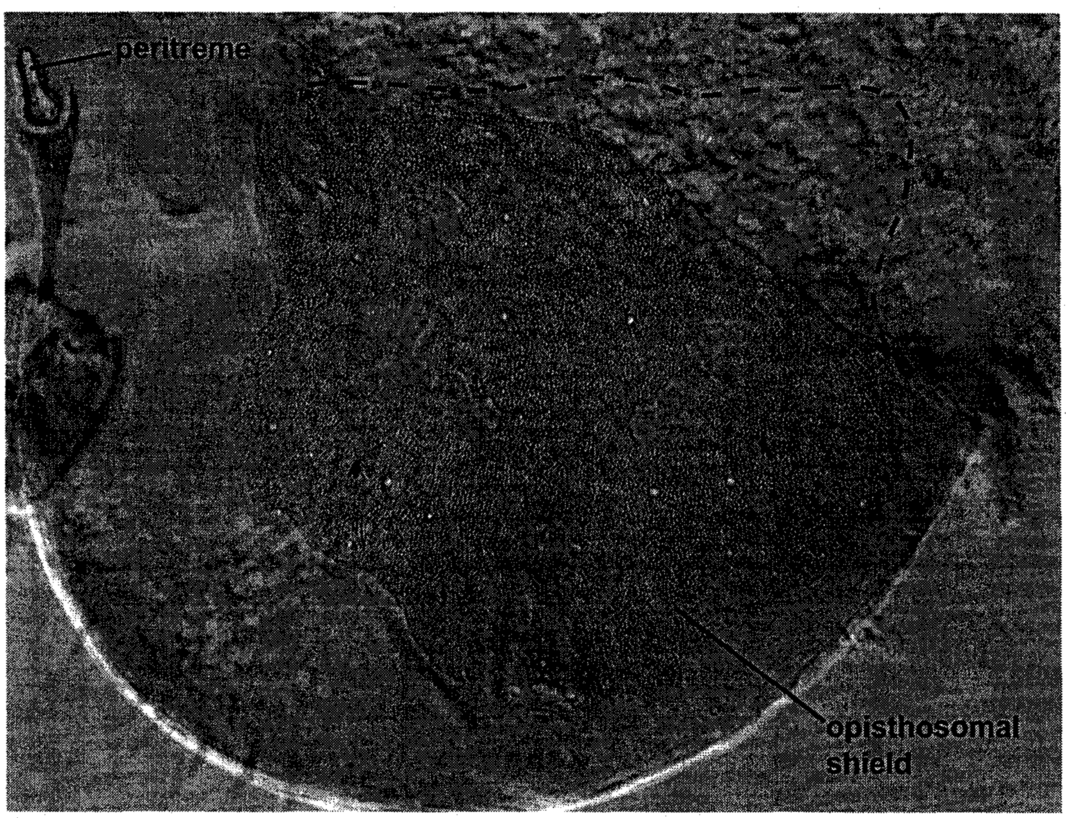


Figure 4.17. *Tinaminyssus zenaidurae* (Crossley, 1952) dorsal opisthosomal shield.

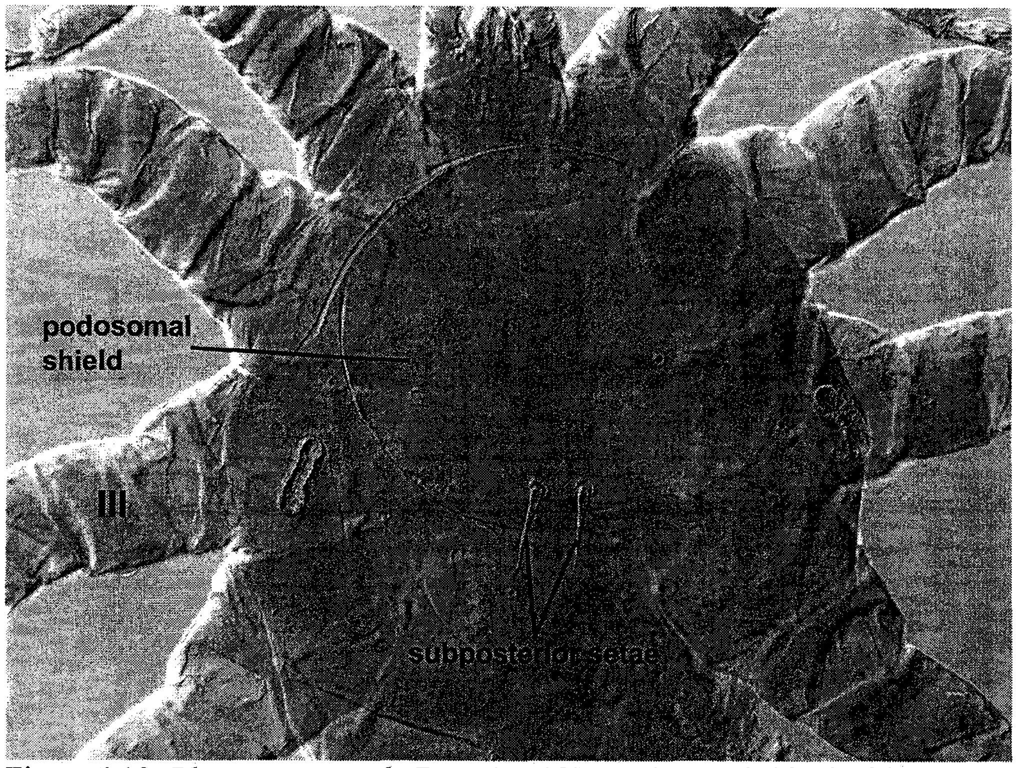


Figure 4.18. *Rhinoecius aegolii* Butenko, 1971 podosomal shield with subposterior setae.

Figure 4.19. *Rhinoecius brikinboricus* Butenko, 1976 podosomal shield with subposterior setae.

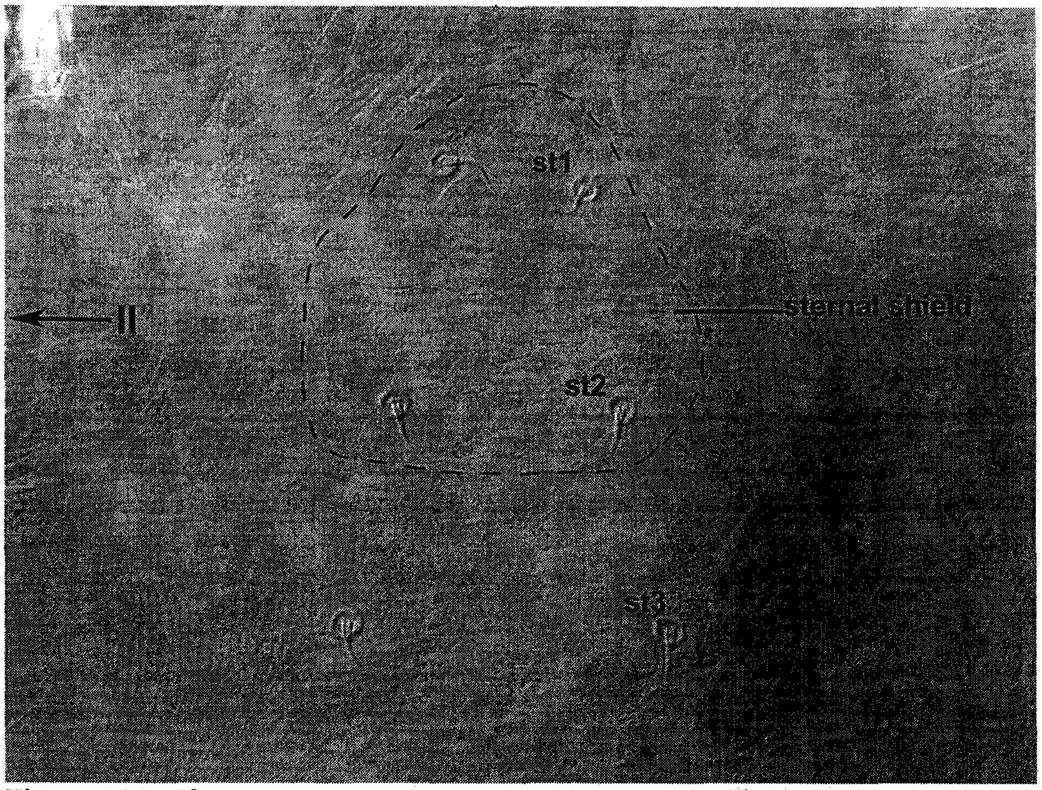


Figure 4.20. *Rhinoecius nycteae* Butenko, 1976 sternal shield.

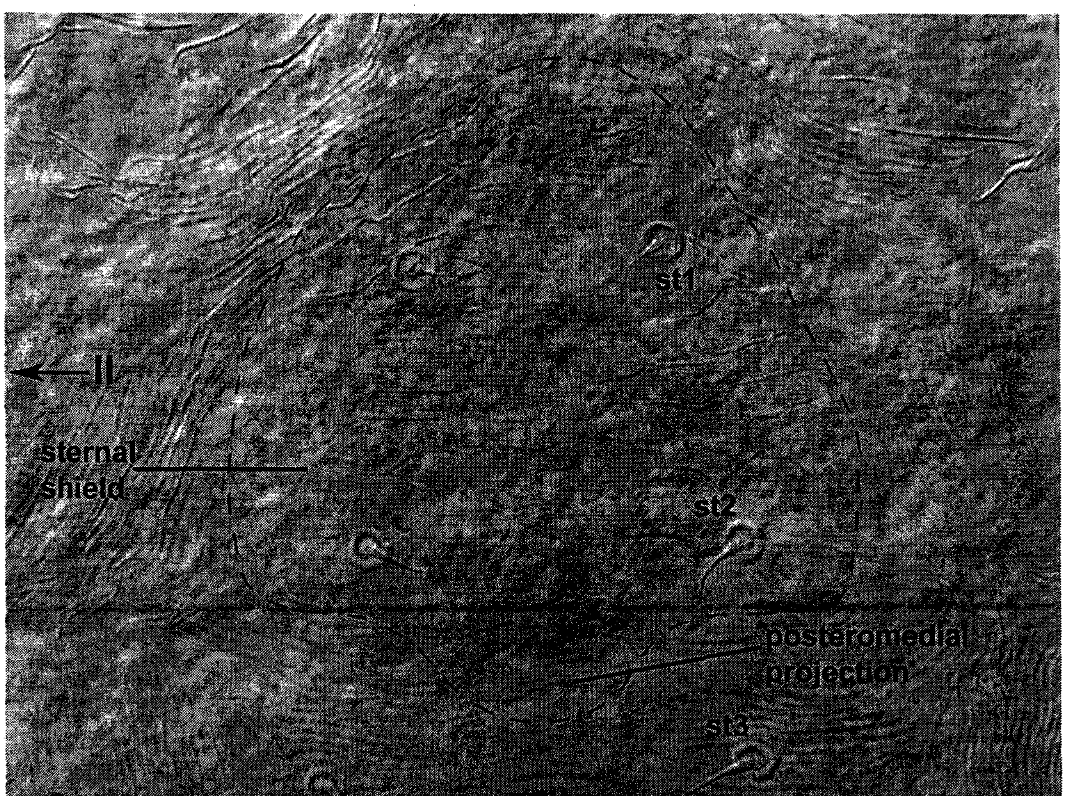


Figure 4.21. *Rhinoecius brikinboricus* Butenko, 1976 sternal shield with posteromedial projection.

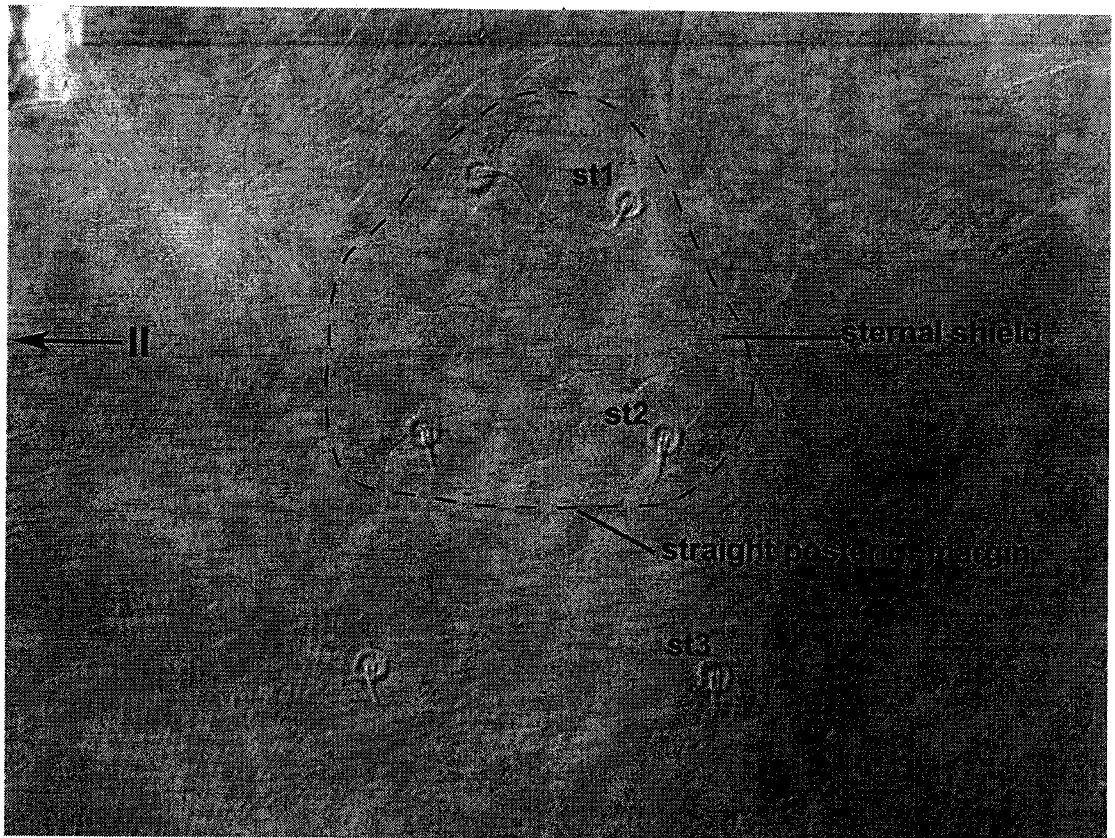


Figure 4.22. *Rhinoecius nycteae* Butenko, 1976 sternal shield, straight posterior margin.

Figure 4.23. *Rhinoecius brikinboricus* Butenko, 1976 sternal shield.

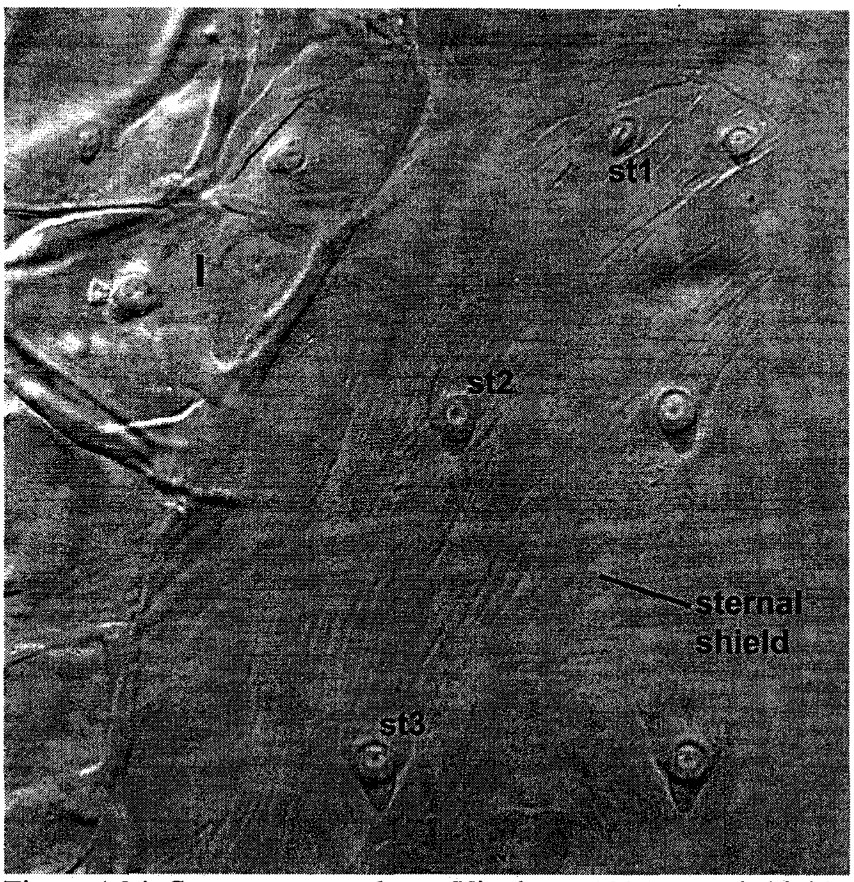


Figure 4.24. *Sternostoma technaui* Vitzthum, 1935 sternal shield.

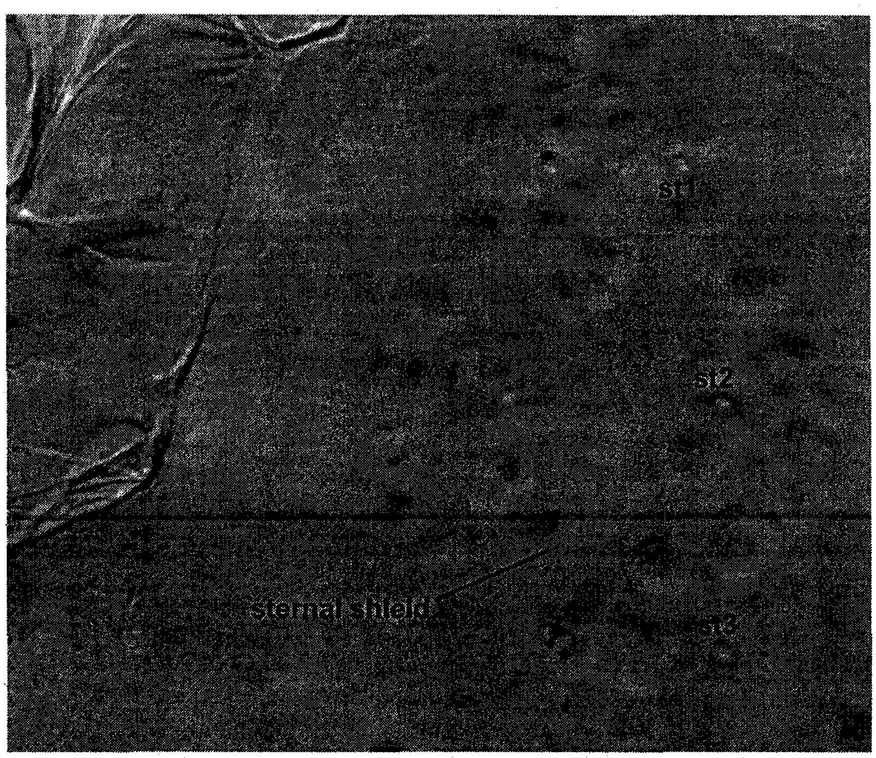


Figure 4.25. *Sternostoma porteri* Hyland, 1962 sternal shield.

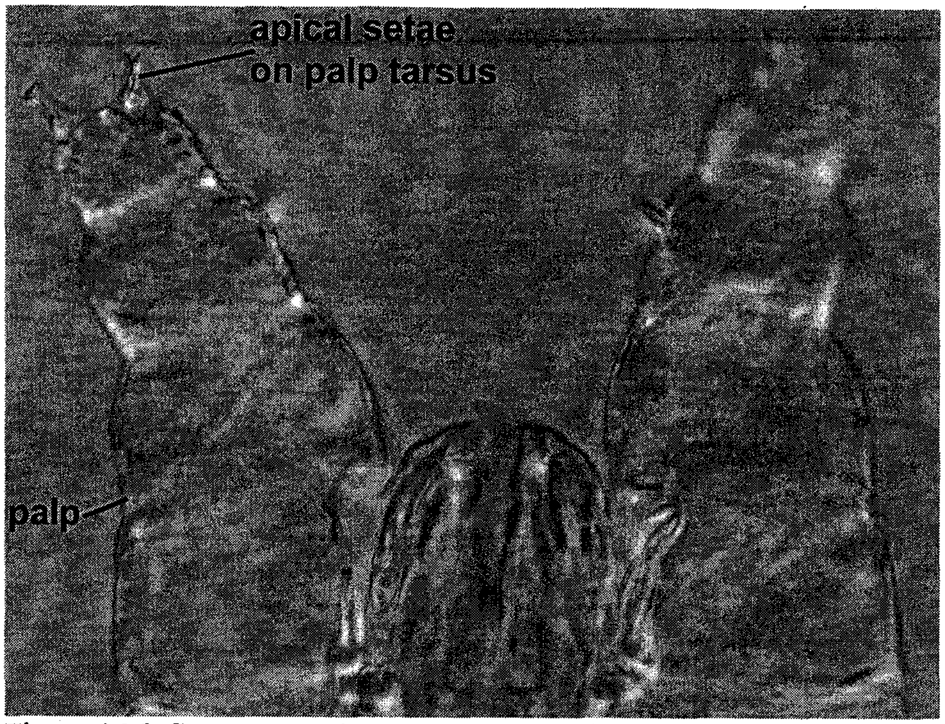


Figure 4.26. *Sternostoma longisetosae* Hyland, 1961 palps.

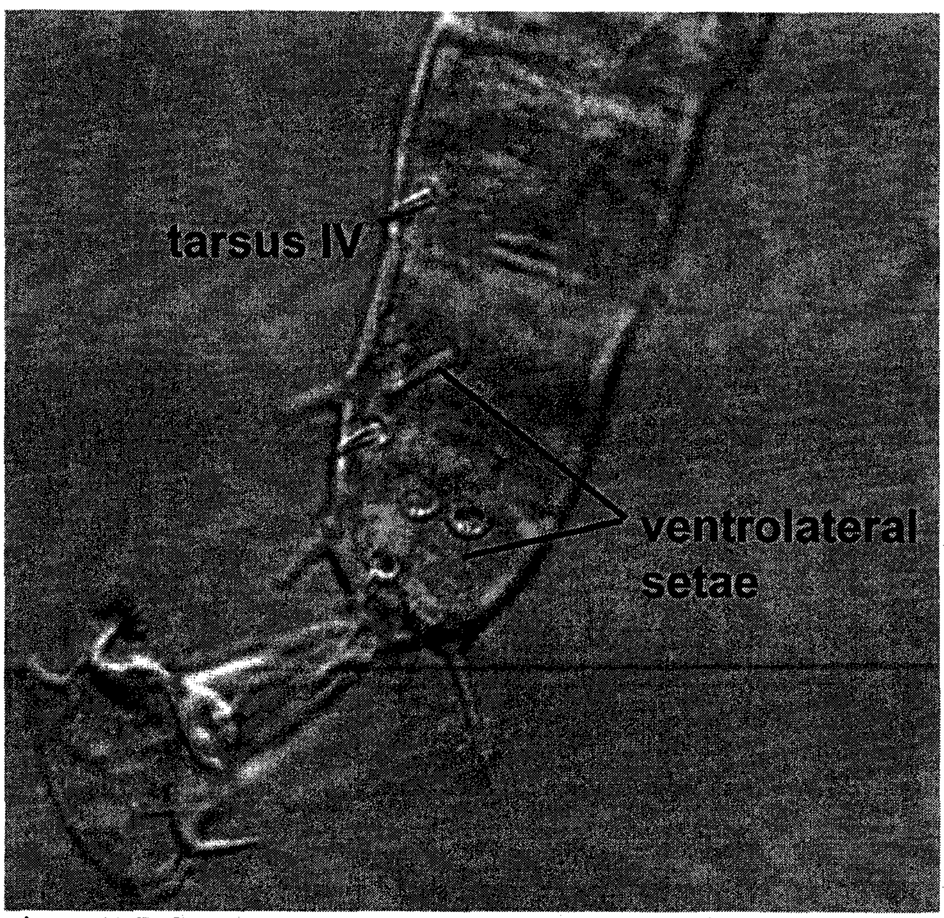


Figure 4.27. *Sternostoma longisetosae* Hyland, 1961 tarsus IV.

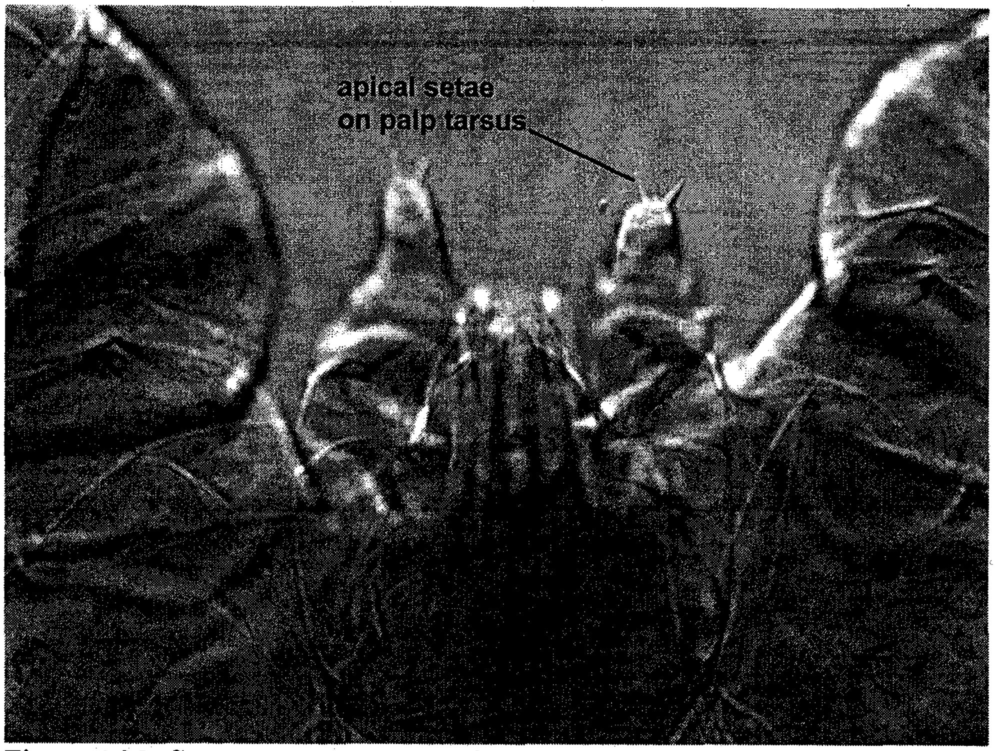


Figure 4.28. *Sternostoma porteri* Hyland, 1962 palps.

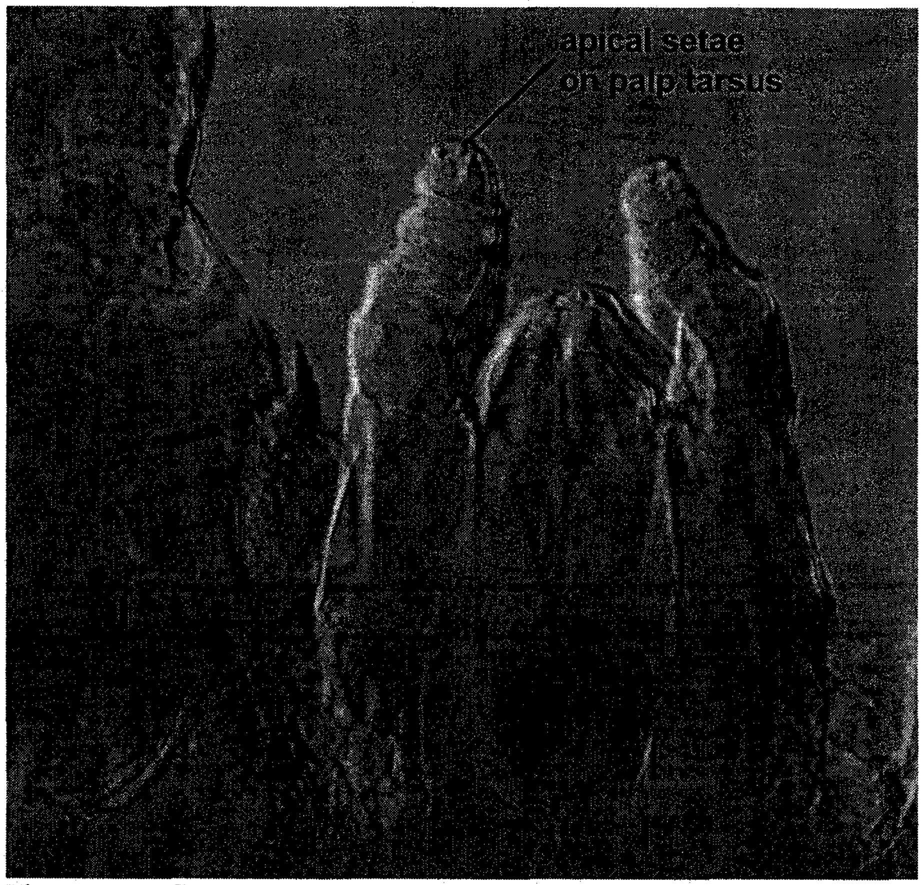


Figure 4.29. *Sternostoma cryptorhynchum* Berlese and Trouessart, 1889 palps.

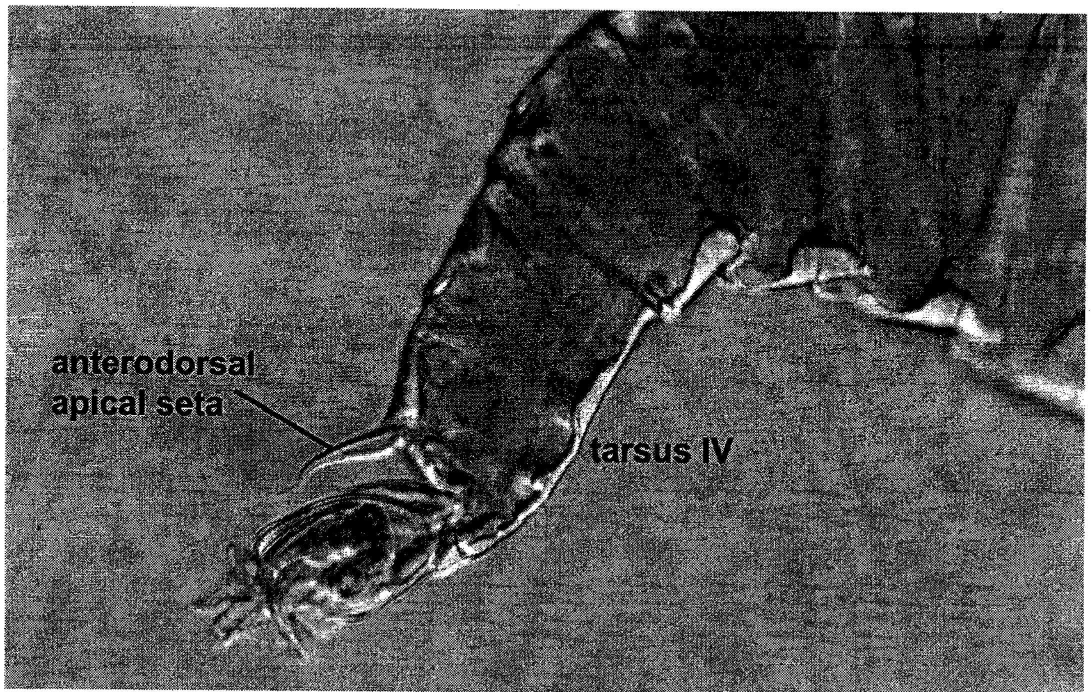


Figure 4.30. *Sternostoma porteri* Hyland, 1962 tarsus IV.

Figure 4.31. *Sternostoma porteri* Hyland, 1962 tarsus IV.

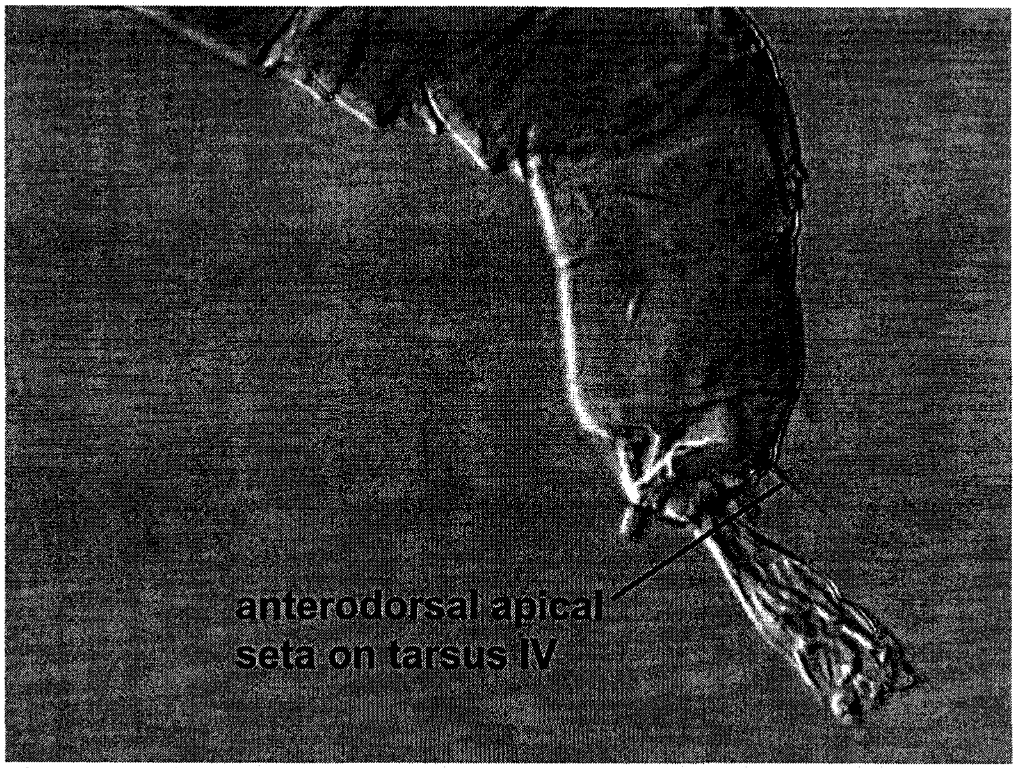


Figure 4.32. *Sternostoma cryptorhynchum* Berlese and Trouessart, 1889 tarsus IV.

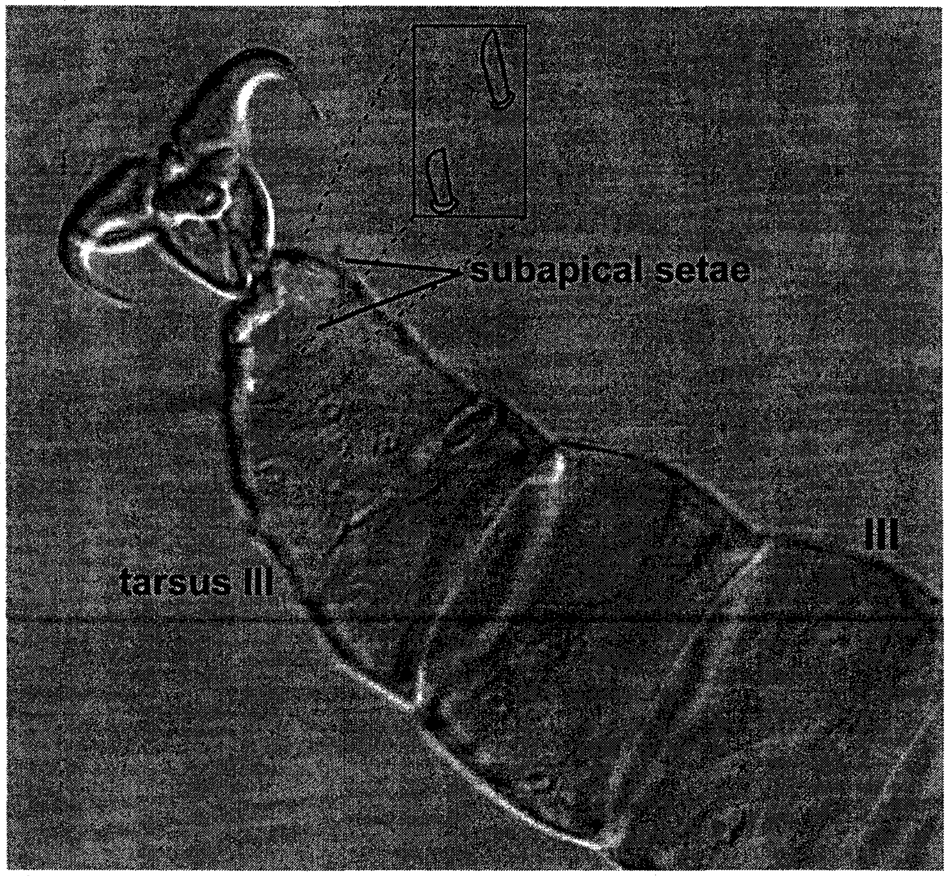


Figure 4.33. *Sternostoma boydi* Strandtmann, 1951 tarsus IV.

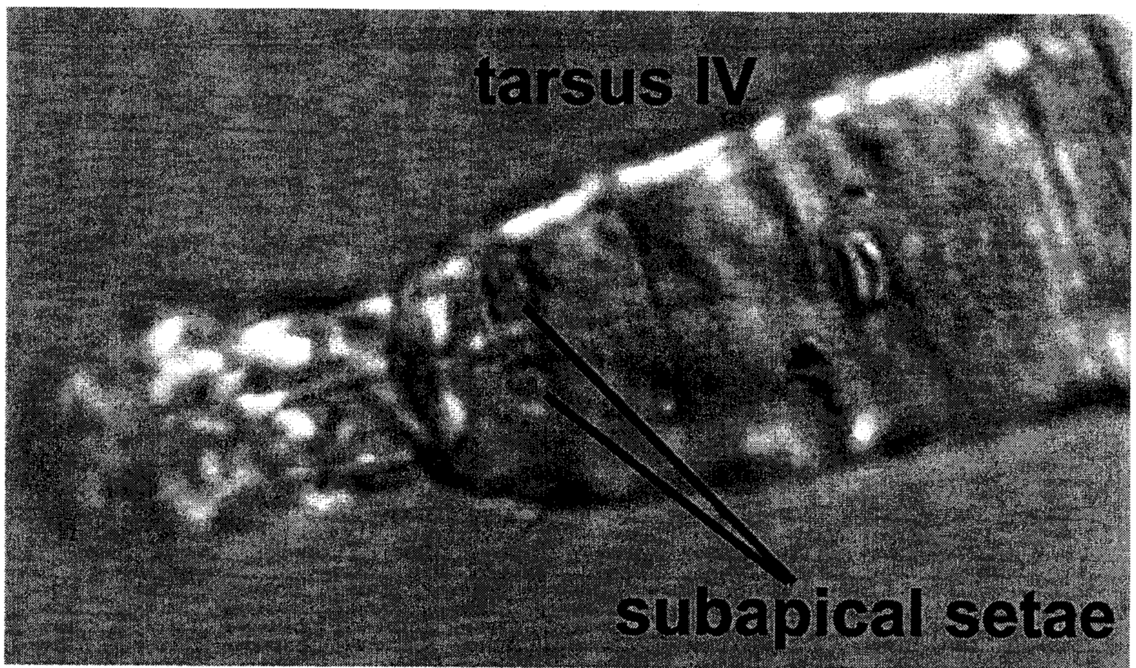


Figure 4.34. *Sternostoma tracheacolum* Lawrence, 1948 tarsus IV.

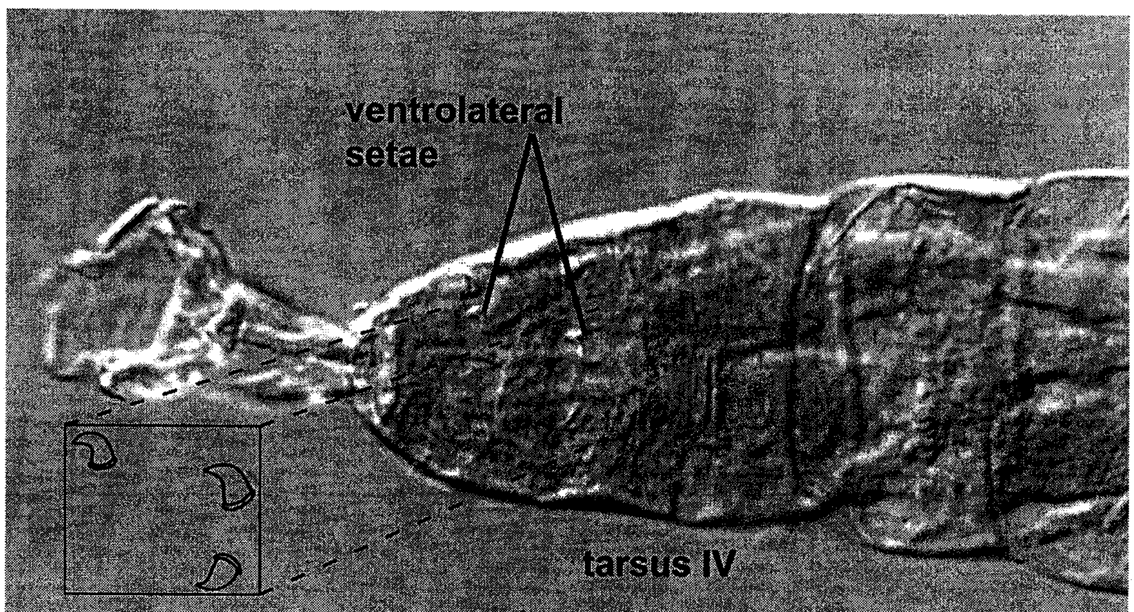


Figure 4.35. *Sternostoma lanorium* Fain 1956 tarsus IV.

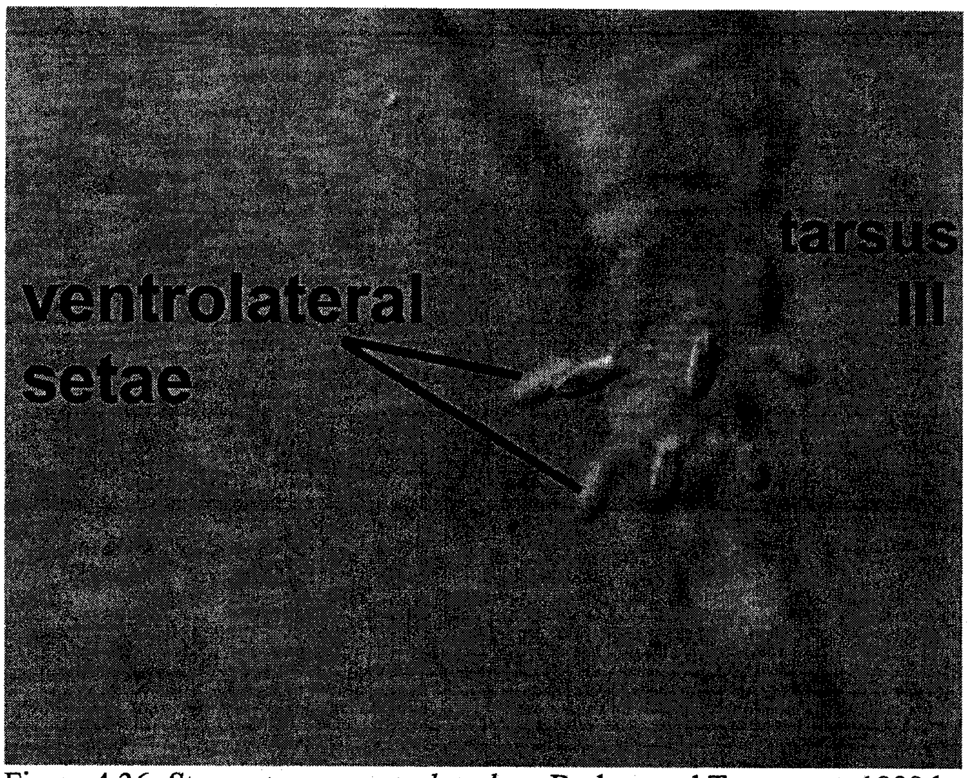


Figure 4.36. *Sternostoma cryptorhynchum* Berlese and Trouessart, 1889 leg IV.

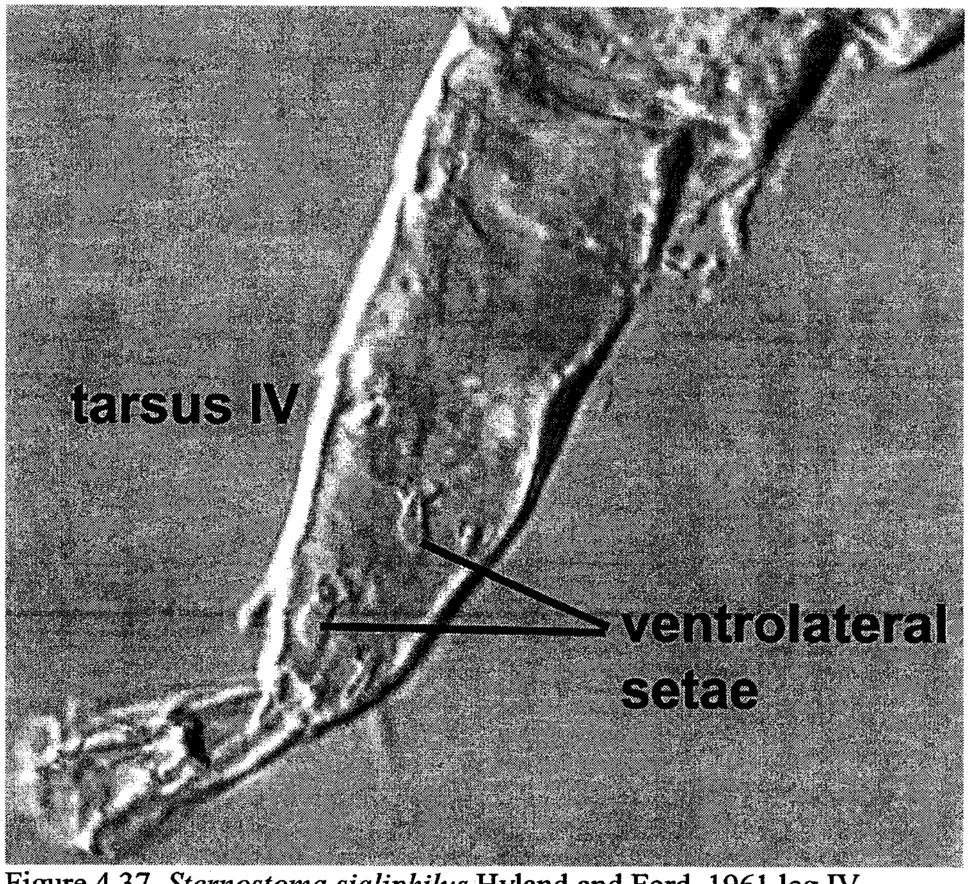


Figure 4.37. *Sternostoma sialiphilus* Hyland and Ford, 1961 leg IV.

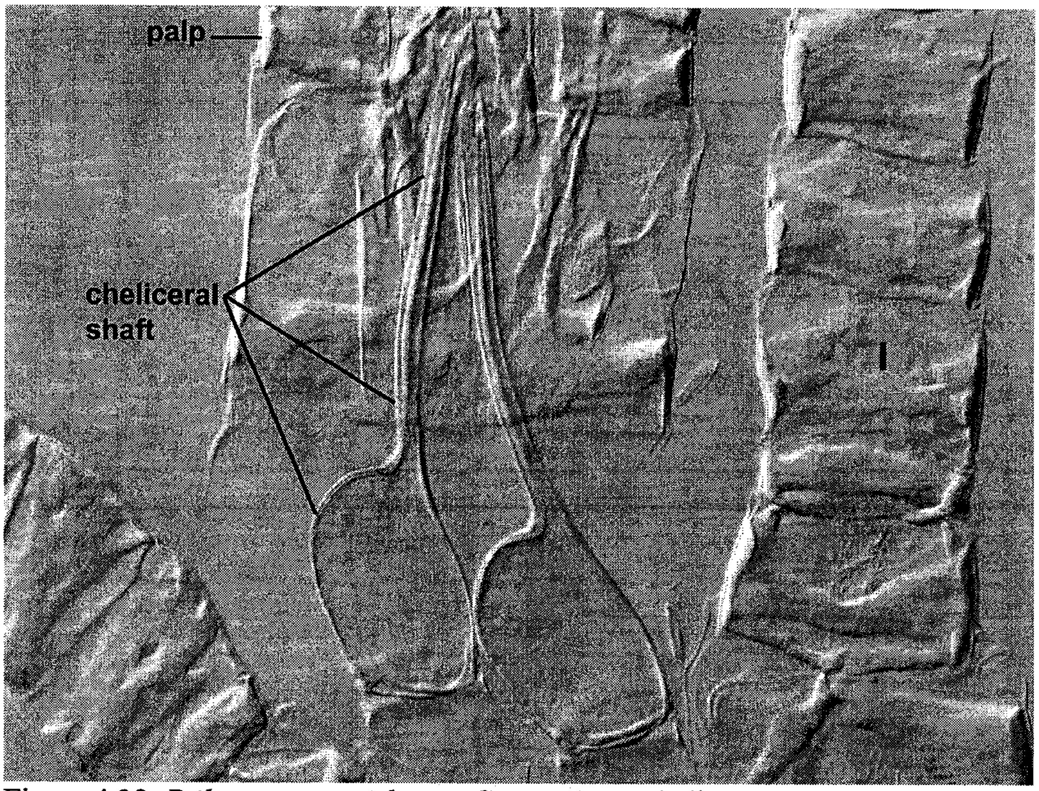


Figure 4.38. *Ptilonyssus japuibensis* Castro, 1948 chelicerae.

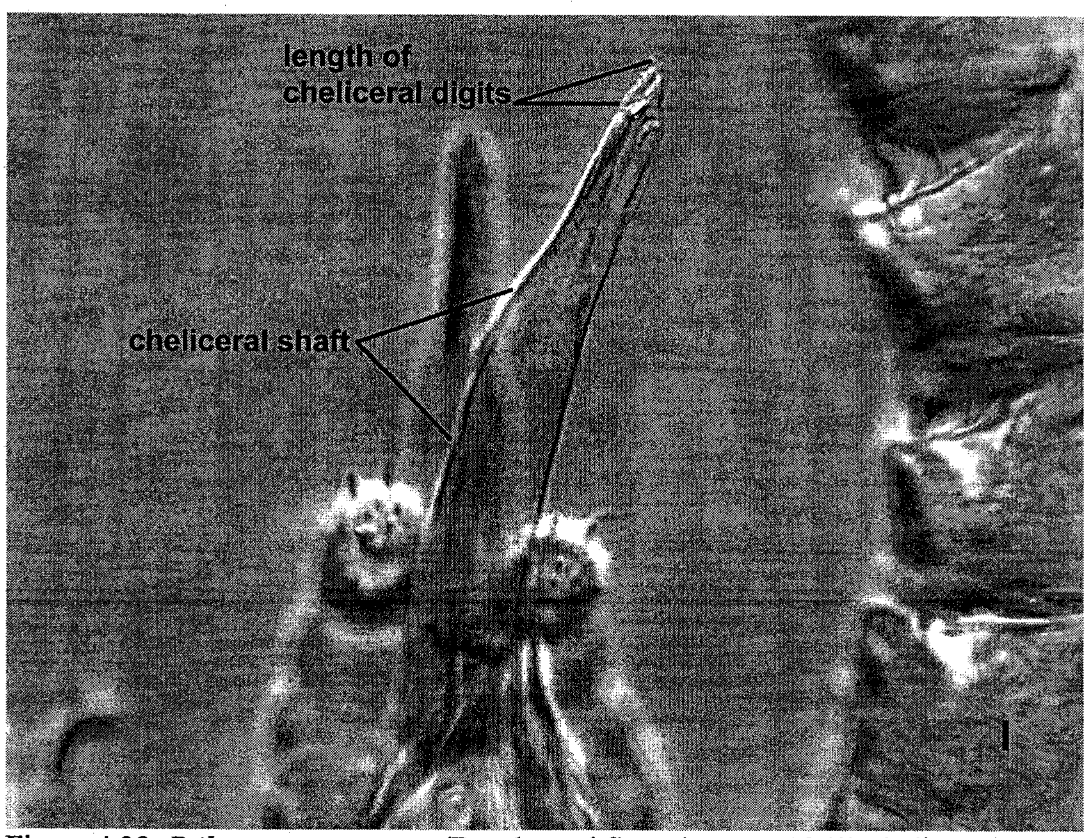


Figure 4.39. *Ptilonyssus tyrannus* (Brooks and Strandtmann, 1960) chelicera.

Figure 4.40. *Ptilonyssus angrensis* (Castro, 1948) anal shield.

Figure 4.41. *Ptilonyssus bombycillae* Fain, 1972 anal shield.

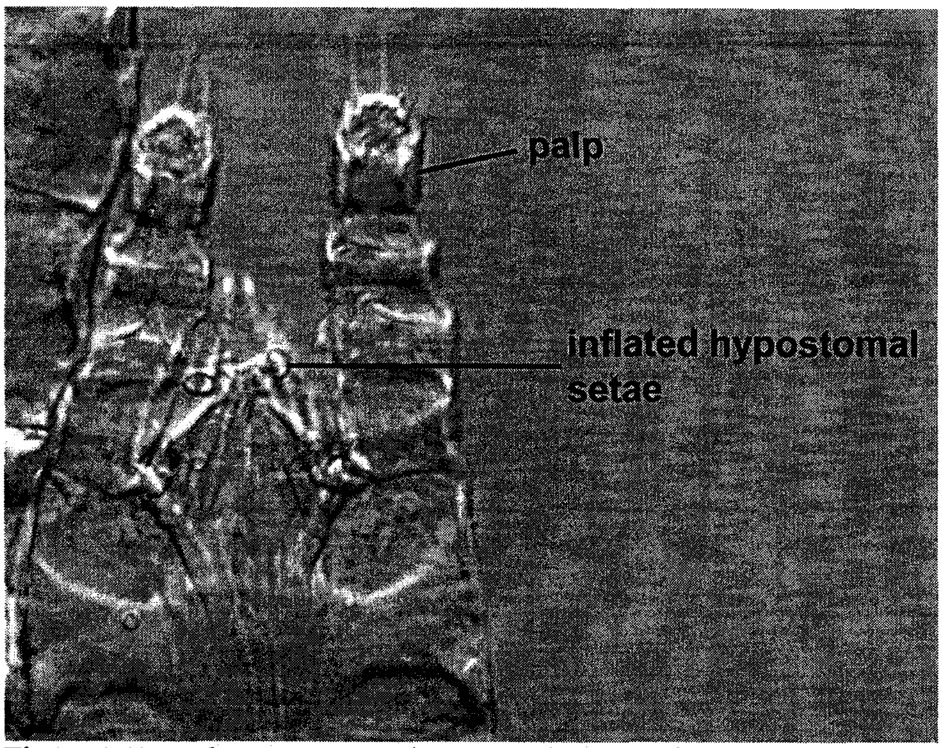


Figure 4.42. *Ptilonyssus coccothraustis* Fain and Bafort, 1963 ventral gnathosoma.

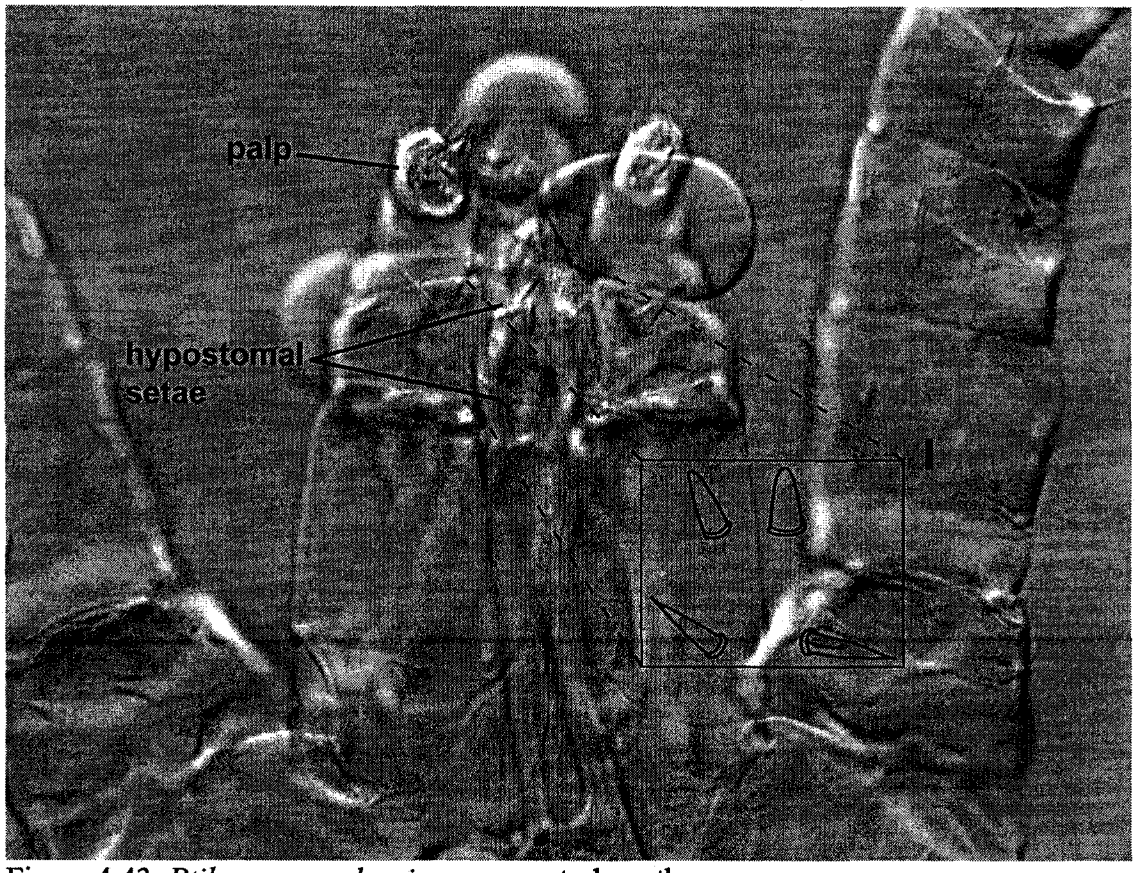


Figure 4.43. *Ptilonyssus calvaria* sp. n. ventral gnathosoma.

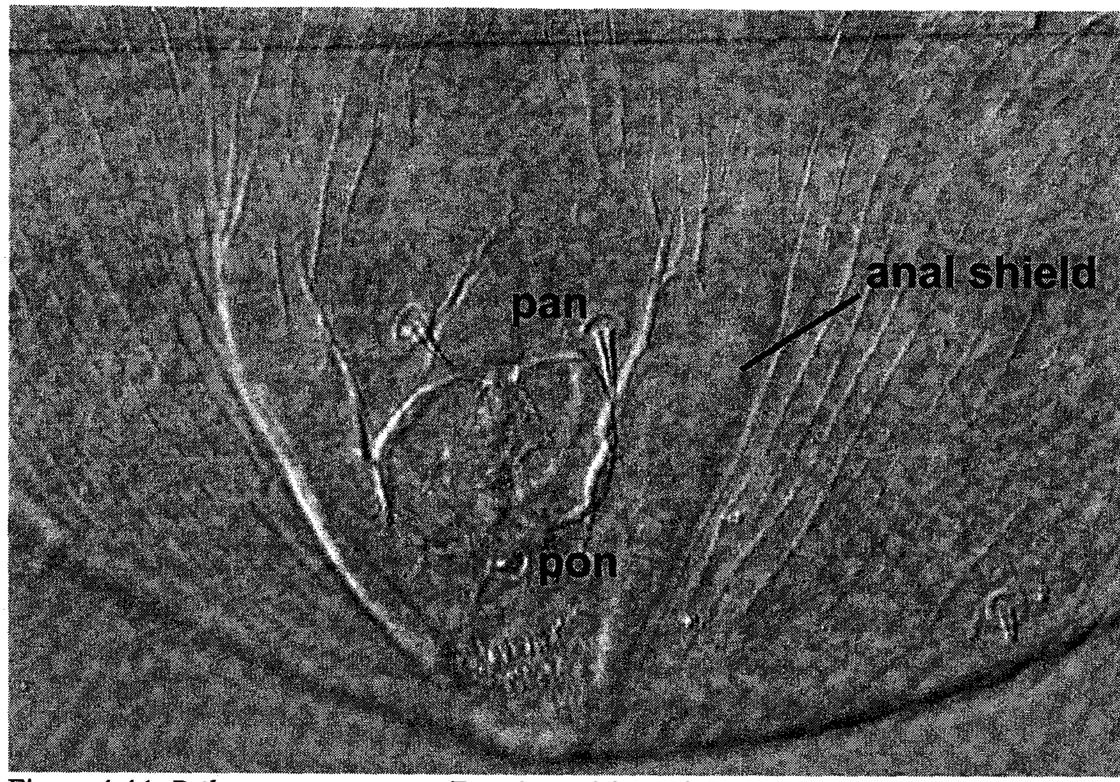


Figure 4.44. *Ptilonyssus tyrannus* (Brooks and Strandtmann, 1960) anal shield.

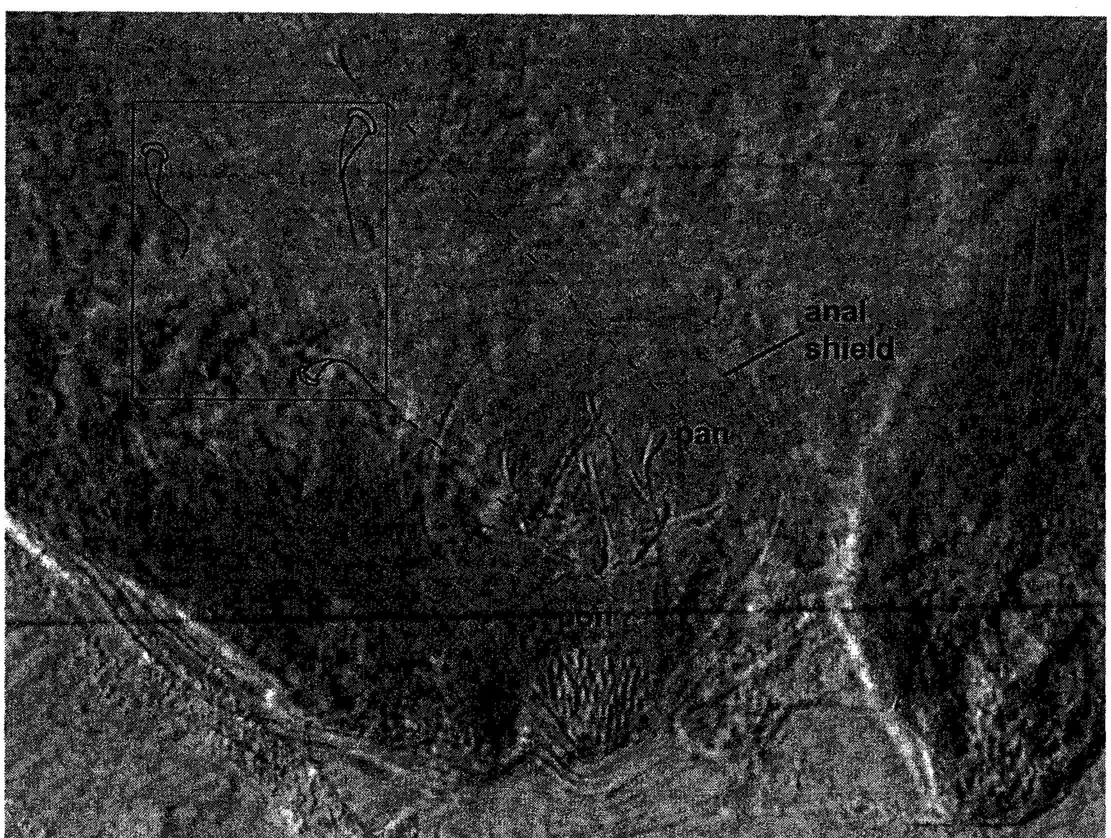


Figure 4.45. *Ptilonyssus plesiotypicus* sp. n. anal shield.

Figure 4.46. *Ptilonyssus pinicola* sp. n. tarsus IV.

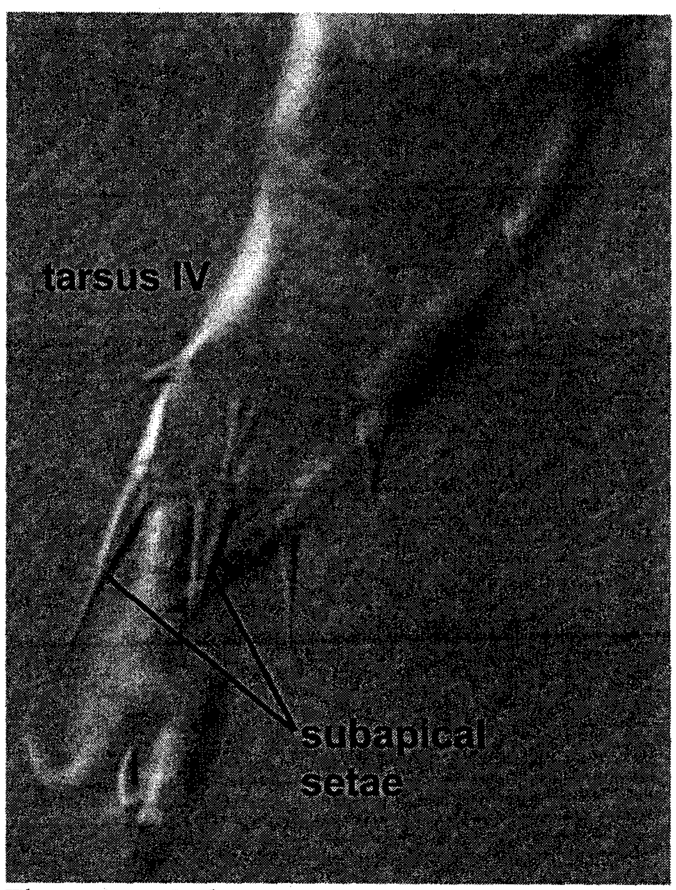


Figure 4.47. *Ptilonyssus coccothraustis* Fain and Bafort, 1963 tarsus IV.

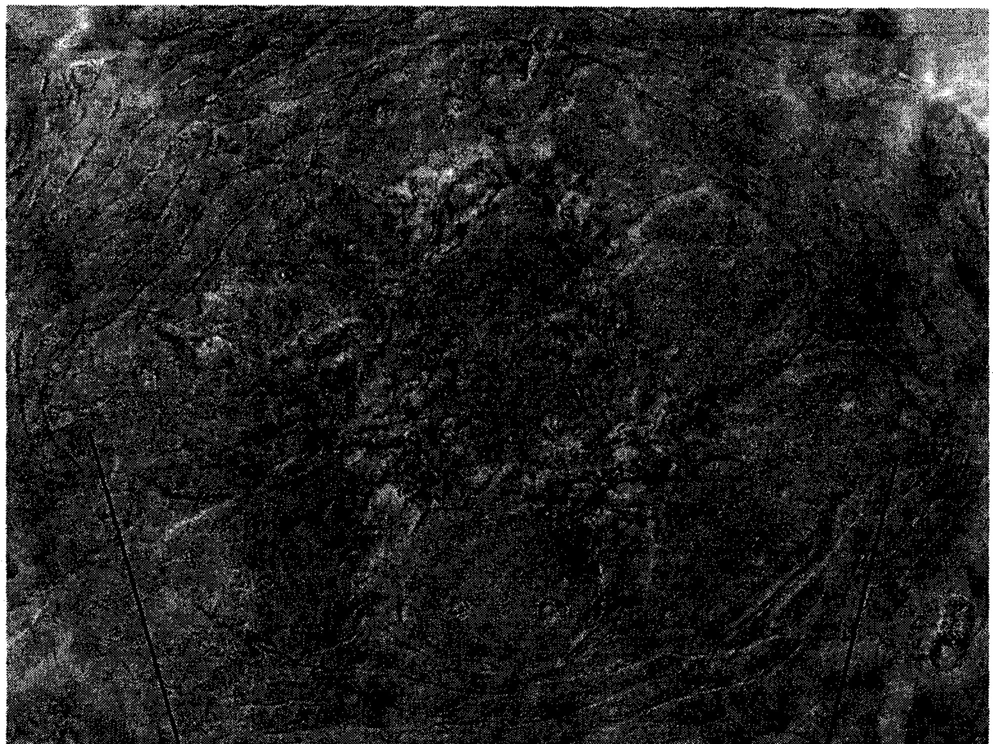


Figure 4.48. *Ptilonyssus callinectoides* (Brooks and Strandtmann, 1969) podosomal shield.

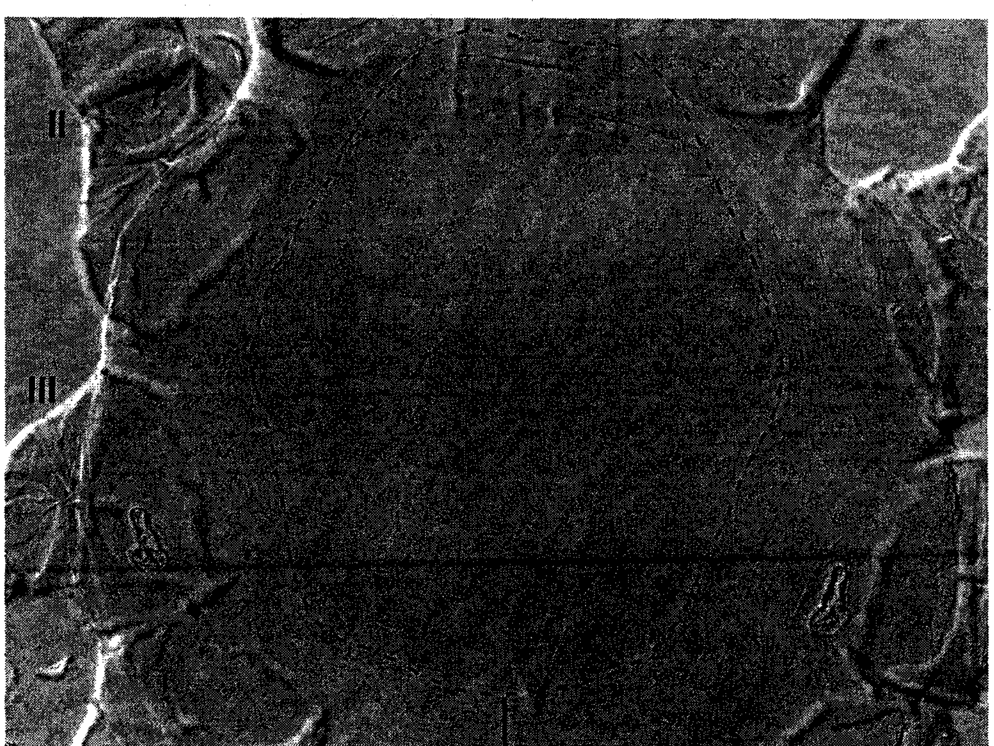


Figure 4.49. *Ptilonyssus nudus* Berlese & Trouessart, 1889 podosomal shield.

Figure 4.50. *Ptilonyssus vireonis* (Dusbabek, 1969) opisthosomal shield showing lateral excavation.

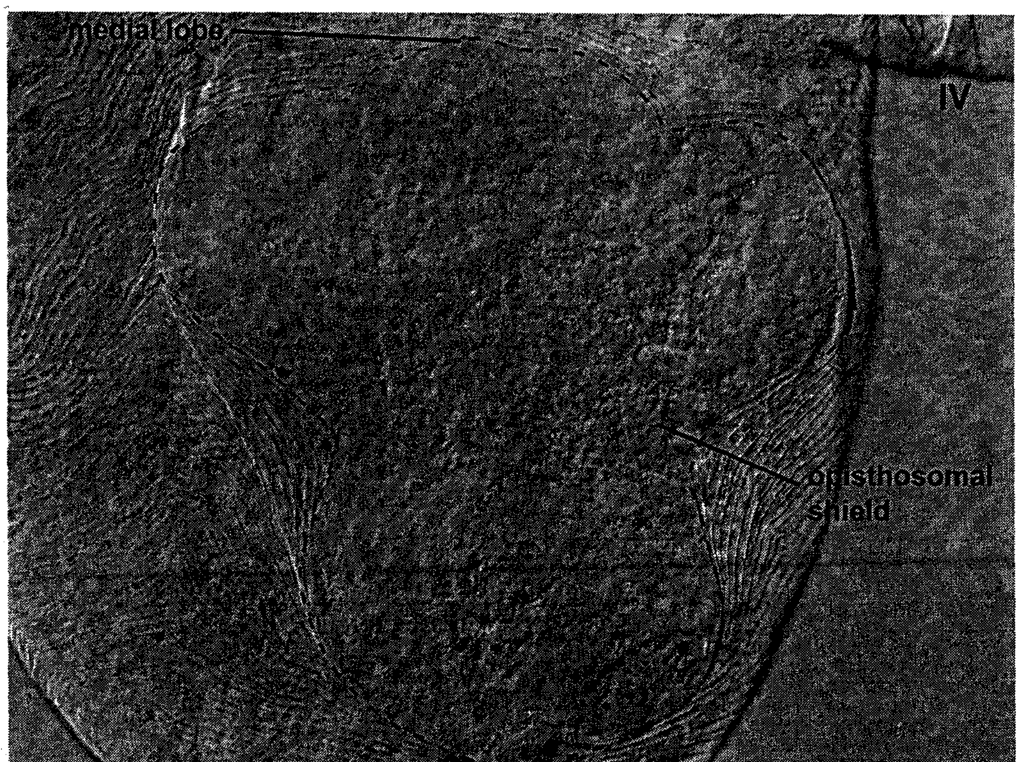


Figure 4.51. *Ptilonyssus vireonis* (Dusbabek, 1969) opisthosomal shield showing anterior projection.

Figure 4.52. *Ptilonyssus pirangae* (Cerny, 1969) opisthosomal shield.

Figure 4.53. *Ptilonyssus coccothraustis* Fain and Bafort, 1963 opisthosomal shield.

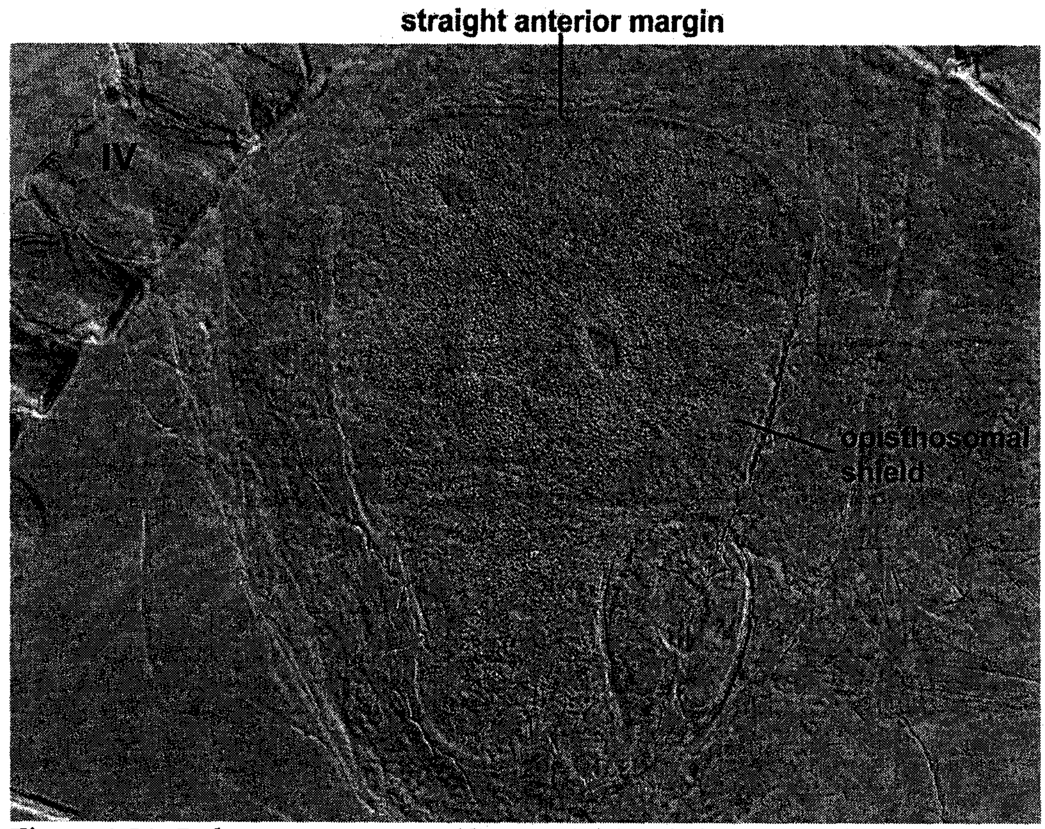


Figure 4.54. *Ptilonyssus pirangae* (Cerny, 1969) opisthosomal shield.

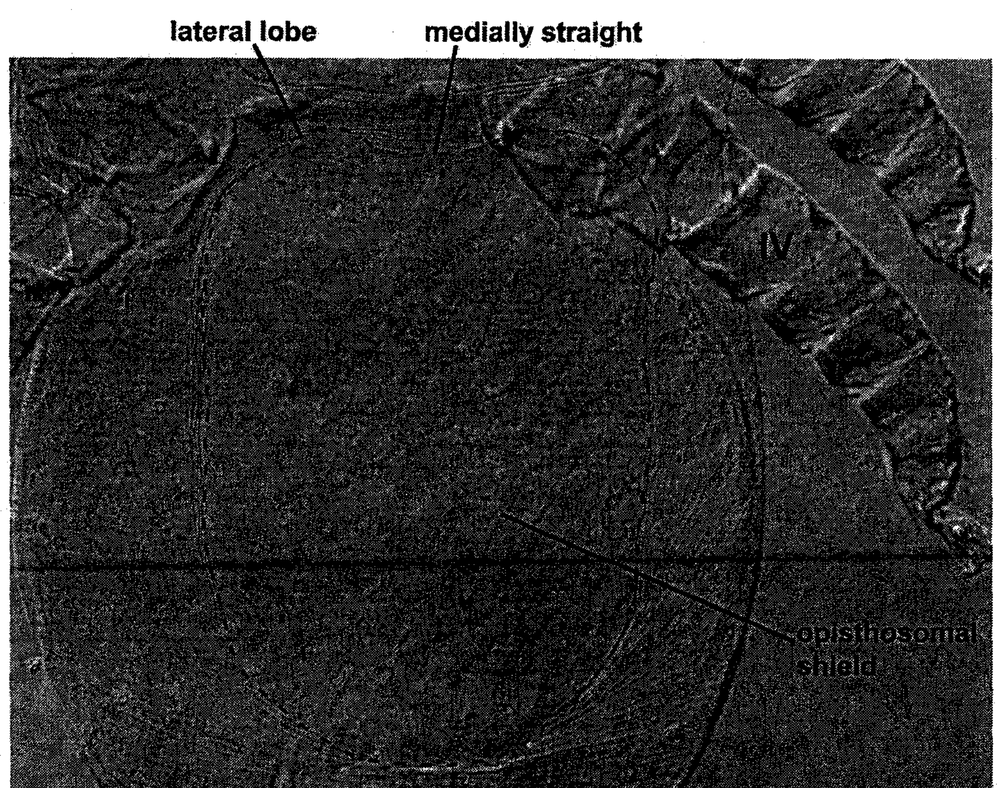


Figure 4.55. *Ptilonyssus coccothraustis* Fain and Bafort, 1963 opisthosomal shield.

Figure 4.56. *Ptilonyssus coccothraustis* Fain and Bafort, 1963 sternal shield.

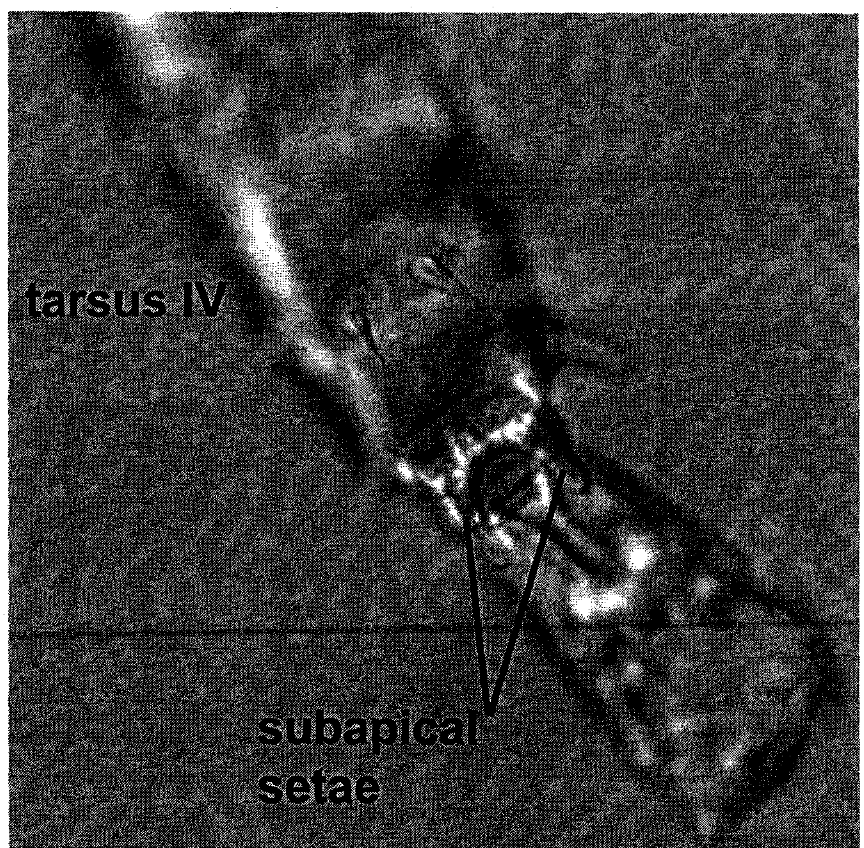


Figure 4.57. *Ptilonyssus tyrannus* (Brooks and Strandtmann, 1960) tarsus IV.

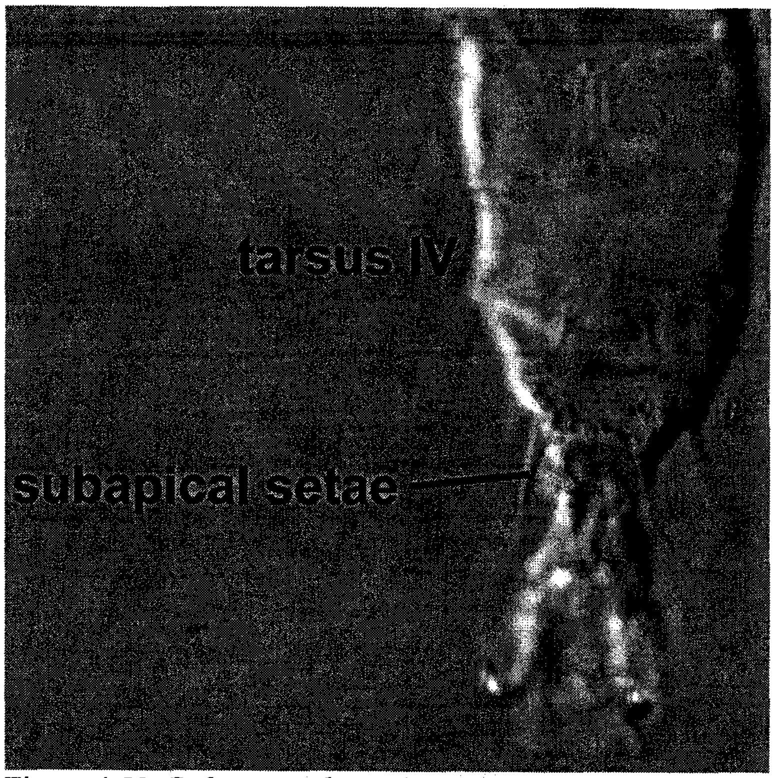


Figure 4.58. *Ptilonyssus hirsti* (Castro & Periera, 1947) tarsus IV.

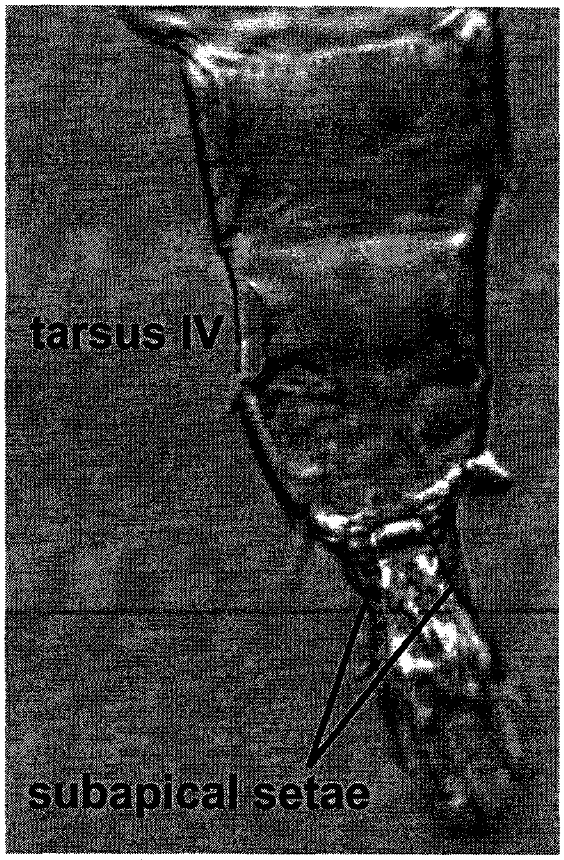


Figure 4.59. *Ptilonyssus icteridius* (Strandtmann and Furman, 1956) tarsus IV.

Figure 4.60. *Ptilonyssus morofskyi* Hyland, 1962 tarsus IV.

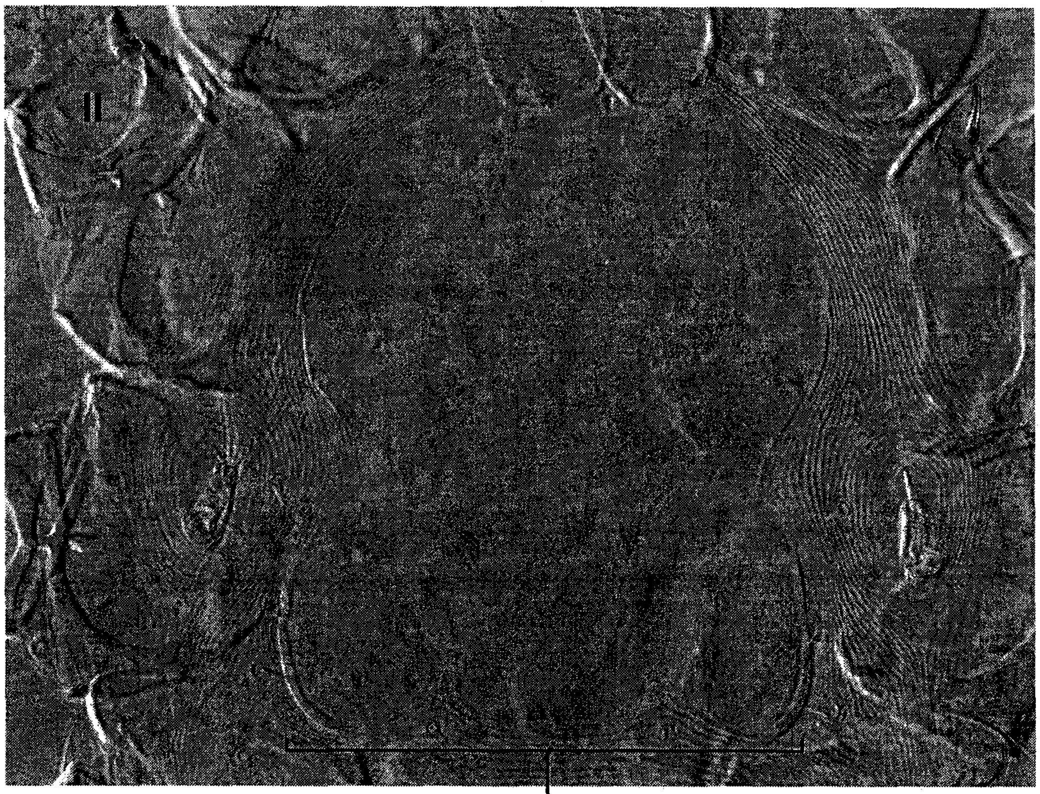


Figure 4.61. *Ptilonyssus calvaria* sp. n. podosomal shield.

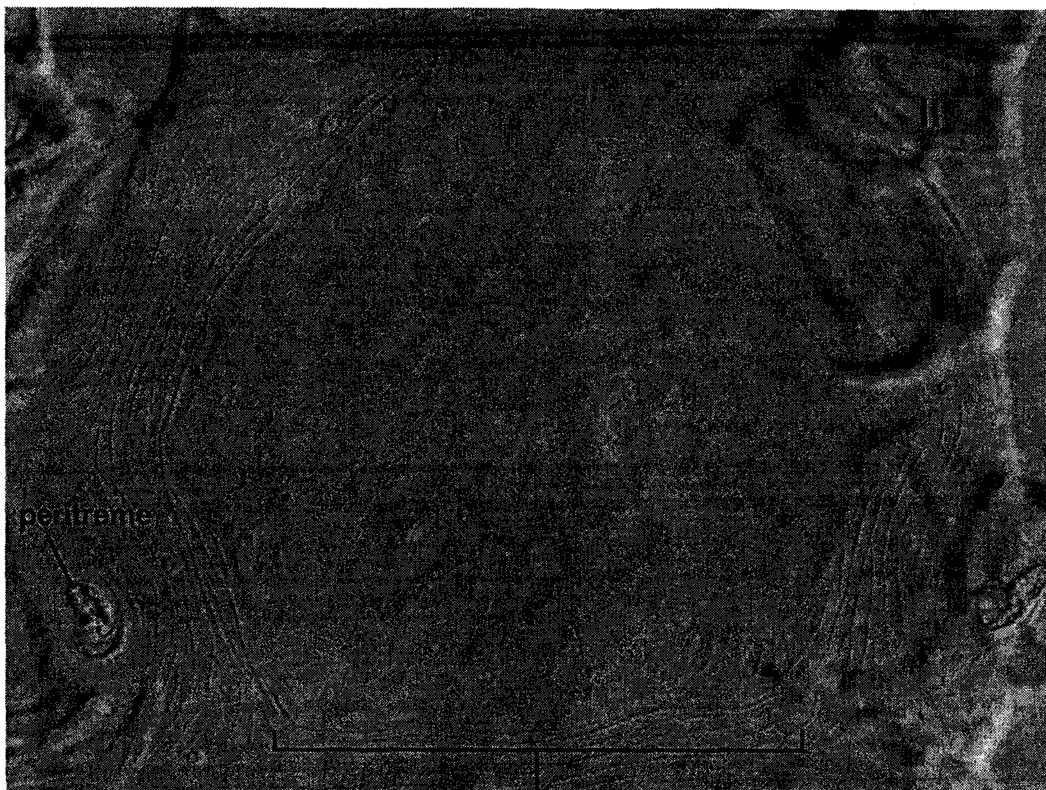


Figure 4.62. *Ptilonyssus hirsti* (Castro & Periera, 1947) podosomal shield.

Figure 4.63. *Ptilonyssus troglodytis* Fain, 1964 pygidial shield fragments (dorsal view).

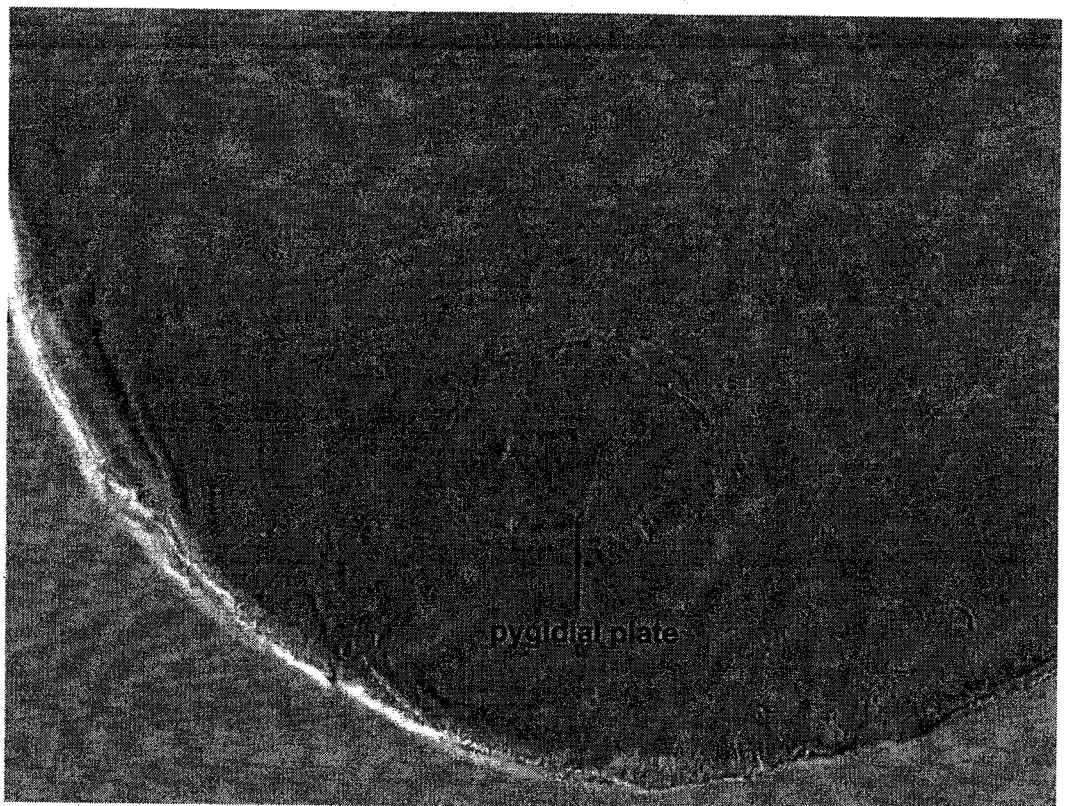


Figure 4.64. *Ptilonyssus nudus* Berlese & Trouessart, 1889 pygidial shield entire (dorsal view).

Figure 4.65. *Ptilonyssus echinatus* Berlese & Trouessart, 1889 genital shield.

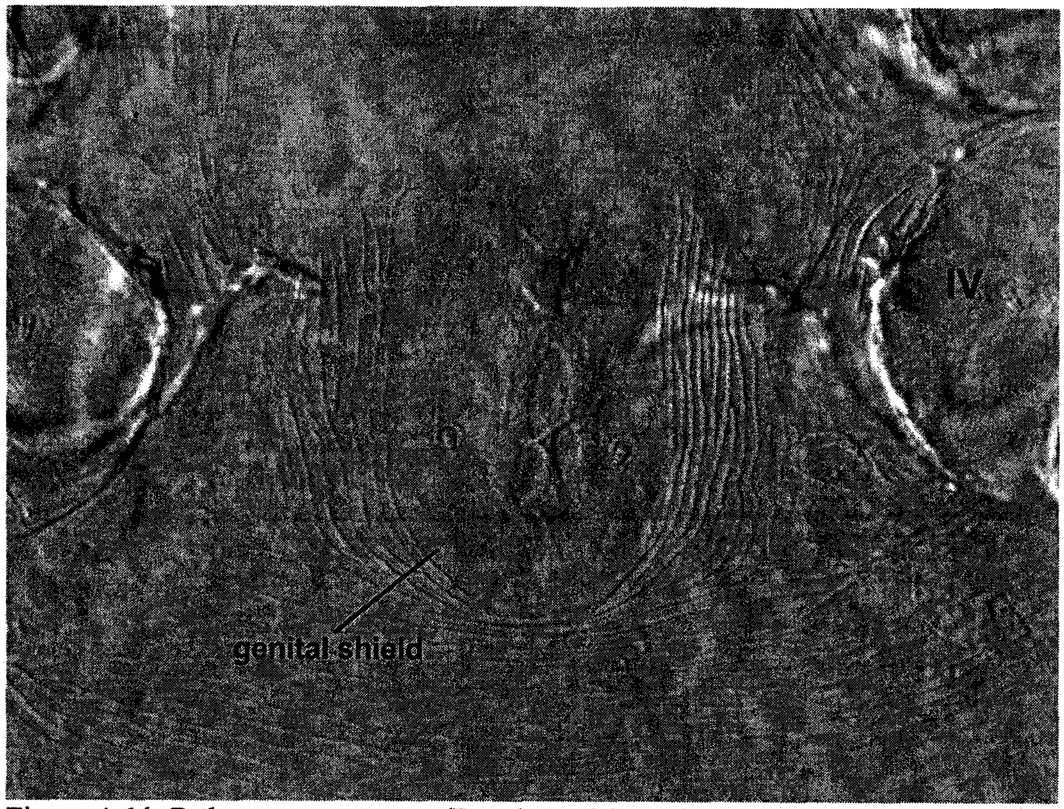


Figure 4.66. *Ptilonyssus tyrannus* (Brooks and Strandtmann, 1960) genital shield.

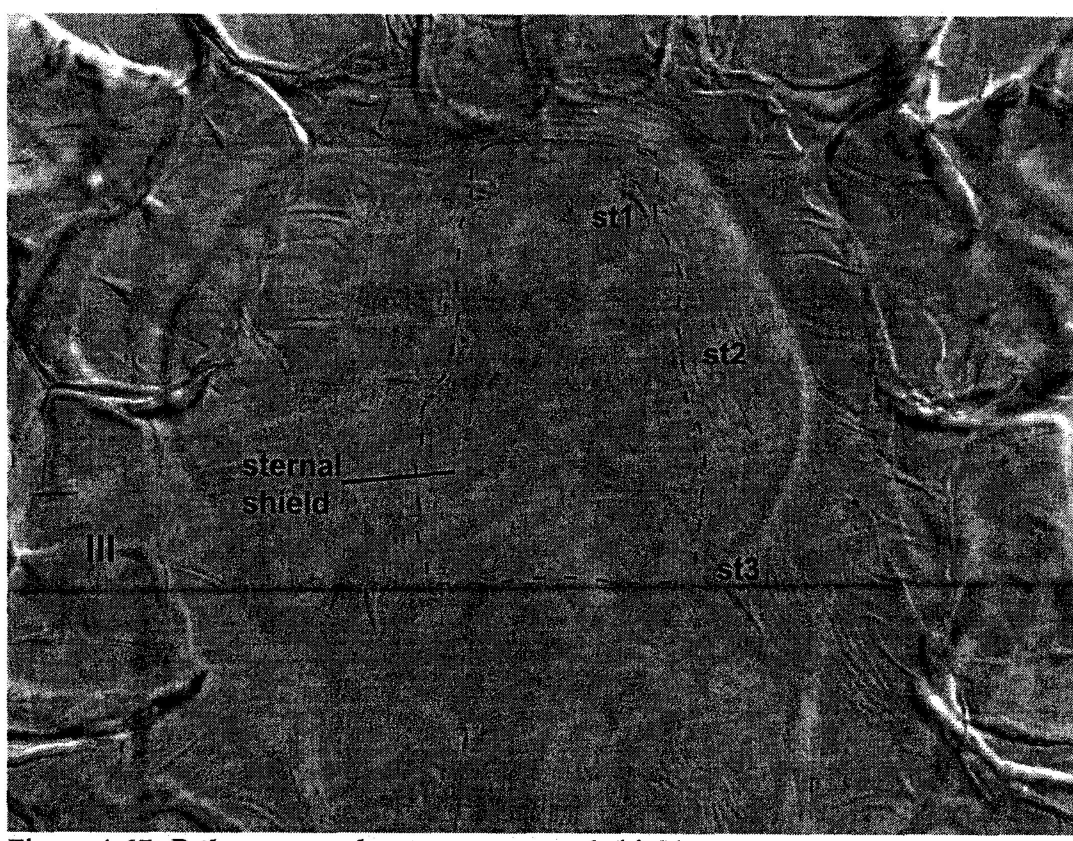


Figure 4.67. *Ptilonyssus calvaria* sp. n. sternal shield.

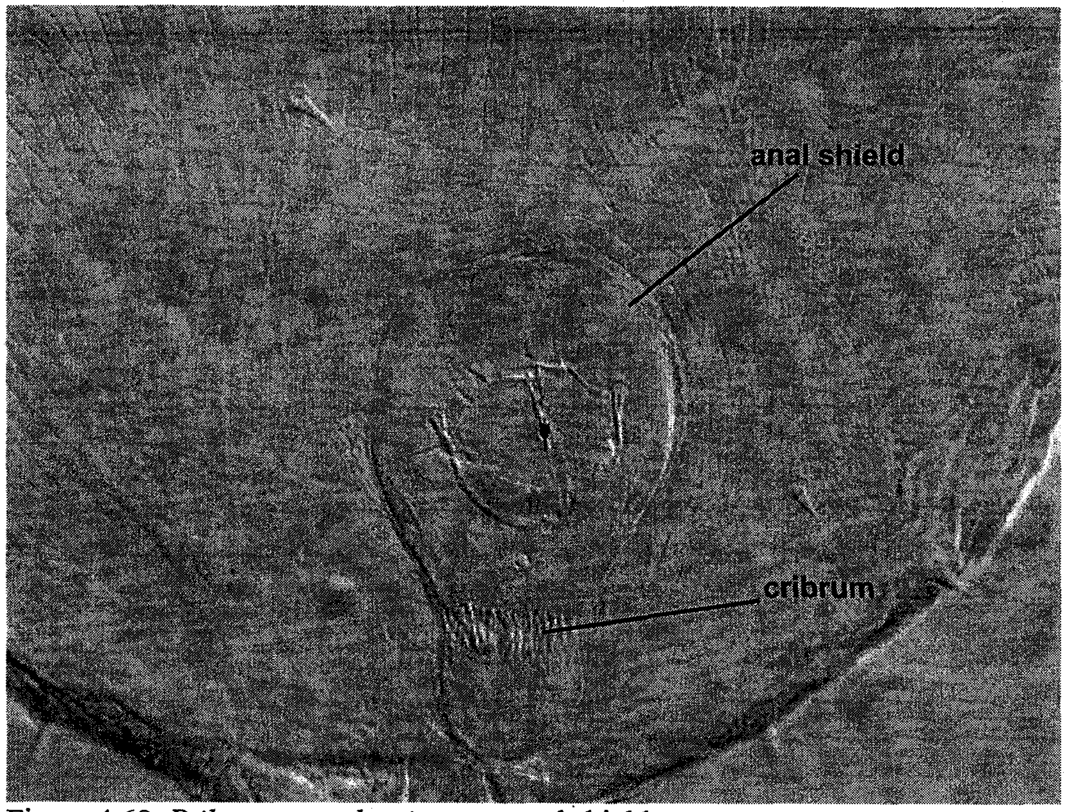


Figure 4.68. *Ptilonyssus calvaria* sp. n. anal shield.

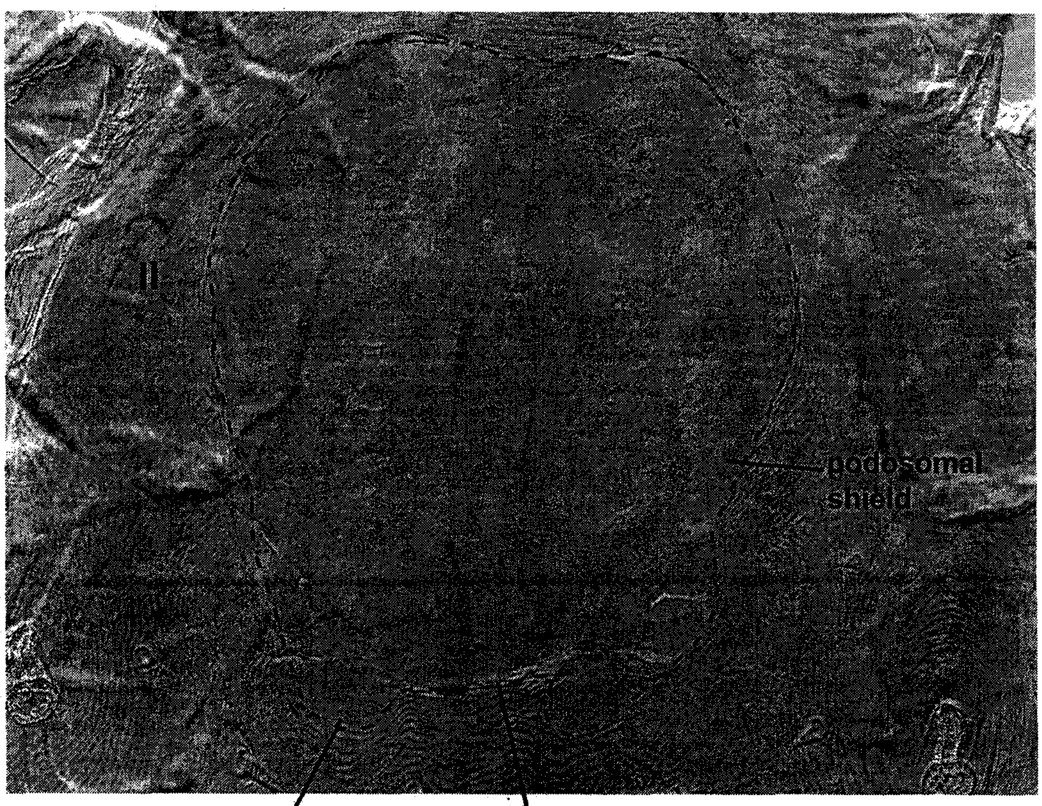


Figure 4.69. *Ptilonyssus euroturdi* Fain & Hyland, 1963 podosomal shield.

Rhinonyssidae species pages:

***Rallinyssus caudistigmus* Strandtmann, 1948**

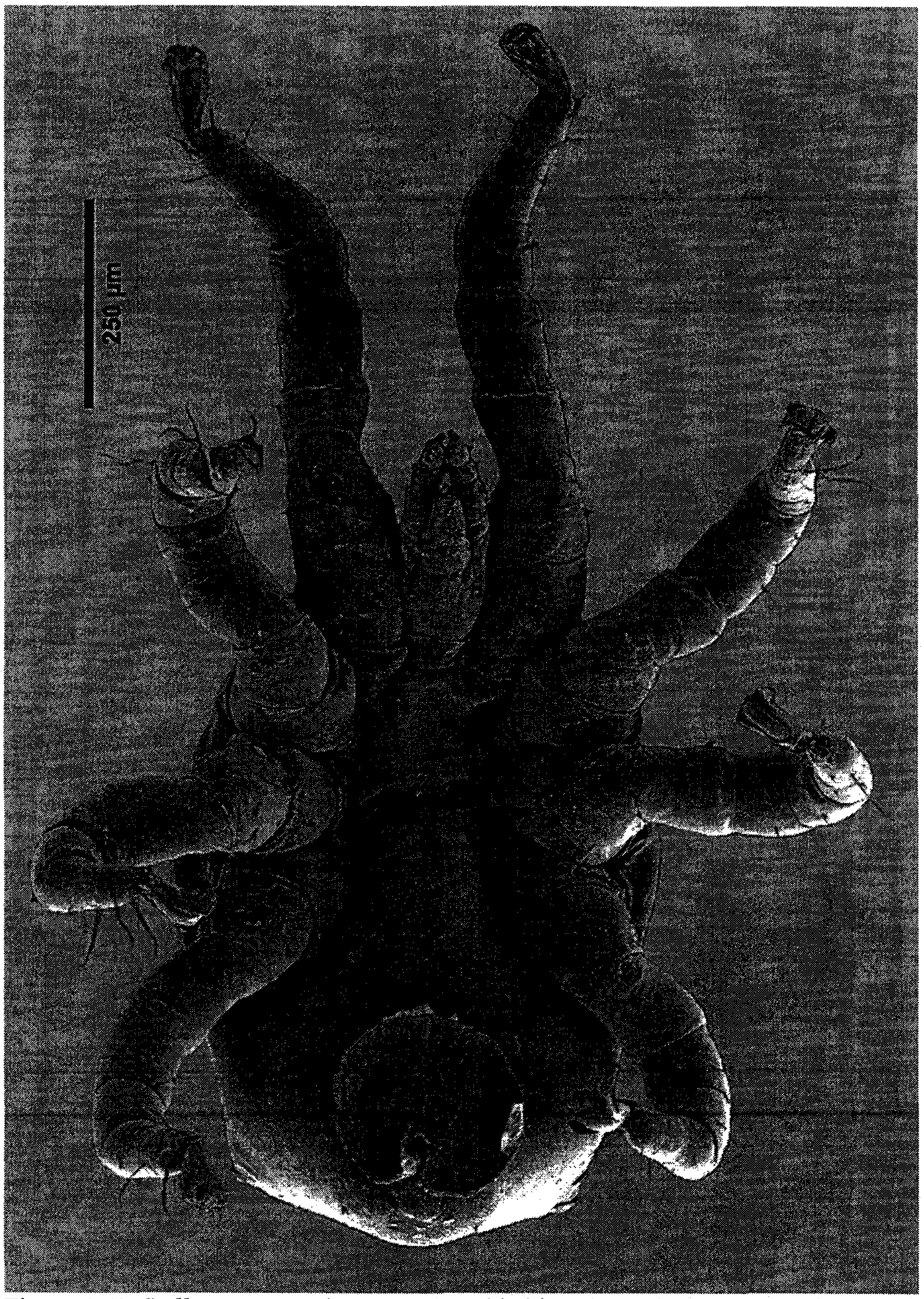


Figure 4.70. *Rallinyssus caudistigmus* dorsal habitus (scanning electron micrograph).

North American host records:
Rallidae:
Fulica americana Strandtmann (1948), Pence (1972; 1975), present study
Rallus elegans Strandtmann (1948), Pence (1975)

Diagnostic characteristics:
- podosomal shield largely complete, without extensive fragmentation

Note:
- Only *Rallinyssus caudistigmus* has so far been found in Canada. Two other species, *R. sorae* Pence and Young, 1979, and *R. verheyeni* Fain, 1963 have been recorded from North American birds. *Rallinyssus verheyeni* and *R. sorae* differ from *R. caudistigmus* by having an extensively fragmented podosomal shield, as well as different chaetotaxy.

References:

Fain, A. 1963. Les acariens nasicoles des oiseaux de Belgique. II. Description de deux espèces nouvelles. Bulletin and Annales de la Societe Royale d'Entomologie de Belgique **99**: 168-181.

Pence, D.B. 1972. The nasal mite of birds from Louisiana. I. Dermanyssids (Rhinonyssinae) from shore and marsh birds. Journal of Parasitology **58**: 153-168.

Pence, D.B. 1975. Keys, species and host list, and bibliography for nasal mites of North American birds (Acarina: Rhinonyssinae, Turbinoptinae,

Pence, D.B., and V.E. Young. 1979. *Rallinyssus sorae* sp. n. (Acari: Dermanyssidae: Rhinonyssinae) from the nasal passages of the sora, *Porzana carolina* (Aves: Rallidae). Journal of Parasitology **65**: 791-793.

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.

***Rhinonyssus rhinolethrum* (Trouessart, 1895)**

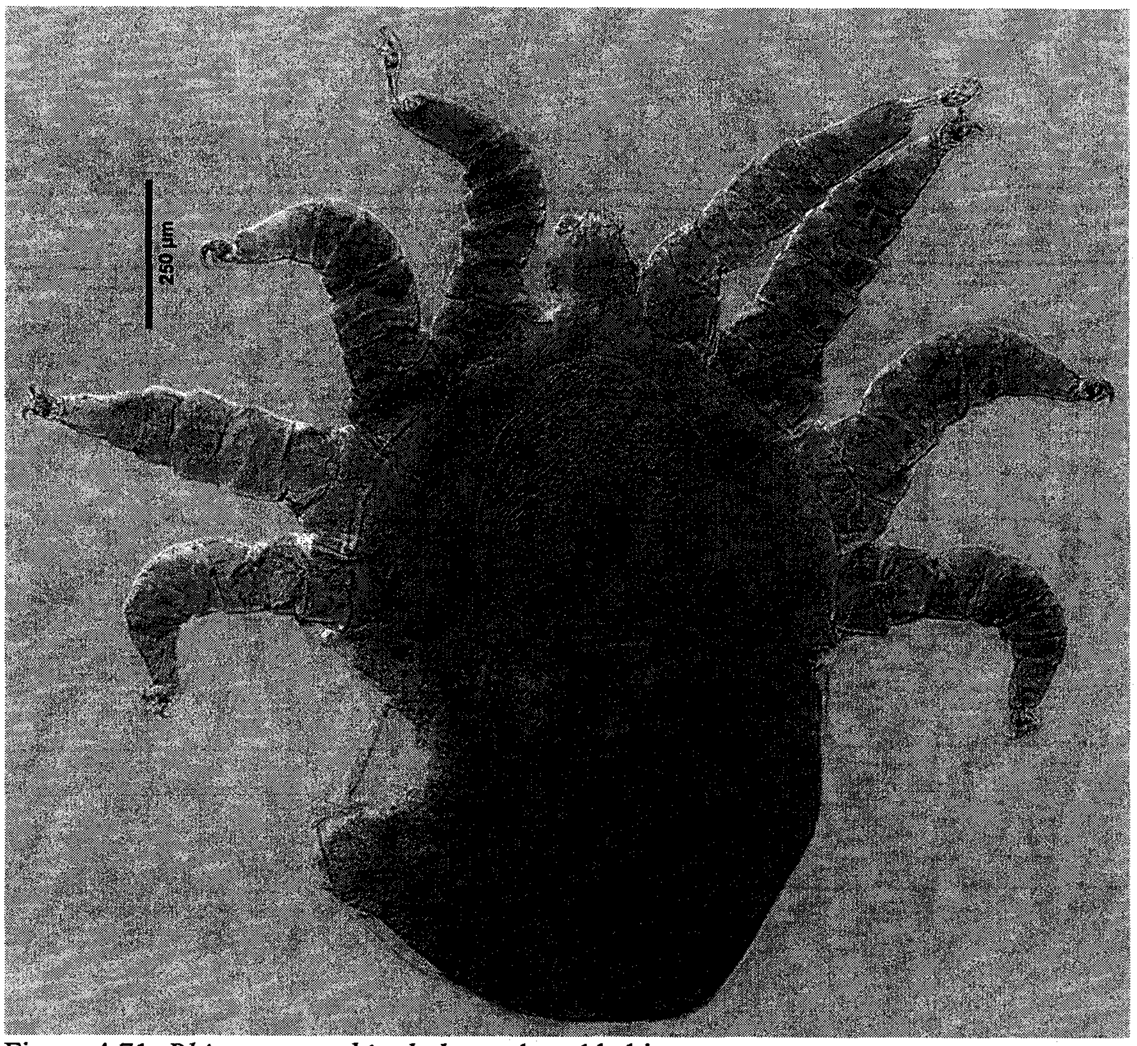


Figure 4.71. *Rhinonyssus rhinolethrum* dorsal habitus.

North American host records:
Anatidae:
Aix sponsa Pence (1972; 1975)
Anas acuta Strandtmann (1951; 1956), Mitchell and Rhodes (1960)
Anas americana Strandtmann (1951; 1956), Mitchell and Rhodes (1960), Wilson (1968)
Anas carolinensis Strandtmann (1951; 1956), Mitchell and Rhodes (1960), Wilson (1968)
Anas clypeata Strandtmann (1951; 1956), Mitchell and Rhodes (1960), Wilson (1968)
Anas discors Mitchell and Rhodes (1960), Pence (1972)
Anas platyrhynchos Strandtmann (1951; 1956), Mitchell and Rhodes (1960), Pence (1975), present study
Anas strepera Strandtmann (1951; 1956)
Anas acuta Pence (1975)
Anas americana Pence (1975)

Anas carolinensis Pence (1975)
Anas clypeata Pence (1975)
Anas discors Pence (1975)
Anas strepera Pence (1975)
Anser caerulescens Mitchell and Rhodes (1960), Pence (1975)
Anser rossii Mitchell and Rhodes (1960), Pence (1975), present study
Aythya affinis Strandtmann (1951; 1956), Mitchell and Rhodes (1960), Pence (1975), Spicer (1987)
Aythya valisineria Mitchell and Rhodes (1960), Pence (1975)
Branta canadensis Strandtmann (1951; 1956), Mitchell and Rhodes (1960), Pence (1975), present study
Cygnus columbianus Strandtmann (1956), present study
Melanitta deglandi Strandtmann (1956), Pence (1975)
Mergus merganser Strandtmann (1956), Wilson (1964)
Mergus serrator Strandtmann (1956), Mitchell and Rhodes (1960), Pence (1975)

Rallidae:
Fulica americana Pence (1972; 1975)

Diagnostic characteristics:
- podosomal shield entire, not medially eroded
- nine or more pairs of ventral opisthosomal setae

References:
Mitchell, R.W., and W.L. Rhodes. 1960. New host records for the mesostigmatid nasal mite *Rhinonyssus rhinonlethrum* (Acarina: Rhinonyssidae). The Southwestern Naturalist **5**: 107-108.
Pence, D.B. 1972. The nasal mite of birds from Louisiana. I. Dermanyssids (Rhinonyssinae) from shore and marsh birds. The Journal of Parasitology **58**: 153-168.
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 Texas Tech University **8**: 1-148.
Spicer, G.S. 1987. Prevalence and host-parasite list of some nasal mites from birds (Acarina: Rhinonyssidae, Speleognathidae). Journal of Parasitology **73**: 259-264.
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.
Strandtmann, R.W. 1951. The Mesostigmatic nasal mites of birds. II. New and poorly known species of Rhinonyssidae. Journal of Parasitology **37**: 129-140.
Wilson, N. 1964. New records and descriptions of Rhinonyssidae, mostly from New Guinea (Acarina: Mesostigmata). Pacific Insects **6**: 357-388.
Wilson, N. 1968. Records of nasal mites (Mesostigmata: Rhinonyssidae) from New Guinea, Philippines and United States. Journal of Medical Entomology **5**: 211-223.

***Rhinonyssus coniventris* Trouessart, 1894**

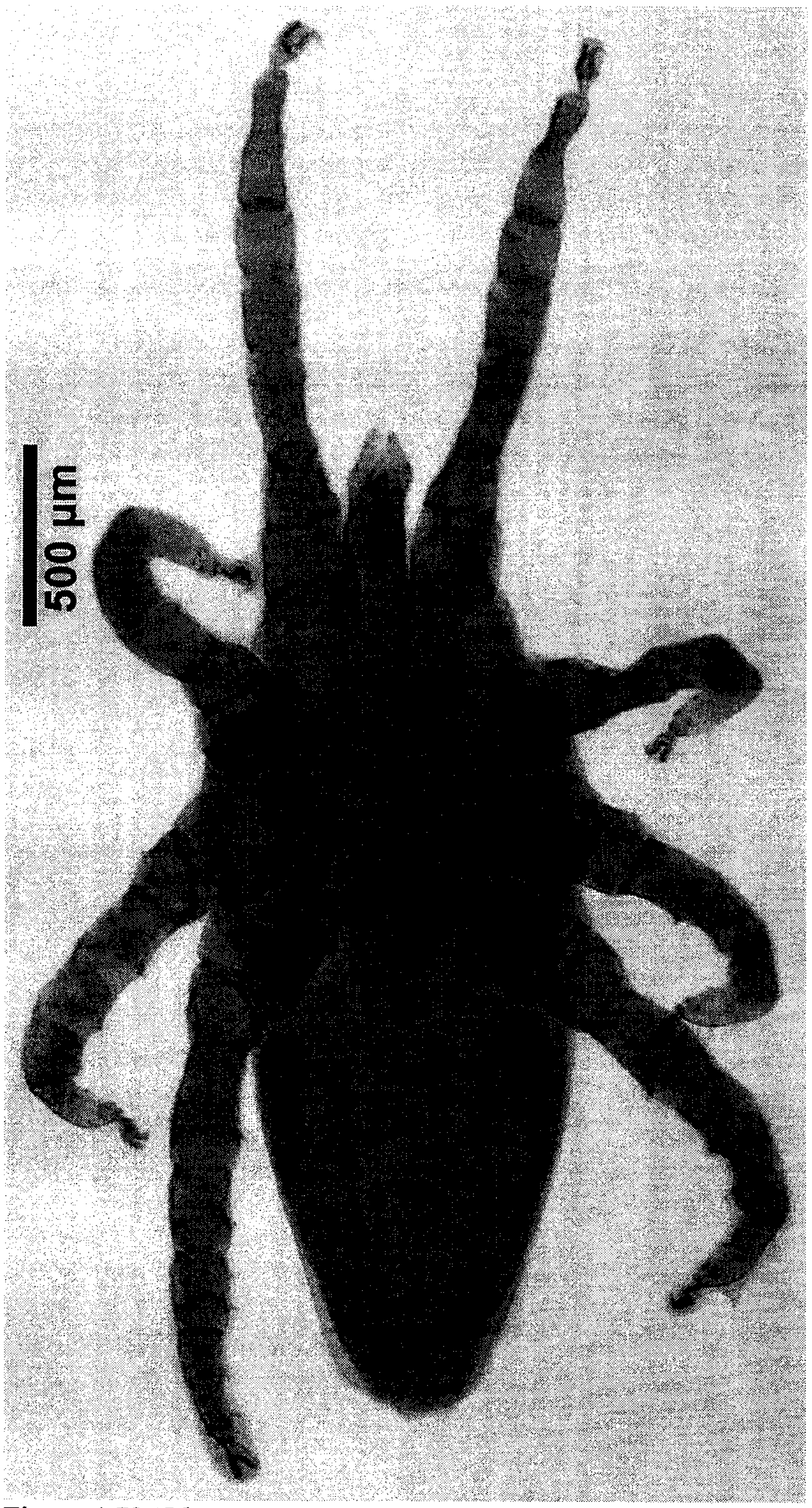


Figure 4.72. *Rhinonyssus coniventris* dorsal habitus.

North American host records:
Charadriidae:
Charadrius alexandrinus Strandtmann (1956), Pence (1975)
Charadrius hiaticula Strandtmann (1956), Pence (1975)
Charadrius riaticula Strandtmann (1951)
Charadrius melodus Pence (1975)
Charadrius wilsoni Pence (1975)
Pluvialis squatarola Mitchell (1961)

Scolopacidae:
Arenaria interpres Strandtmann (1951; 1956), Pence (1975)
Calidris alba Strandtmann (1951; 1956), Pence (1972)
Calidris alpina Strandtmann (1956), Pence (1975)
Calidris canutus Mitchell (1961), Canadian National Collection of Insects and Arachnids
Calidris ptilocnemis Strandtmann (1956), Pence (1975)
Catoptrophorus semipalmatus Strandtmann (1951; 1956), Pence (1972; 1975)
Tringa flavipes Strandtmann (1951; 1956), Pence (1972; 1975)

Diagnostic characteristics:
- podosomal shield is medially eroded, often medially divided.
- five or fewer pairs of ventral opisthosomal setae

References:
Mitchell, R.W. 1961. New avian host records for some mesostigmatid mites. The Southwestern Naturalist **6**: 103-105.

Pence, D.B. 1972. The nasal mite of birds from Louisiana. I. Dermanyssids (Rhinonyssinae) from shore and marsh birds. Journal of Parasitology **58**: 153-168.

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 Texas Tech University **8**: 1-148.

Strandtmann, R.W. 1951. The Mesostigmatic nasal mites of birds. II. New and poorly known species of Rhinonyssidae. Journal of Parasitology **37**: 129-140.

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.

Tinaminyssus columbae **(Crossley, 1950)**

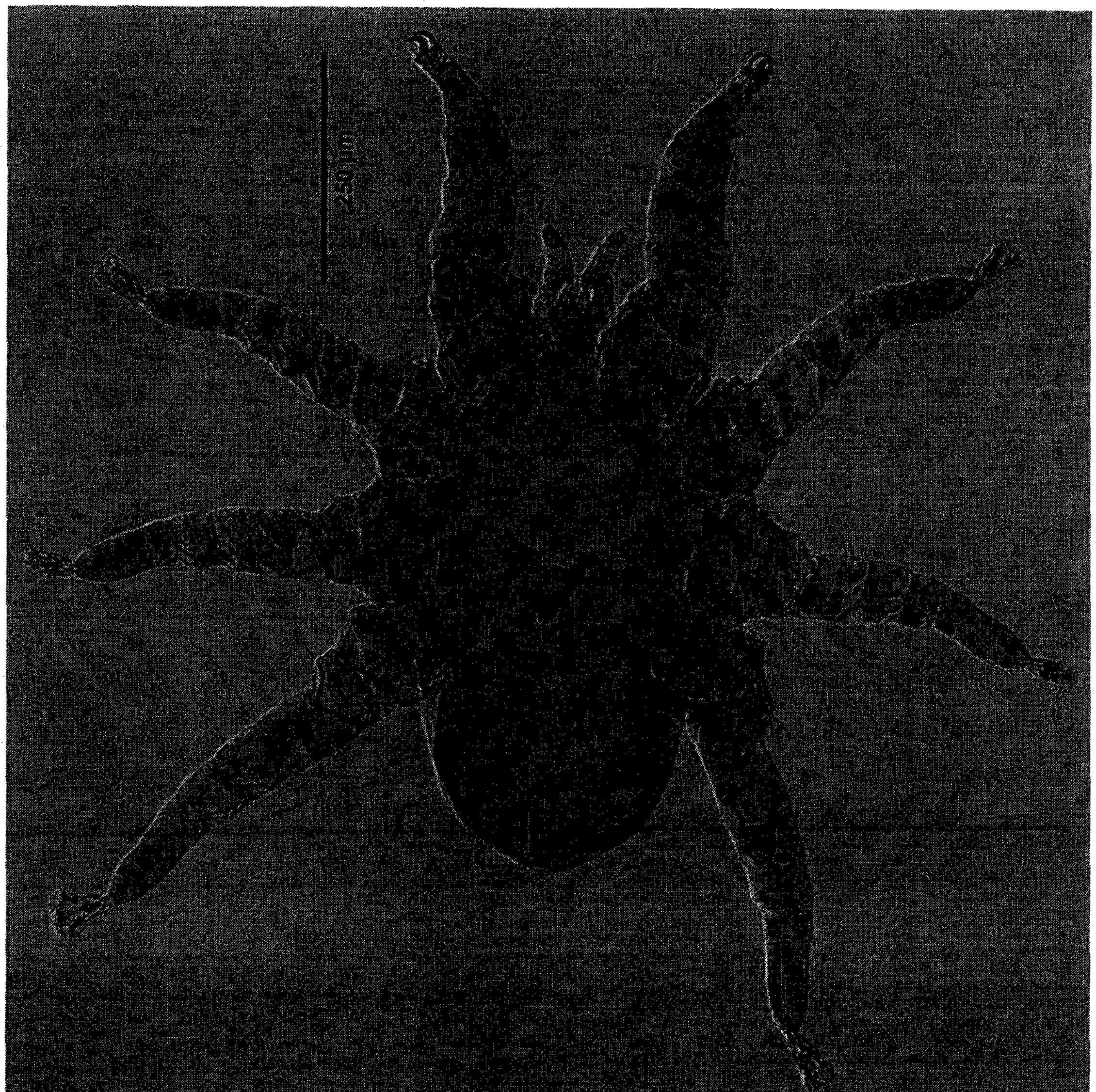


Figure 4.73. *Tinaminyssus columbae* dorsal habitus.

North American host records:
Columbidae:
Columba livia Strandtmann (1961), Wilson (1964), Pence (1975), present study
Columba domestica Crossley (1950)

Diagnostic characteristics:
- poststigmatal platelets absent
- relatively short body and leg setae

References:

Crossley, D.A. 1950. A new species of nasal mite *Neonyssus* (*Neonyssus*) *columbae*, from the pigeon. Proceedings of the Entomological Society of Washington **52**: 309-313.

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 Texas Tech University **8**: 1-148.

Strandtmann, R.W. 1961. *Neonyssus triangulus* n.sp. nasal mite (Acarina: Mesostigmata) from the white winged dove (Aves: Columbiformes) and key to the species of the genus *Neonyssus*. Journal of Parasitology **47**: 323-328.

Wilson, N. 1964. New records and descriptions of Rhinonyssidae, mostly from New Guinea (Acarina: Mesostigmata). Pacific Insects **6**: 357-388.

***Tinaminyssus melloi* (Castro, 1948)**

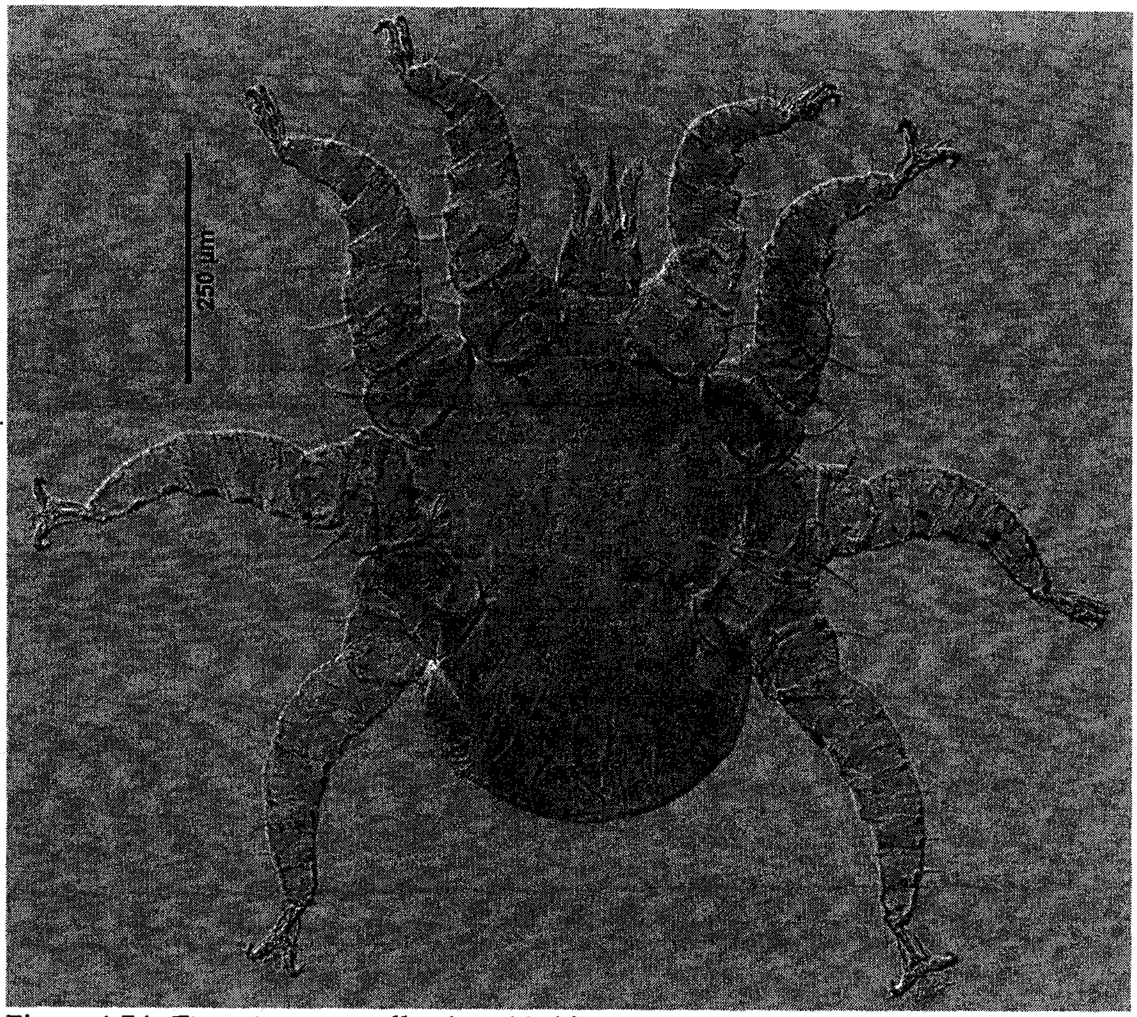


Figure 4.74. *Tinaminyssus melloi* dorsal habitus.

North American host records:
Columbidae:
Columba livia Strandtmann (1961), Wilson (1964), Pence (1975), Zamudio (1988), present study
Zenaida macroura present study

Diagnostic characteristics:
- poststigmatal platelets present
- relatively long body and leg setae
- paranal setae anterior to anal opening

References:

Wilson, N. 1964. New records and descriptions of Rhinonyssidae, mostly from New Guinea (Acarina: Mesostigmata). Pacific Insects **6**: 357-388.

Strandtmann, R.W. 1961. *Neonyssus triangulus* n.sp. nasal mite (Acarina: Mesostigmata) from the white winged dove (Aves: Columbiformes) and key to the species of the genus *Neonyssus*. Journal of Parasitology **47**: 323-328.

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 Texas Tech University **8**: 1-148.

Zamudio, M.L. 1988. Desarrollo de *Tinaminyssus melloi* (Castro, 1948) (Mesostigmata: Rhinonyssidae). Folia Entomologica Mexicana **74**: 205-214.

***Tinaminyssus zenaidurae* (Crossley, 1952)**

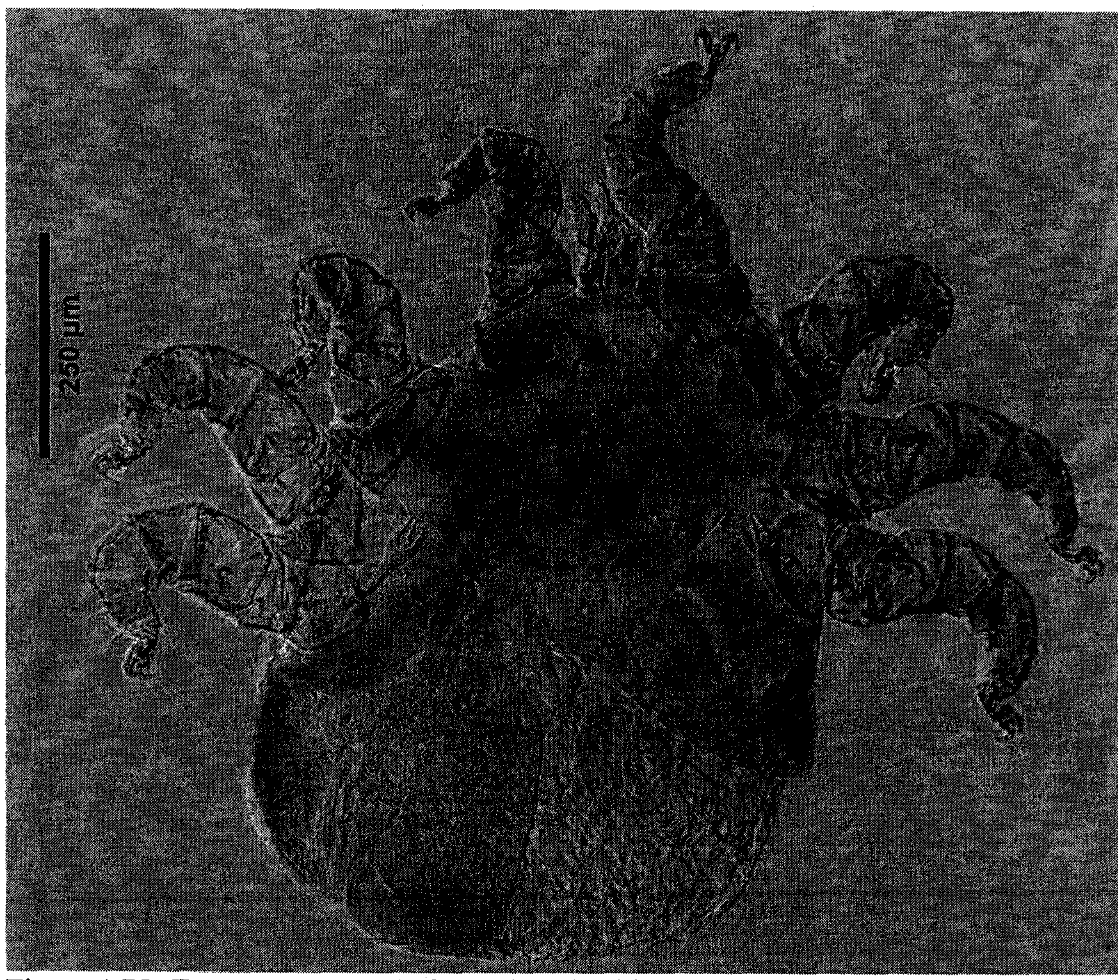


Figure 4.75. *Tinaminyssus zenaidurae* dorsal habitus.

North American host records:
Columbidae:
Columbina passerina Crossley (1952), Strandtmann (1961), Wilson (1964), Pence (1975)
Zenaida macroura Crossley (1952), Owen (1958), Strandtmann (1961), Wilson (1964; 1968), Pence (1973; 1975), Spicer (1987), present study

Diagnostic characteristics:
- poststigmatal platelet present
- paranal setae at level with anal opening

References:

Crossley, D.A. 1952. Two new nasal mites from Columbiform birds. Journal of Parasitology **38**: 385-390.
Owen, B.L. 1958. Records of nasal mites of the mourning dove. The Texas Journal of

Science **10**: 447.

Pence, D.B. 1973. The nasal mites of birds from Louisiana. VI. New and additional records of Dermanyssids (Rhinonyssinae) with description of a new species. Journal of Parasitology **59**: 359-362.

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 Texas Tech University **8**: 1-148.

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

Strandtmann, R.W. 1961. *Neonyssus triangulus* n.sp. nasal mite (Acarina: Mesostigmata) from the white winged dove (Aves: Columbiformes) and key to the species of the genus *Neonyssus*. Journal of Parasitology **47**: 323-328.

Wilson, N. 1964. New records and descriptions of Rhinonyssidae, mostly from New Guinea (Acarina: Mesostigmata). Pacific Insects **6**: 357-388.

Wilson, N. 1968. Records of nasal mites (Mesostigmata: Rhinonyssidae) from New Guinea, Philippines and United States. Journal of Medical Entomology **5**: 211-223.

***Rhinoecius aegolii* Butenko, 1971**

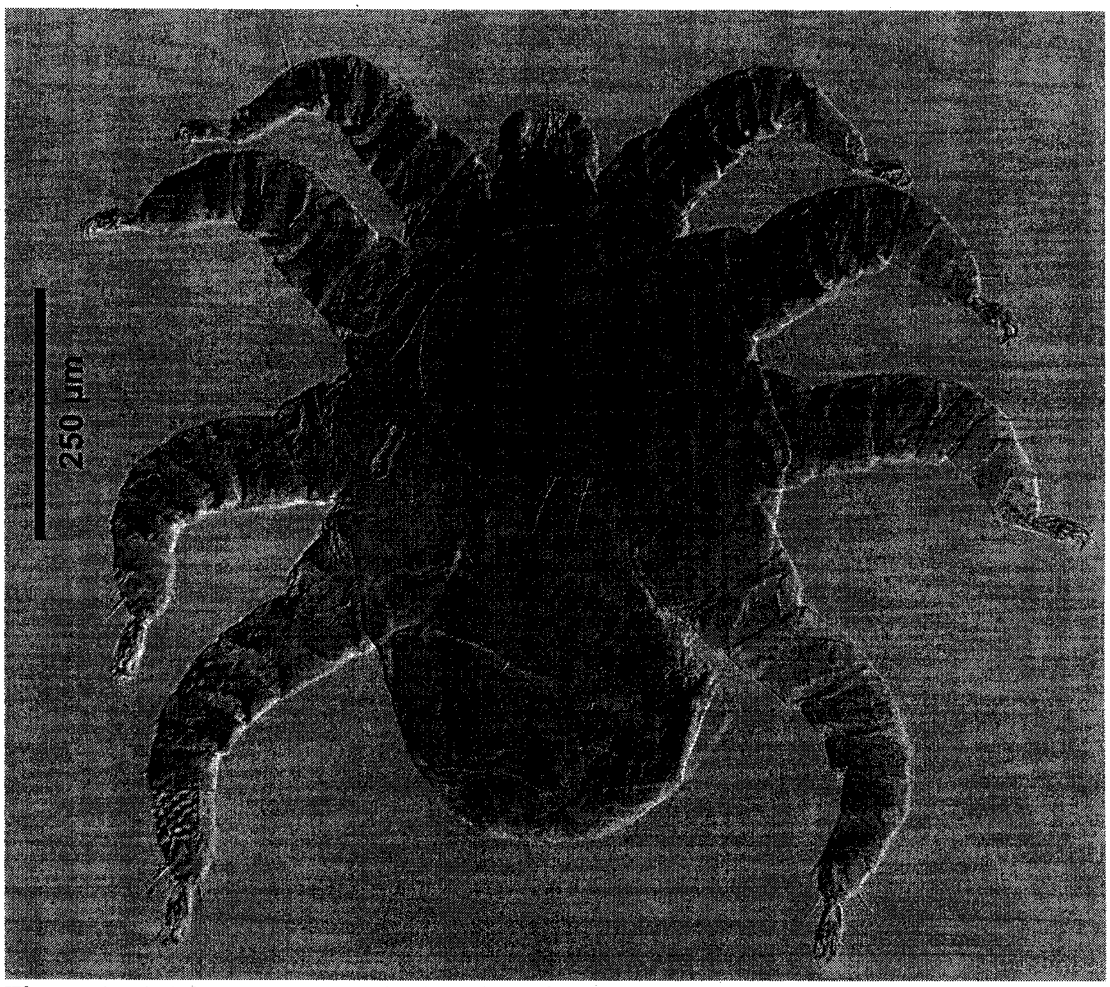


Figure 4.76. *Rhinoecius aegolii* dorsal habitus.

North American host records:
Strigidae:
Aegolius funereus present study (has been recorded from *A. funereus* in Russia by Butenko (1984))
Aegolius acadicus present study

Diagnostic characteristics:
- subposterior pair of dorsal podosomal setae on posterior margin of podosomal shield and very long, at least 70 µm long
- sternal shield absent
- paranal setae at level with anal opening, and postanal seta absent

References:
Butenko, O.M. 1984. Non-passerine nasal mites of Russia. Zool. Inst. Acad. Sciences (St. Petersburg). 187pp.

***Rhinoecius cooremani* Strandtmann, 1952**

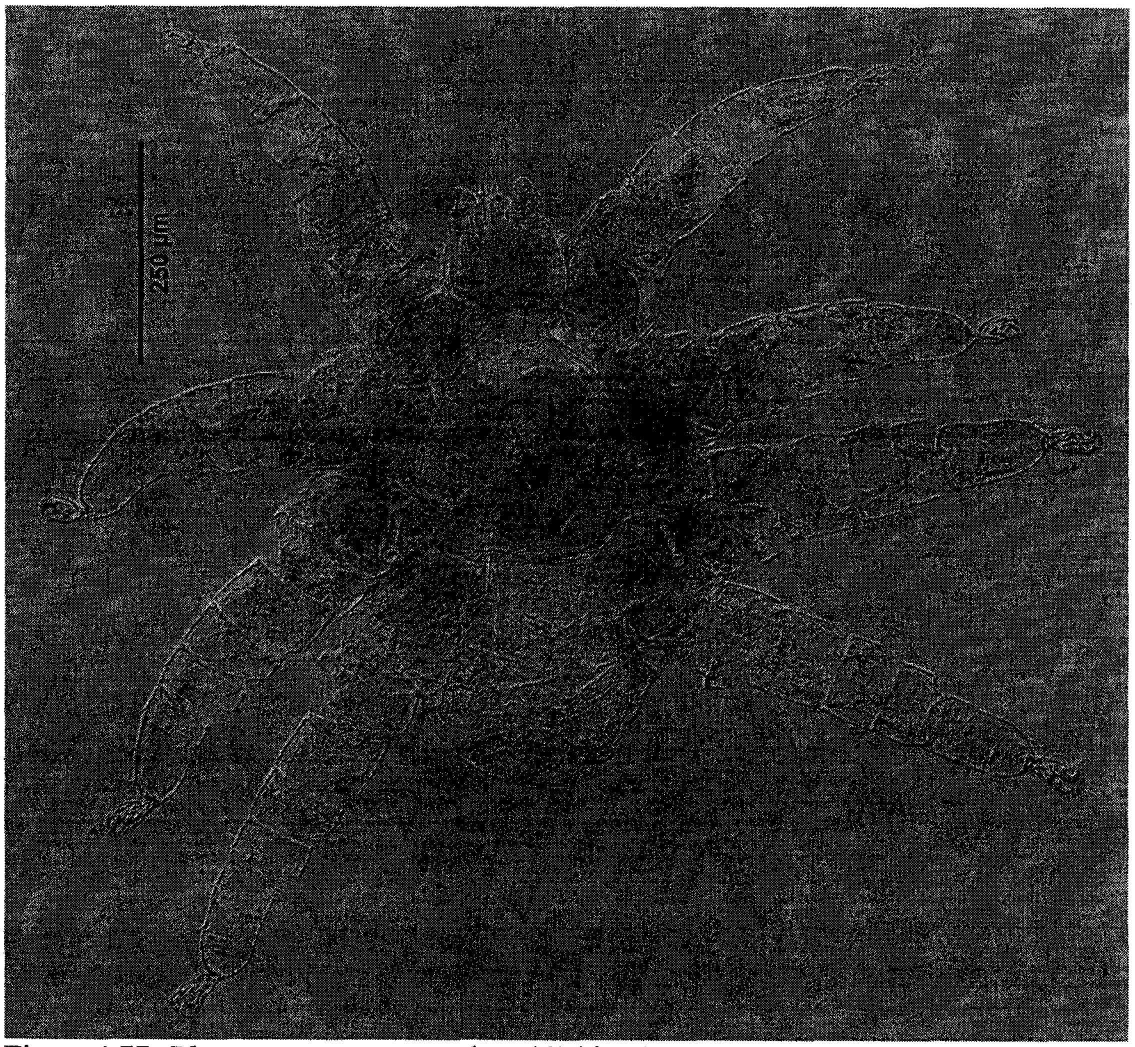


Figure 4.77. *Rhinoecius cooremani* dorsal habitus.

North American host records:
Strigidae:
Strix nebulosa present study
Strix varia Strandtmann (1952), Pence (1973; 1975)

Diagnostic characteristics:
- subposterior pair of dorsal podosomal setae in unsclerotized integument just off posterior
 margin of podosomal shield and much < 70 µm long
- sternal shield highly reduced, and sternal setae not on shield
- paranal setae anterior to anal opening, and postanal seta absent

References:

Pence, D.B. 1973. The nasal mites of birds from Louisiana. VI. New and additional records of Dermanyssids (Rhinonyssinae) with description of a new species. Journal of Parasitology **59**: 359-362.

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 Texas Tech University **8**: 1-148.

Strandtmann, R.W. 1952. The Mesostigmatic nasal mites of birds, III. New species of *Rhinoecius* from owls. Proceedings of the Entomological Society of Washington **54**: 205-216.

***Rhinoecius brikinboricus* Butenko, 1976**

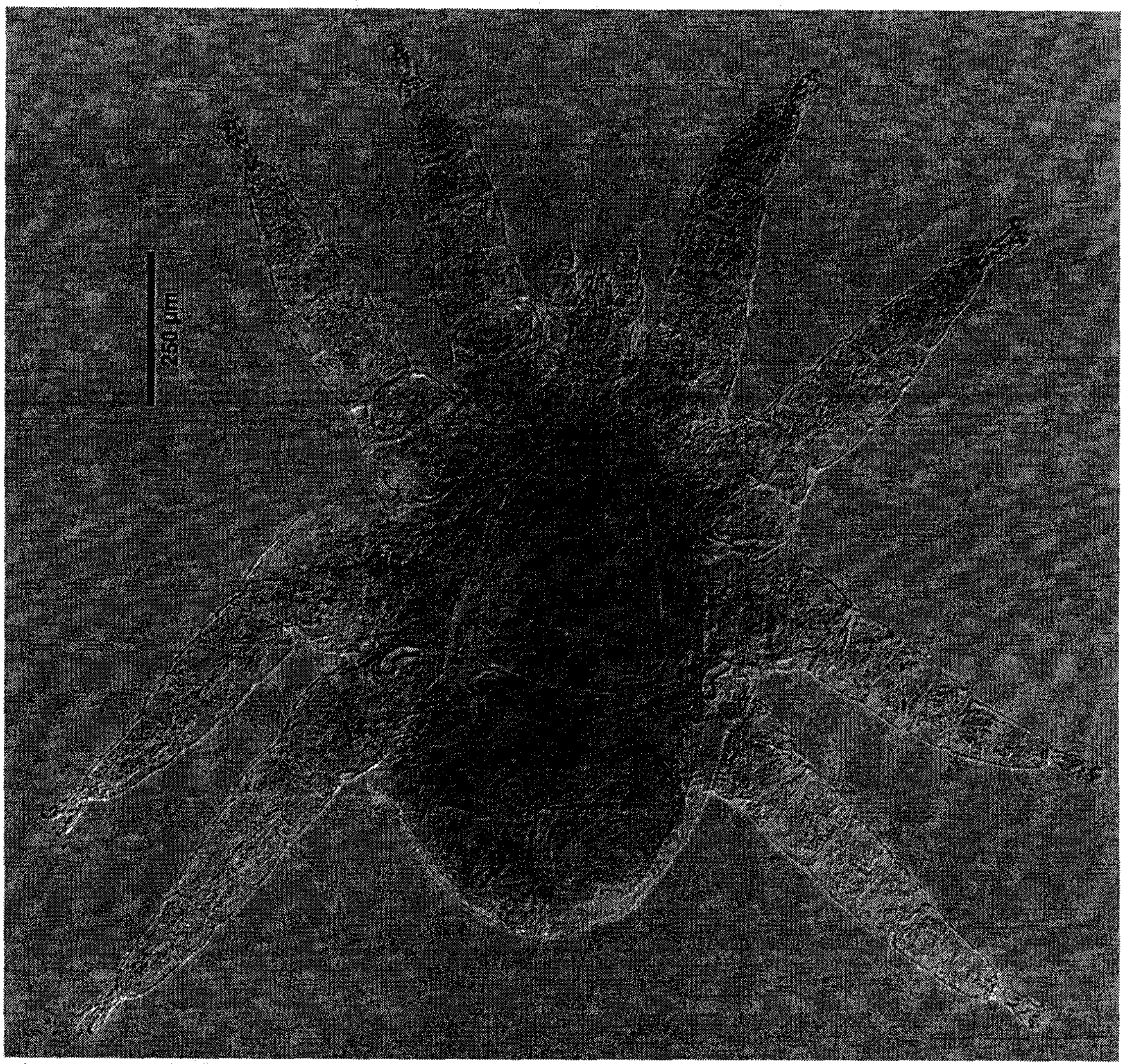


Figure 4.78. *Rhinoecius brikinboricus* dorsal habitus.

North American host records:
Strigidae:
Asio otus present study (has been recorded from *A. otus* in Russia by Butenko (1976))

Diagnostic characteristics:
- subposterior pair of dorsal podosomal setae on posterior margin of podosomal shield, and much < 70 μm long
- sternal shield with posteromedial projection, sternal setae on shield, and shielding extends anteriorly beyond st1
- paranal setae anterior to anal opening, and postanal seta absent

Note:

- *R. alifanovi, R. brikinboricus, R. grandis,* and *R. nycteae* comprise the *Rhinoecius* "*grandis*" species complex. These four species are difficult to separate. In particular, the sternal shield morphology used to separate species is not always consistent across individuals for a particular species. I find host species to be the best character to delineate among these species.

References:

Butenko, O.M. 1976. New species of rhinonyssid mites (Gamasoidea, Rhinonyssidae), parasitic in owls. Parazitologiya (St. Petersburg) **10**: 303-309.

***Rhinoecius grandis* Strandtmann, 1952**

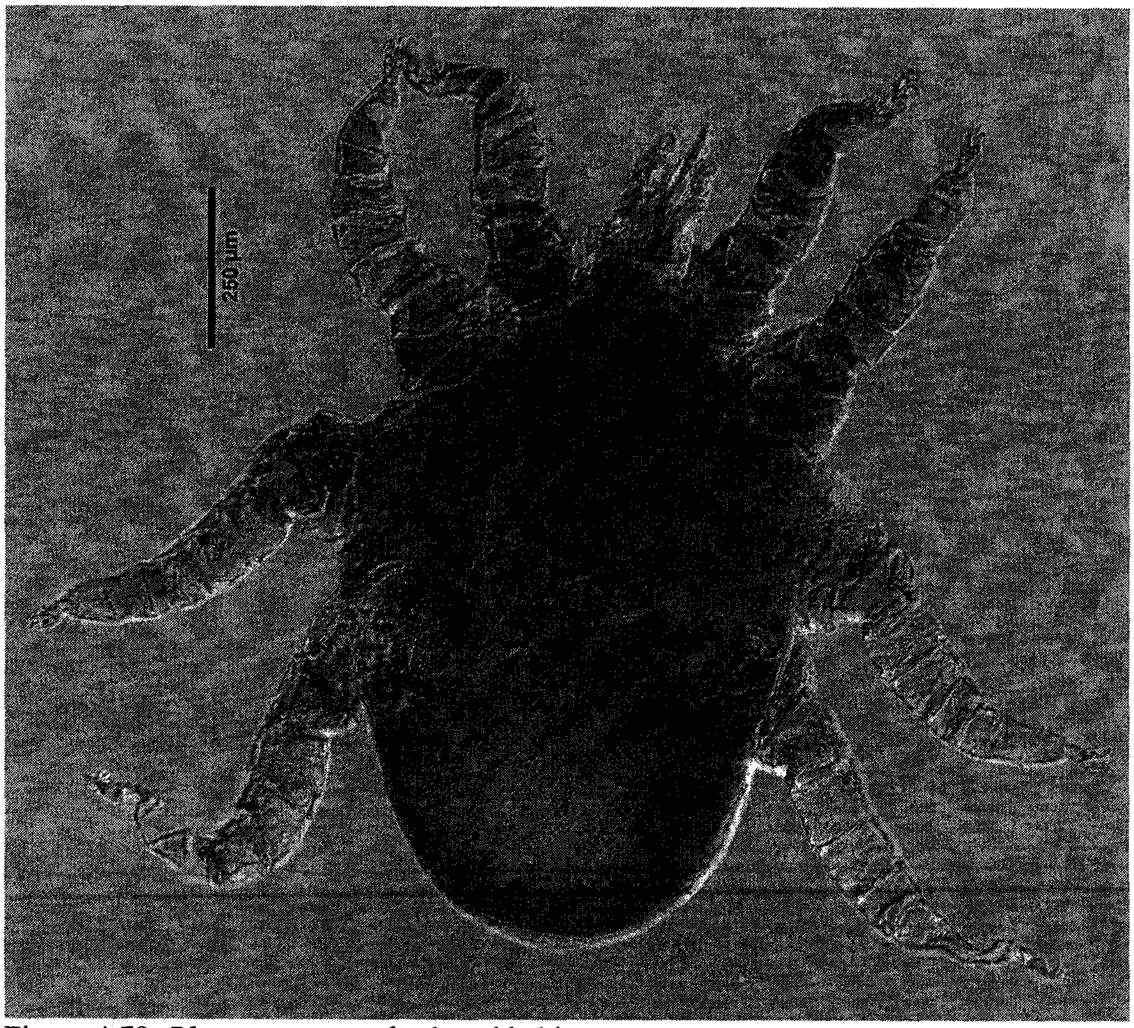


Figure 4.79. *Rhinoecius grandis* dorsal habitus.

North American host records:
Strigidae:
Bubo virginianus Strandtmann (1952), Pence (1975), present study

Diagnostic characteristics:
- subposterior pair of dorsal podosomal setae on posterior margin of podosomal shield, and much < 70 µm long
- sternal shield with posteromedial projection, sternal setae on shield, and shielding extends anteriorly beyond st1
- paranal setae anterior to anal opening, and postanal seta present

Note:
- *R. alifanovi, R. brikinboricus, R. grandis,* and *R. nycteae* comprise the *Rhinoecius* "*grandis*" species complex. These four species are difficult to separate. In particular, the

sternal shield morphology used to separate species is not always consistent across individuals for a particular species. I find host species to be the best character to delineate among these species.

References:

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 Texas Tech University **8**: 1-148.

Strandtmann, R.W. 1952. The Mesostigmatic nasal mites of birds, III. New species of *Rhinoecius* from owls. Proceedings of the Entomological Society of Washington **54**: 205-216.

***Rhinoecius alifanovi* Butenko, 1976**

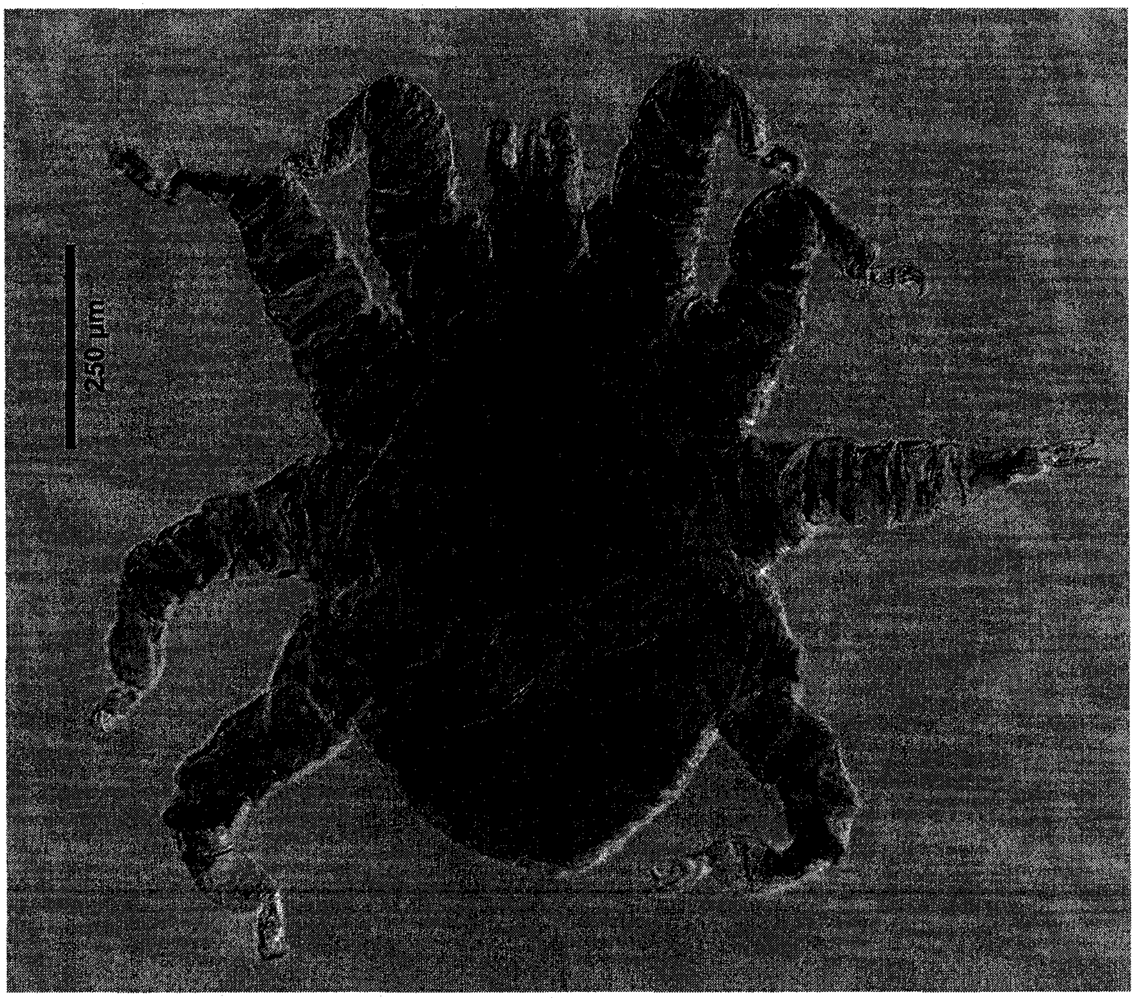


Figure 4.80. *Rhinoecius alifanovi* dorsal habitus.

North American host records:
Strigidae:
Asio flammeus present study (has been recorded from *A. flammeus* in Russia by Butenko (1976))

Diagnostic characteristics:
- subposterior pair of dorsal podosomal setae on posterior margin of podosomal shield, and much < 70 µm long
- posterior margin of sternal shield straight, sternal setae on shield, and shielding does not extend far beyond st1
- paranal setae anterior to anal opening, and postanal seta present

Note:

- *R. alifanovi, R. brikinboricus, R. grandis,* and *R. nycteae* comprise the *Rhinoecius* "*grandis*" species complex. These four species are difficult to separate. In particular, the sternal shield morphology used to separate species is not always consistent across individuals for a particular species. I find host species to be the best character to delineate among these species.

References:

Butenko, O.M. 1976. New species of rhinonyssid mites (Gamasoidea, Rhinonyssidae), parasitic in owls. Parazitologiya (St. Petersburg) **10**: 303-309.

***Rhinoecius nycteae* Butenko, 1976**

Figure 4.81. *Rhinoecius nycteae* dorsal habitus.

North American host records:
Strigidae:
Nyctea scandiaca present study (has been recorded from *N. scandiaca* in Russia by Butenko (1976))

Diagnostic characteristics:
- subposterior pair of dorsal podosomal setae on posterior margin of podosomal shield, and
 much < 70 µm long
- posterior margin of sternal shield straight, sternal setae on shield, and shielding extends anteriorly beyond st1
- vestigial tritosternum present
- paranal setae anterior to anal opening, and postanal seta present

Note:

- *R. alifanovi, R. brikinboricus, R. grandis,* and *R. nycteae* comprise the *Rhinoecius* "*grandis*" species complex. These four species are difficult to separate. In particular, the sternal shield morphology used to separate species is not always consistent across individuals for a particular species. I find host species to be the best character to delineate among these species.

References:

Butenko, O.M. 1976. New species of rhinonyssid mites (Gamasoidea, Rhinonyssidae), parasitic in owls. Parazitologiya (St. Petersburg) **10**: 303-309.

***Sternostoma technaui* Vitzthum, 1935**

Figure 4.82. *Sternostoma technaui* dorsal habitus.

North American host records:
Turdidae:
Turdus migratorius Pence (1972; 1975), present study

Diagnostic characteristics:
- one dorsal shield
- sternal setae are large, proximally inflated blunt-tipped spines
- subapical ventral and ventrolateral setae of tarsi II - IV relative to body setae are short spines
- at least five pairs of setae in the dorsal opisthosomal unsclerotized integument
- paranal setae level with anal opening, and postanal seta absent

References:
Pence, D.B. 1972. The nasal mites of birds from Louisiana II. The genus *Sternostoma* (Dermanyssidae: Rhinonyssinae). Journal of Parasitology **58**: 781-889.

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 Texas Tech University **8**: 1-148.

***Sternostoma longisetosae* Hyland, 1961**

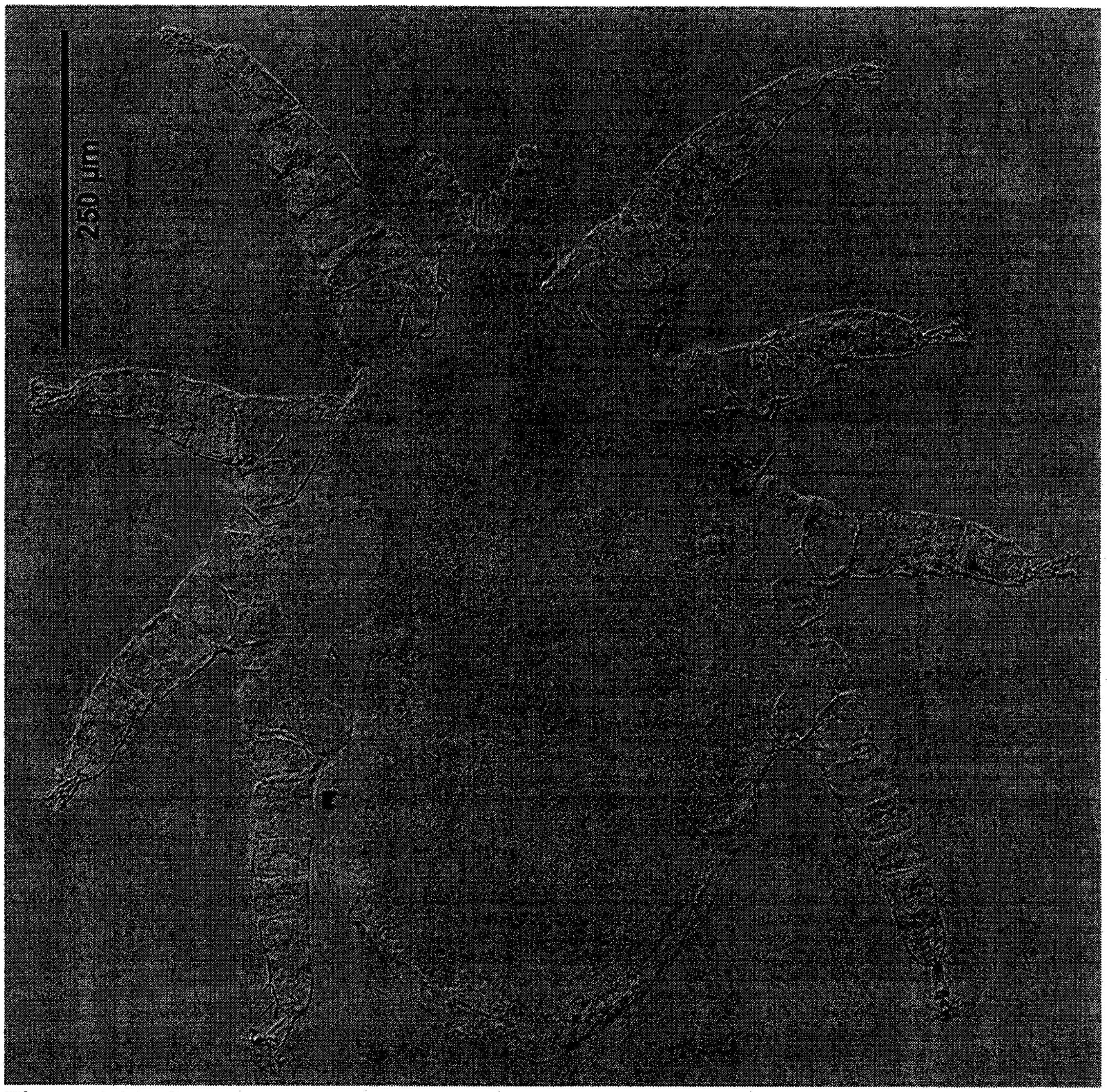


Figure 4.83. *Sternostoma longisetosae* dorsal habitus.

North American host records:
Tyrannidae:
Empidonax alnorum Hyland and Moorhouse (1970), Pence (1975)
Empidonax minimus present study
Empidonax traillii Hyland and Moorhouse (1970), Pence (1975)
Empidonax virescens Hyland and Moorhouse (1970), Pence (1975)
Pyrocephalus rubinus Hyland and Moorhouse (1970), Pence (1975)
Tyrannus savana Hyland and Moorhouse (1970)
Tyrannus tyrannus Hyland (1961), Pence (1975), present study

Diagnostic characteristics:

- apical setal pair on palp tarsus is proximally inflated, medially constricted, and distally flattened, resembling a T with an inflated base
- subapical ventral and ventrolateral setae of tarsi II - IV are relatively long spines
- no setae in the dorsal opisthosomal unsclerotized integument
- paranal setae level with anal opening, and postanal seta absent

References:

Hyland, K.E. 1961. *Sternostoma longisetosa*, a new species of nasal mite from the eastern
kingbird with notes on the occurrence of *Tyranninyssus spinosus* Brooks and Strandtmann in southern Michigan (Acarina: Rhinonyssidae). Acarologia **3**: 279-284.

Hyland, K.E., and A. Moorhouse. 1970. Nasal mites from Mexican birds. I. Rhinonyssidae (Mesostigmata) from the host family Tyrannidae. Acarologia **12**: 43-58.

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 Texas Tech University **8**: 1-148.

***Sternostoma porteri* Hyland, 1962**

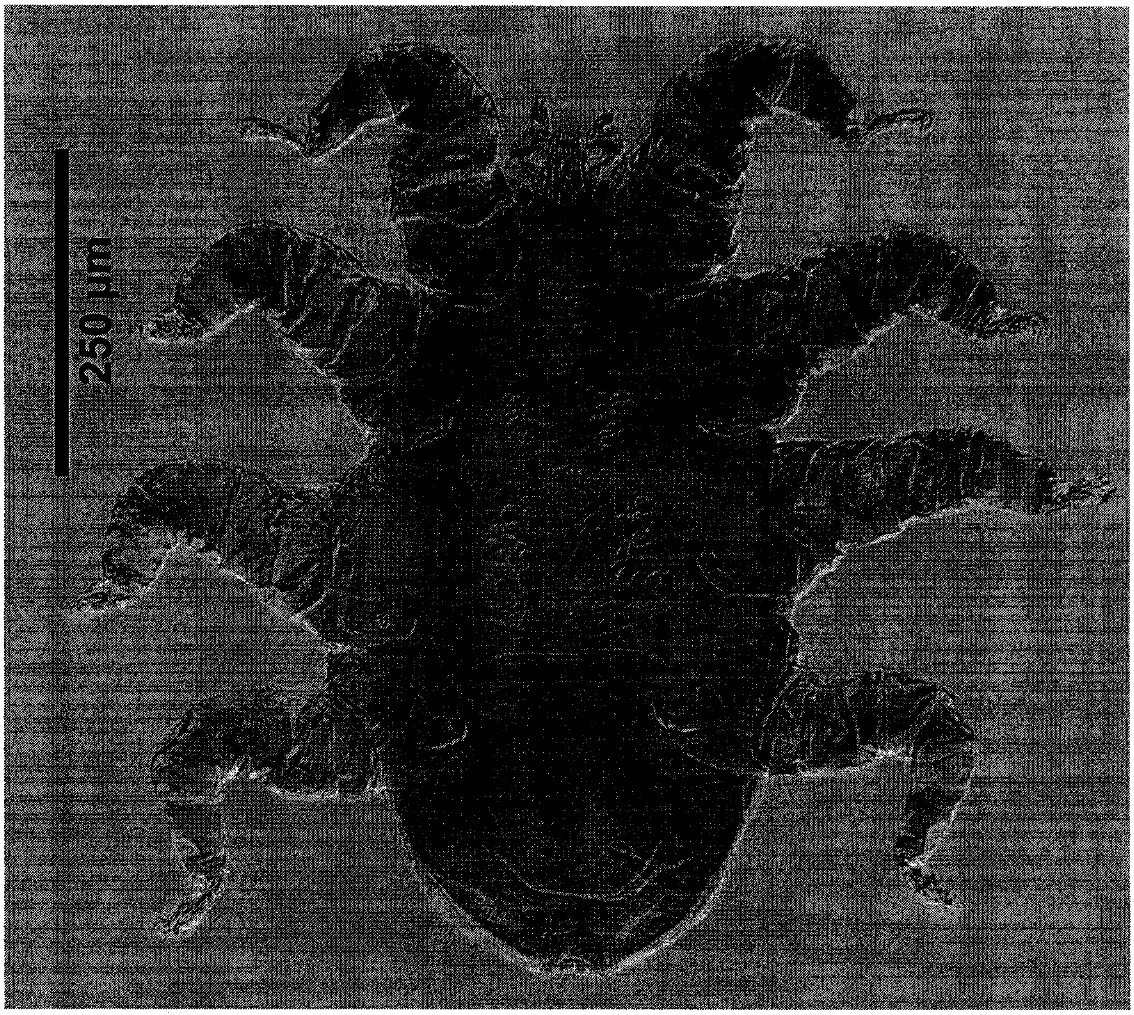


Figure 4.84. *Sternostoma porteri* dorsal habitus.

North American host records:
Picidae:
Colaptes auratus Hyland (1962), Pence (1972; 1975), present study
Melanerpes aurifrons Pence and Casto (1975), Estebanes-Gonzalez (1997)
Picoides pubescens Hyland (1962), Fain and Johnson (1966)
Sphyrapicus varius present study

Diagnostic characteristics:
- anterodorsal apical seta on tarsus IV is a long prominently swollen spike with flexible tip
- subapical ventral setal pair on tarsi II - IV are short blunt-tipped stout spines, most obvious on tarsus IV
- three pairs of setae in the dorsal opisthosomal unsclerotized integument
- paranal setae posterior to anal opening, and postanal seta present

References:

Estebanes-Gonzalez, M.L. 1997. Acarofauna en nidos de aves silvestres en Mexico. Acta Zoologica Mexicana. **71**: 1-15.

Fain, A., and D.E. Johnson. 1966. Nouveaux acariens nasicoles d'oiseaux nord-americains (Acari: Rhinonyssidae). Bulletins de la Societe Royal de Zoologie d'Anvers **38**: 25-41.

Hyland, K.E. 1962. Two new nasal mites, *Ptilonyssus morofskyi*, n.sp., and *Sternostoma porteri* n.sp., from North American birds (Acarina; Rhinonyssidae). Bulletin of the Brooklyn Entomological Society **57**: 146-156.

Pence, D.B. 1972. The nasal mites of birds from Louisiana II. The genus *Sternostoma* (Dermanyssidae: Rhinonyssinae). Journal of Parasitology **58**: 781-889.

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 Texas Tech University **8**: 1-148.

Pence, D.B., and S. Casto. 1975. Two new species and new records of nasal mites of the genus *Sternostoma* (Acarina: Rhinonyssinae) from birds in Texas. Journal of Parasitology **61**: 360-368.

***Sternostoma hylandi* Fain and Johnston, 1966**

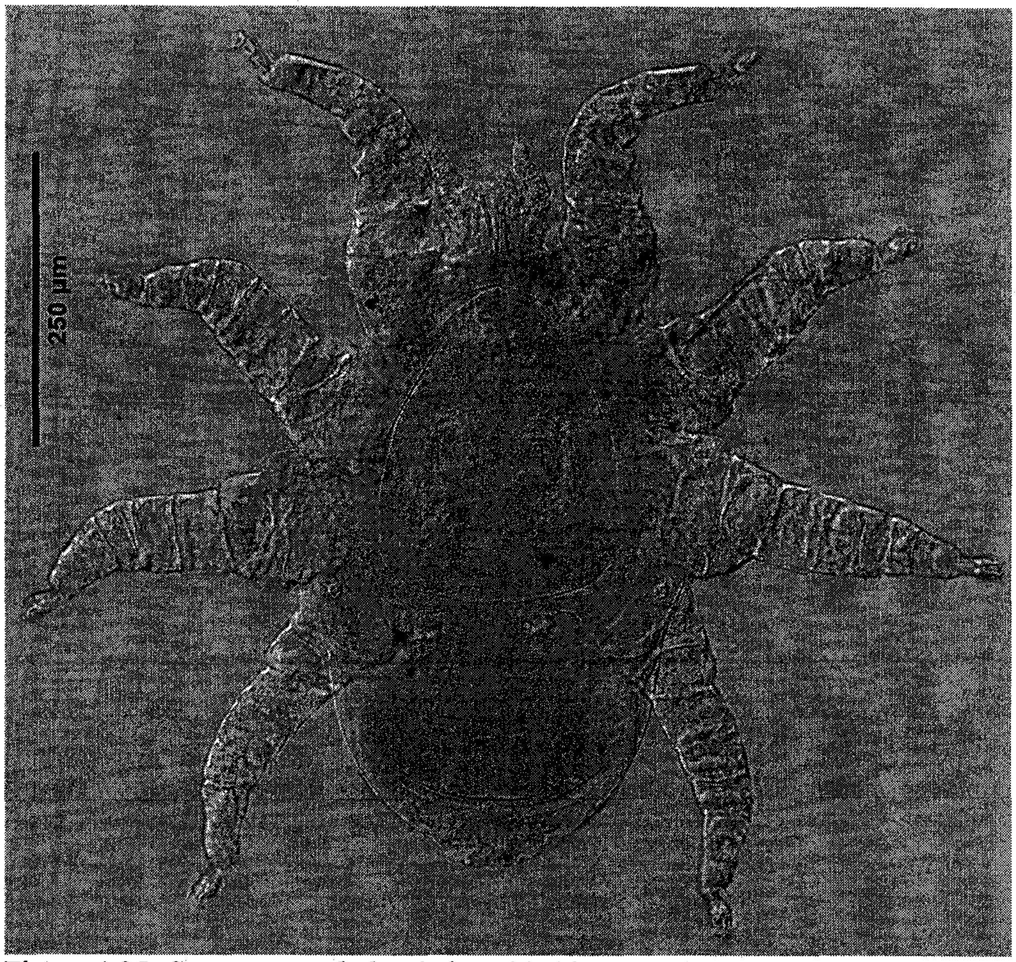


Figure 4.85. *Sternostoma hylandi* dorsal habitus.

North American host records:
Picidae:
Picoides pubescens Pence (1975), present study

Diagnostic characteristics:
- anterodorsal apical seta on tarsus IV is a long hair-like seta without swelling
- subapical ventral setal pair on tarsi II - IV are short blunt-tipped stout spines, most obvious on tarsus IV
- three pairs of setae in the dorsal opisthosomal unsclerotized integument
- paranal setae posterior to anal opening, and postanal seta present

References:

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 Texas Tech University **8**: 1-148.

***Sternostoma boydi* Strandtmann, 1951**

Figure 4.86. *Sternostoma boydi* dorsal habitus.

North American host records:
Laridae:
Larus argentatus TerBush (1963), Pence (1972; 1975)
Larus atricilla Pence (1975)
Larus californicus Spicer (1978)
Larus delawarensis Pence (1972; 1975)
Larus occidentalis Spicer (1978)

Sterna forsteri Mitchell (1961)
Sterna hirundo Pence (1972; 1975)

Scolopacidae:
Arenaria interpres Pence (1975), Canadian National Collection of Insects and Arachnids
Calidris alba Strandtmann (1951), Pence (1975)
Calidris canutus Mitchell (1961)
Tringa melanoleuca Mitchell (1961), Pence (1972; 1975)

Diagnostic characteristics:
- subapical ventral setal pair on tarsi II - IV are short flattened setae with rounded tips
- no setae in the dorsal opisthosomal unsclerotized integument
- paranal setae posterior to anal opening, and postanal seta absent

References:
Mitchell, R.W. 1961. New avian host records for some mesostigmatid mites. The Southwestern Naturalist **6**: 103-105.

Pence, D.B. 1972. The nasal mites of birds from Louisiana II. The genus *Sternostoma* (Dermanyssidae: Rhinonyssinae). Journal of Parasitology **58**: 781-889.

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 Texas Tech University **8**: 1-148.

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.

Strandtmann, R.W. 1951. The Mesostigmatic nasal mites of birds. II. New and poorly known species of Rhinonyssidae. Journal of Parasitology **37**: 129-140.

TerBush, L.E. 1963. Incidence of nasal mites in different age classes of herring gulls (*Larus argentatus*). Journal of Parasitology **49**: 525.

***Sternostoma setifer* sp. n.**

Figure 4.87. *Sternostoma setifer* sp. n. dorsal habitus.

North American host records:
Tyrannidae:
Empidonax minimus present study

Diagnostic characteristics:
- subapical ventral and ventrolateral setae of tarsi II - IV are relatively long spines
- four pairs of setae in the dorsal opisthosomal unsclerotized integument
- paranal setae posterior to anal opening, and postanal seta absent

Sternostoma tracheacolum Lawrence, 1948

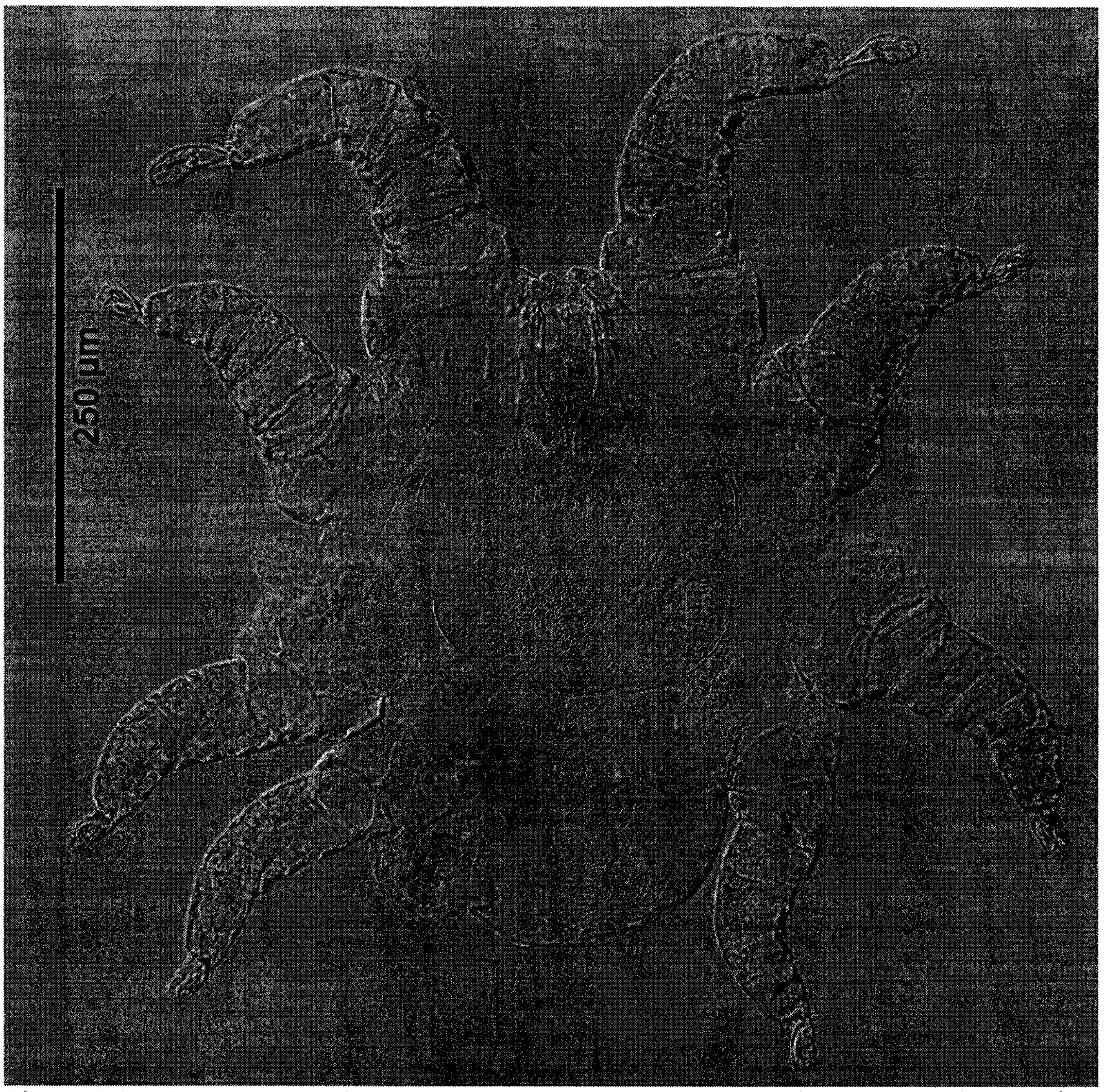


Figure 4.88. *Sternostoma tracheacolum* dorsal habitus.

North American host records:
Emberizidae:
Cardinalis sinuatus Pence and Casto (1975), Estebanes-Gonzalez (1997)
Melospiza melodia Fain and Hyland (1962), Pence (1975)
Passerella iliaca Fain and Hyland (1962), Pence (1975)
Passerina cyanea Fain and Hyland (1962), Pence (1975)
Pipilo fuscus Pence and Casto (1975)
Pooecetes gramineus Fain and Hyland (1962), Pence (1975)
Spizella pusilla Fain and Hyland (1962), Wilson (1964), Pence (1975)

Fringillidae:
Serinus canaria Fain and Hyland (1962)

Hirundinidae:
Riparia riparia Fain and Hyland (1962), Pence (1975)
Tachycineta bicolor Pence (1972; 1975)

Icteridae:
Agelaius phoeniceus Hood and Welch (1980)
Agelaius tricolor Furman (1957), Fain and Hyland (1962), Pence (1975)
Icterus bullock Furman (1957), Fain and Hyland (1962), Pence (1975)
Molothrus ater Fain and Hyland (1962), Pence (1972; 1975)
Sturnella magna Fain and Hyland (1962), Pence (1975)

Parulidae:
Mniotilta varia present study
Seiurus aurocapillus Fain and Hyland (1962), Pence (1975)
Seiurus noveboracensis Fain and Hyland (1962), Pence (1975)

Passeridae:
Passer domesticus Fain and Hyland (1962), Pence (1975)

Tyrannidae:
Myiarchus crinitus Pence (1972; 1975)
Tyrannus melancholicus Hyland and Moorhouse (1970)

Diagnostic characteristics:
- subapical ventral and ventrolateral setae of tarsi II - IV are minute spines, barely visible
- two pairs of setae in the dorsal opisthosomal unsclerotized integument
- paranal setae posterior to anal opening, and postanal seta absent

References:
Estebanes-Gonzalez, M.L. 1997. Acarofauna en nidos de aves silvestres en Mexico. Acta Zoologica Mexicana. **71**: 1-15.
Fain, A., and K.E. Hyland. 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.
Furman, D.P. 1957. Revision of the genus *Sternostoma* Berlese and Trouessart. Hilgardia **26**: 473-495.
Hood, D.E., and H.E. Welch. 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., and A. Moorhouse. 1970. Nasal mites from Mexican birds. I. Rhinonyssidae (Mesostigmata) from the host family Tyrannidae. Acarologia **12:** 43-58.
Pence, D.B. 1972. The nasal mites of birds from Louisiana II. The genus *Sternostoma*

(Dermanyssidae: Rhinonyssinae). Journal of Parasitology **58**: 781-889.

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 Texas Tech University **8**: 1-148.

Pence, D.B., and S. Casto. 1975. Two new species and new records of nasal mites of the genus *Sternostoma* (Acarina: Rhinonyssinae) from birds in Texas. Journal of Parasitology **61**: 360-368.

Wilson, N. 1964. New records and descriptions of Rhinonyssidae, mostly from New Guinea (Acarina: Mesostigmata). Pacific Insects **6**: 357-388.

***Sternostoma lanorium* Fain, 1956**

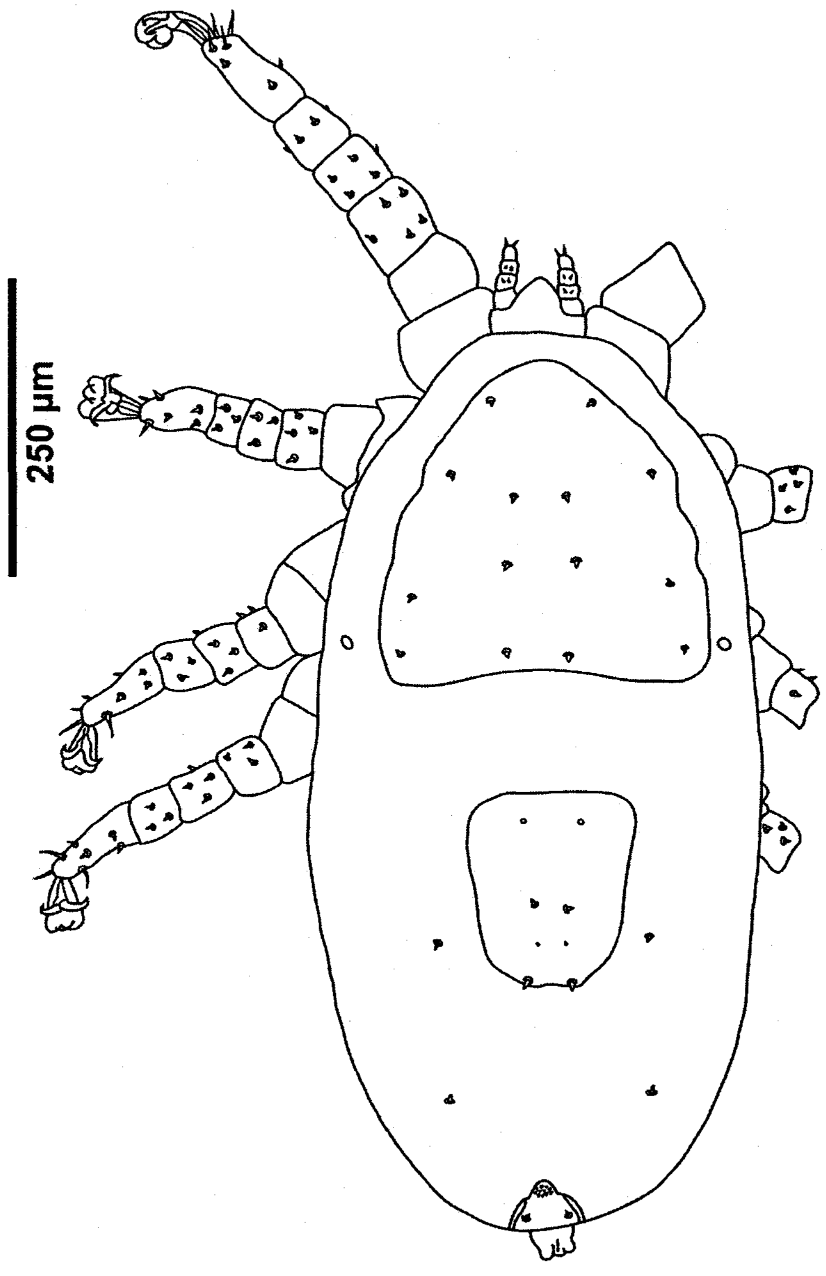


Figure 4.89. *Sternostoma lanorium* dorsal habitus.
Image redrawn from Pence (1975) with permission from the author

North American host records:
Laniidae:
Lanius ludovicianus Pence (1973; 1975)

Turdidae:
Catharus ustulatus present study

Diagnostic characteristics:
- subapical ventral and ventrolateral setae of tarsi II - IV are hook-like short spines
- two pairs of setae in the dorsal opisthosomal unsclerotized integument
- paranal setae posterior to anal opening, and postanal seta absent

References:
Pence, D.B. 1973. The nasal mites of birds from Louisiana. VIII. Additional records and descritpion of a new species (Acarina: Dermanyssidae, Ereynetidae, Epidermoptidae, and Cytoditidae). Journal of Parasitology **59**: 874-880.

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 Texas Tech University **8**: 1-148.

Sternostoma cryptorhynchum **Berlese and Trouessart, 1889**

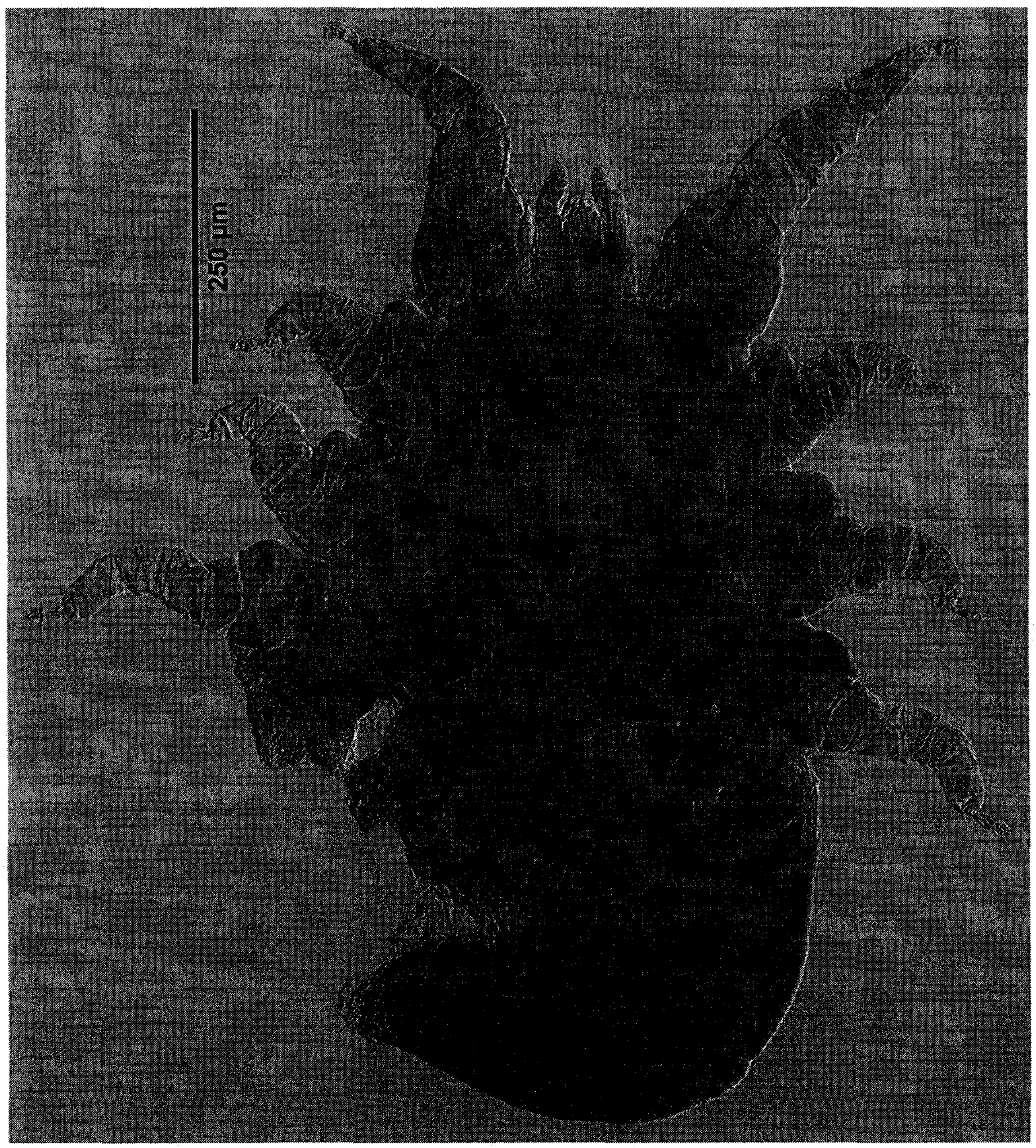


Figure 4.90. *Sternostoma cryptorhynchum* dorsal habitus.

North American host records:
Fringillidae:
Pinicola enucleator present study

Diagnostic characteristics:
- subapical ventral and ventrolateral setae of tarsi II - IV are distally inflated symmetrical setae

- two pairs of setae in the dorsal opisthosomal unsclerotized integument
- paranal setae level with anal opening, and postanal seta absent

References:

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 Texas Tech University **8**: 1-148.

***Sternostoma loxiae* Fain, 1965**

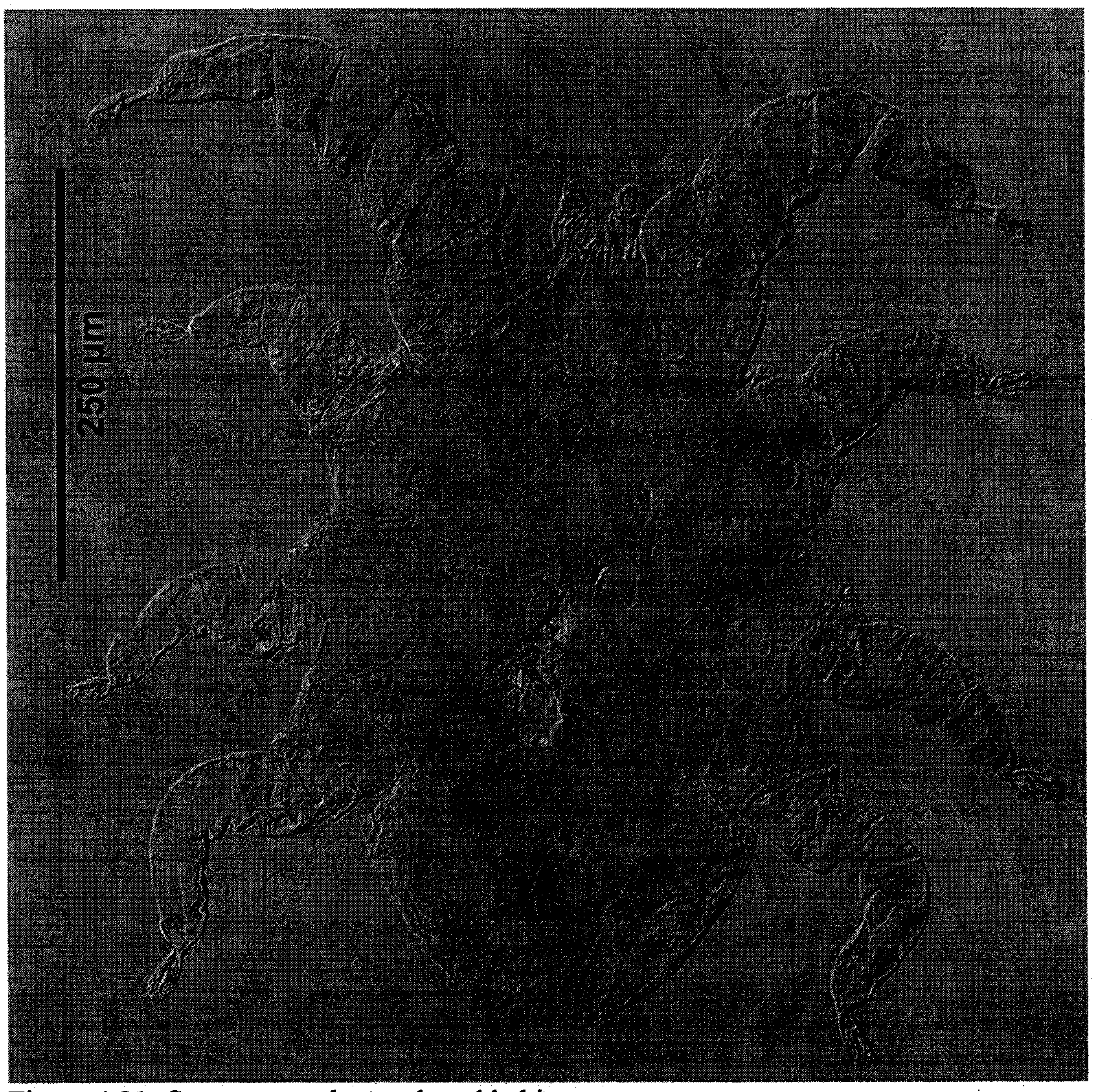


Figure 4.91. *Sternostoma loxiae* dorsal habitus.

North American host records:
Parulidae:
Dendroica petechia present study

Turdidae:
Sialia currucoides present study

Diagnostic characteristics:
- subapical ventral and ventrolateral setae of tarsi II - IV are distally inflated asymmetrical setae

- two pairs of setae in the dorsal opisthosomal unsclerotized integument
- paranal setae posterior to anal opening, and postanal seta absent

References:

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 Texas Tech University **8**: 1-148.

Sternostoma sialiphilus **Hyland and Ford, 1961**

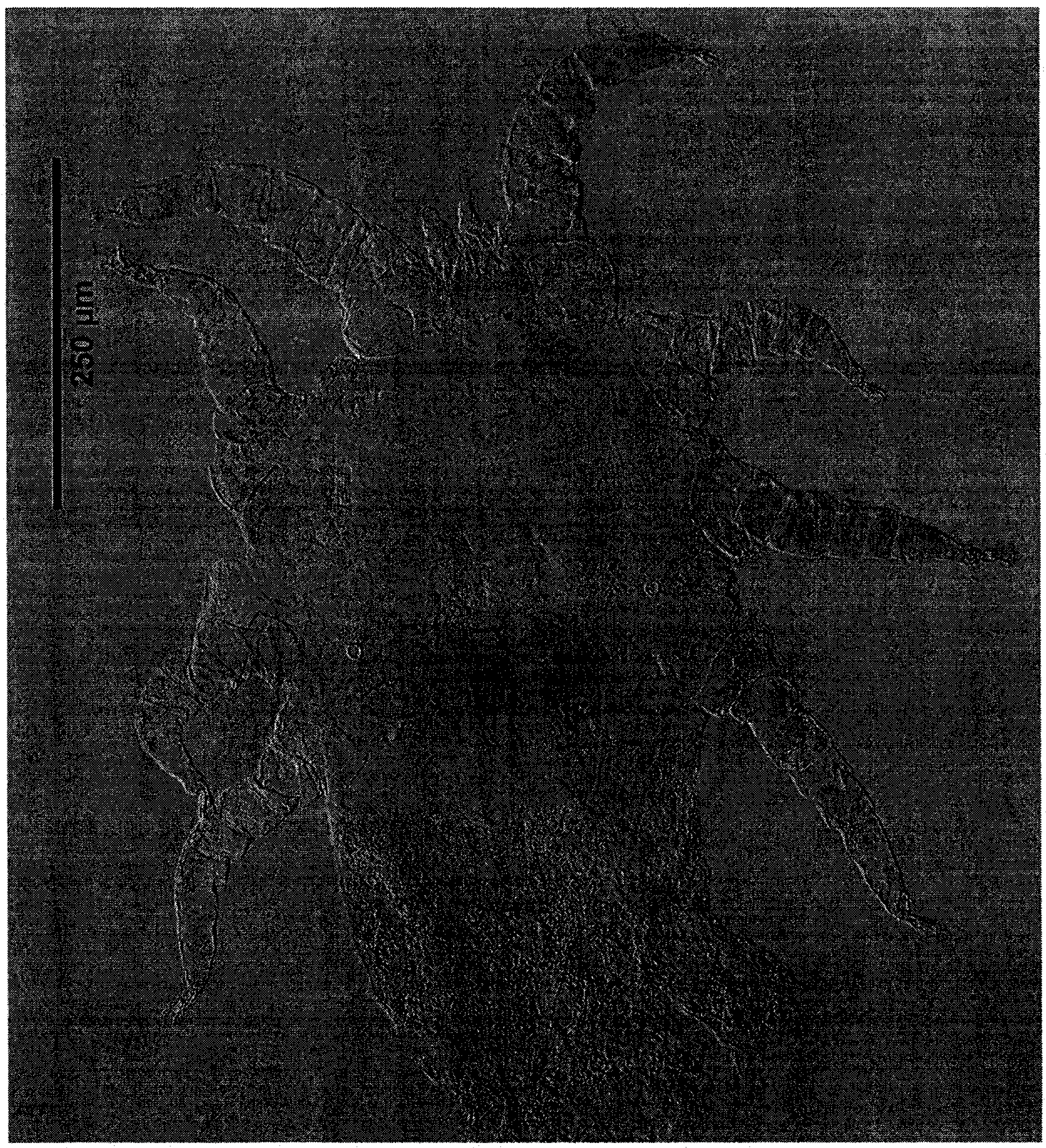


Figure 4.92. *Sternostoma sialiphilus* dorsal habitus.

North American host records:
Hirundinidae:
Riparia riparia present study

Turdidae:
Sialia sialis Hyland (1961), Hyland and Ford (1961), Pence (1972; 1975)

Diagnostic characteristics:
- subapical ventral and ventrolateral setae of tarsi II - IV are distally inflated asymmetrical setae
- one pair of setae in the dorsal opisthosomal unsclerotized integument
- paranal setae posterior to anal opening, and paranal seta absent

References:

Hyland, K. E., and H.G. Ford. 1961. *Sternostoma sialiphilus* n. sp. (Acarina: Rhinonyssidae) from the nasal cavities of the eastern bluebird, *Sialia sialis* (Linnaeus). Journal of Parasitology **47**: 101-104.

Pence, D.B. 1972. The nasal mites of birds from Louisiana II. The genus *Sternostoma* (Dermanyssidae: Rhinonyssinae). Journal of Parasitology **58**: 781-889.

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 Texas Tech University **8**: 1-148.

***Ptilonyssus angrensis* (Castro, 1948)**

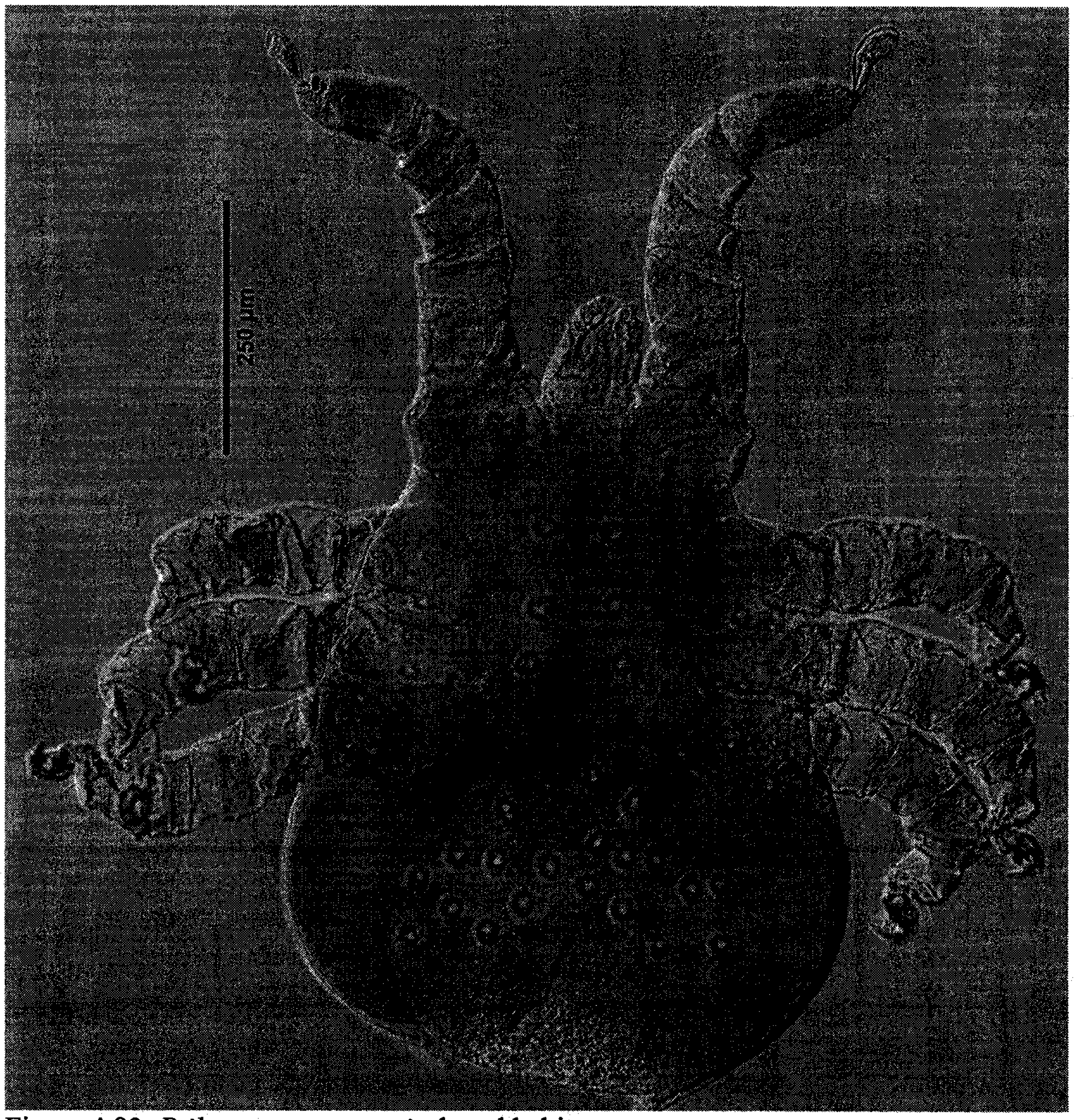


Figure 4.93. *Ptilonyssus angrensis* dorsal habitus.

North American host records:
Hirundinidae:
Hirundo fluva Pence (1975)
Hirundo pyrrhonota Pence (1975)
Progne subis Pence (1972; 1975), present study
Tachycineta bicolor Pence (1975)

Diagnostic characteristics:
- one dorsal shield
- sternal shield absent

- posterior margin of podosomal shield with a medial lobe and lacking lateral lobes
- peritreme absent
- subapical ventral setal pair on tarsus IV are relatively short spikes proximally inflated
- seven or more pairs of ventral opisthosomal setae
- two pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are as long or almost as long as the longest mesolateral setae
- cribrum absent or unnoticeable
- paranal setae level with anal opening, paranal and postanal setae are equal or almost equal in length

Note:

- *Ptilonyssus* species are typically characterized as having peritremes, the exceptions are *P. angrensis, P. vireonis*, and *P. hoseini* (Fain and Aitken, 1967) all of which lack peritremes. These three species are still considered to be *Ptilonyssus* species because of the ventroterminal placement of the anus, and the terminal placement of the gnathosoma.

References:

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. 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 Texas Tech University **8**: 1-148.

Ptilonyssus coccothraustis **Fain and Bafort, 1963**

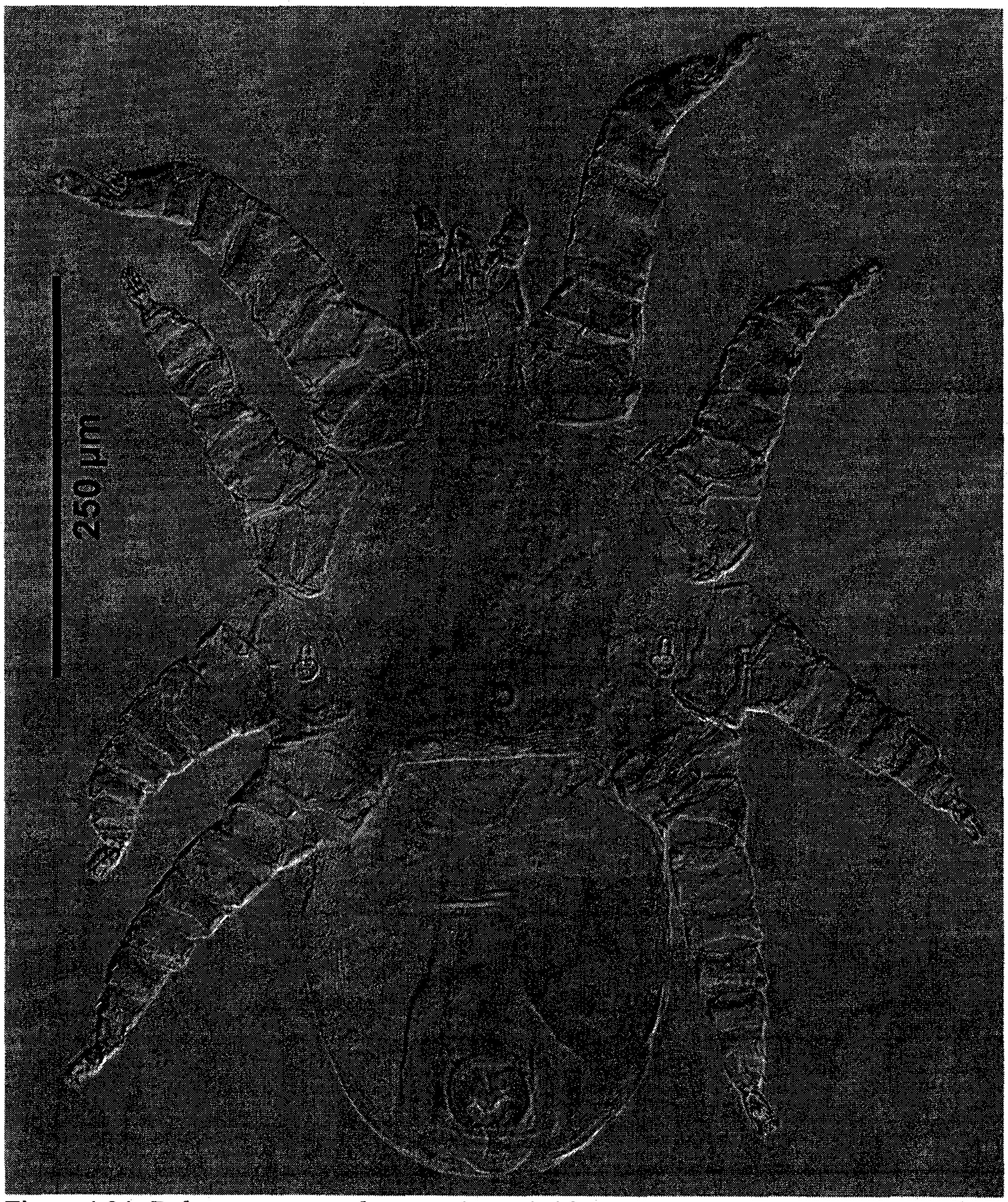


Figure 4.94. *Ptilonyssus coccothraustis* dorsal habitus.

North American host records:
Fringillidae:
Coccothraustes vespertinus present study

Diagnostic characteristics:
- three dorsal shields

- posterior margin of podosomal shield is straight, occasionally a slight medial lobe is present
- opisthosomal shield is longer than wide, but not twice as long as wide
- opisthosomal shield without lateral excavation
- posterior margin of opisthosomal shield is rounded
- anterior margin of opisthosomal shield is medially straight with anterolateral projections
- st1 st2 and st3 on the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long, one strong spike and one filamentous spike
- six pairs of ventral opisthosomal setae
- four pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are as long or almost as long as the longest mesolateral setae
- ventral hypostomal setae large distally inflated bulbs
- paranal setae level with anal opening, paranal and postanal setae are unequal in length

References:

Fain, A., and J. Bafort. 1963. Les acariens parasites nasicoles des oiseaux de Belgique. III. Nouvelles observations sur les rhinonyssides avec description de cinq especes nouvelles. Bulletin and Annales de la Societe Royale d'Entomologie de Belgique **99**: 471-485.

***Ptilonyssus plesiotypicus* sp. n.**

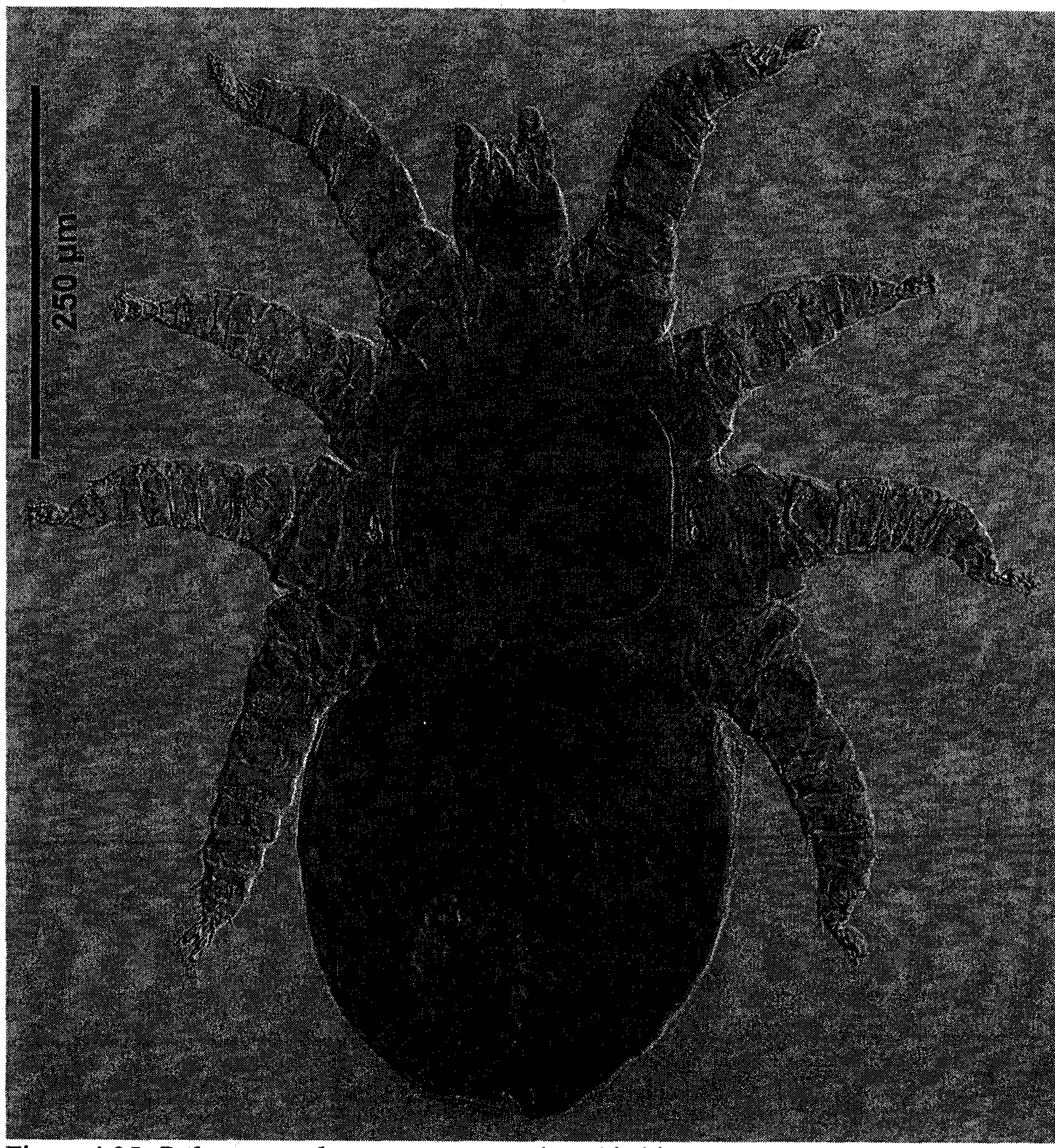


Figure 4.95. *Ptilonyssus plesiotypicus* sp. n. dorsal habitus.

North American host records:
Fringillidae:
Carpodacus purpureus present study

Diagnostic characteristics:
- three dorsal shields
- posterior margin of podosomal shield is slightly trilobed
- opisthosomal shield is longer than wide, but not twice as long as wide
- opisthosomal shield without lateral excavation

- posterior margin of opisthosomal shield is rounded
- anterior margin of opisthosomal shield is medially straight with anterolateral projections
- st1 st2 and st3 on the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- seven or more pairs of ventral opisthosomal setae
- four pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are longer than mesolateral setae
- ventral hypostomal setae large distally inflated bulbs
- anal setae constricted proximally (within 1/3 of length from base) forming a long filamentous tip
- paranal setae level with anal opening, paranal and postanal setae are unequal in length

***Ptilonyssus callinectoides* (Brooks and Strandtmann, 1969)**

Figure 4.96. *Ptilonyssus callinectoides* dorsal habitus.

North American host records:
Tyrannidae:
Myiarchus cinerascens Brooks and Strandtmann (1969), Pence (1975)
Myiarchus crinitus Pence (1972; 1973; 1975), present study
Myiarchus tyrannulus Hyland and Moorhouse (1970)

Diagnostic characteristics:
- three dorsal shields
- podosomal shield with lateral winglike processes
- posterior margin of podosomal shield is rounded
- opisthosomal shield is twice as long as wide
- lateral excavation of the posterior portion of the opisthosomal shield
- posterior margin of opisthosomal shield is rounded
- anterior margin of opisthosomal shield is straight
- st2 and st3 on with st1 off the sternal shield shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes with a rounded terminus
- four pairs of ventral opisthosomal setae
- two pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are as long or almost as long as the longest mesolateral setae
- dorsum of genu III with oblique row of four stout spine setae close together
- paranal setae level with anal opening, paranal and postanal setae are unequal in length

References:

Brooks, D.L., and R.W. Strandtmann. 1969. The nasal mites (Acarina) of some West Texas flycatchers (Tyrannidae). Journal of Parasitology **46**: 418-432.

Hyland, K.E., and A. Moorhouse. 1970. Nasal mites from Mexican birds. I. Rhinonyssidae (Mesostigmata) from the host family Tyrannidae. Acarologia **12**: 43-58.

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. VIII. Additional records and descritpion of a new species (Acarina: Dermanyssidae, Ereynetidae, Epidermoptidae, and Cytoditidae). Journal of Parasitology **59**: 874-880.

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 Texas Tech University **8**: 1-148.

***Ptilonyssus vireonis* (Dusbabek, 1969)**

Figure 4.97. *Ptilonyssus vireonis* dorsal habitus.

North American host records:
Vireonidae:
Vireo olivaceus Pence (1972; 1975), present study
Vireo solitarius present study

Diagnostic characteristics:
- three dorsal shields
- peritreme absent
- posterior margin of podosomal shield with a medial lobe and lacking lateral lobes
- opisthosomal shield is almost as wide as long
- opisthosomal shield laterally excavated medially with excavation extending posteriorly
- posterior margin of opisthosomal shield is rounded
- anterior margin of opisthosomal shield with a medial lobe and lacking lateral lobes
- st1 on with st2 and st3 off the sternal shield
- subapical ventral setal pair on tarsus IV are long heavyset inflated spikes
- six pairs of ventral opisthosomal setae
- three pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are as long or almost as long as the longest mesolateral setae
- paranal setae anterior to anal opening, paranal and postanal setae are unequal in length

Note:
- *Ptilonyssus* species are typically characterized as having peritremes, the exceptions are *P. angrensis, P. vireonis*, and *P. hoseini* (Fain and Aitken, 1967) all of which lack peritremes. These three species are still considered to be *Ptilonyssus* species because of the ventroterminal placement of the anus, and the terminal placement of the gnathosoma.

References:

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. 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 Texas Tech University **8**: 1-148.

***Ptilonyssus tyrannus* (Brooks and Strandtmann, 1960)**

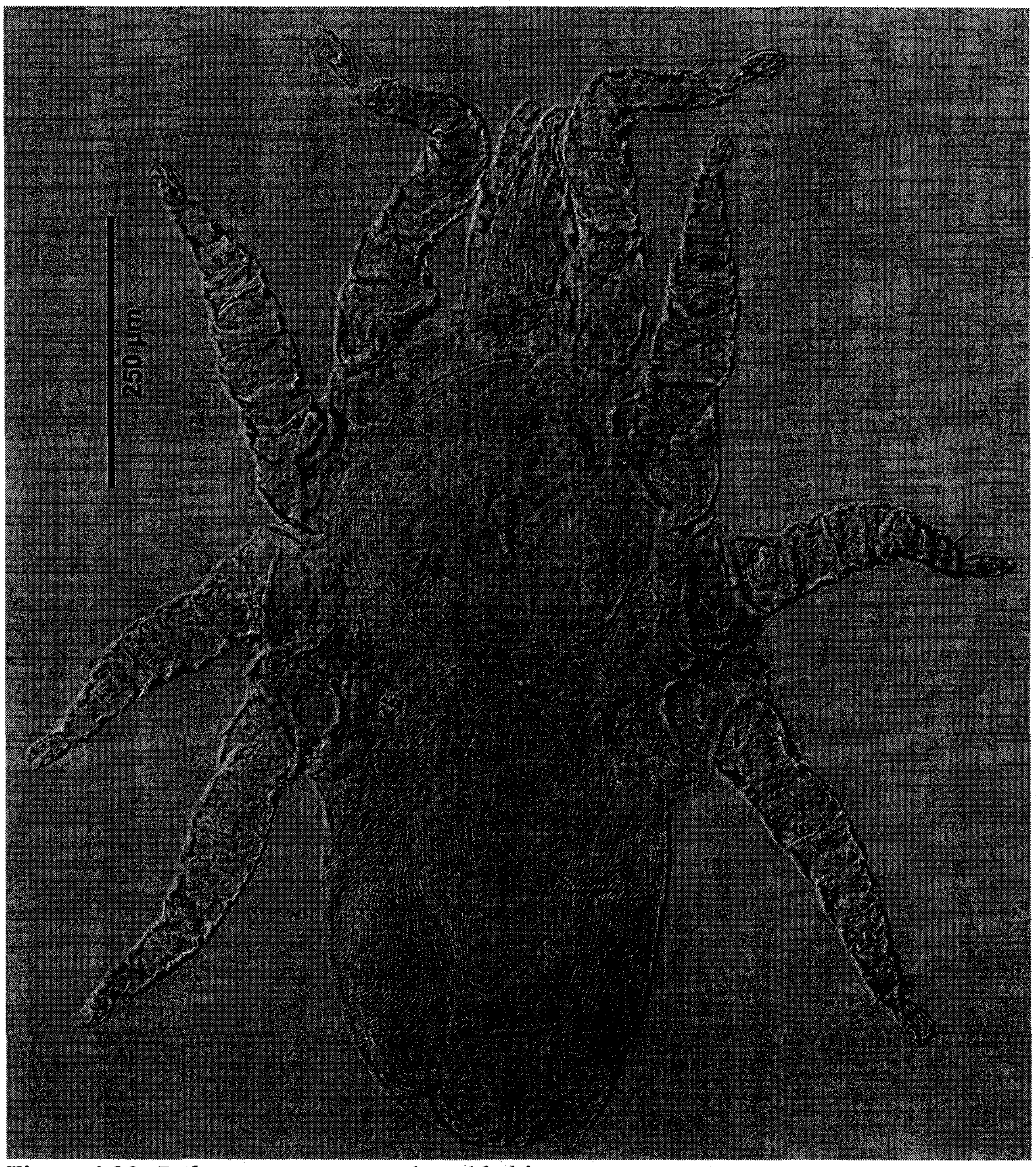


Figure 4.98. *Ptilonyssus tyrannus* dorsal habitus.

North American host records:

Tyrannidae:

Contopus borealis Brooks and Strandtmann (1969), Hyland and Moorhouse (1970), Pence (1975)

Contopus sordidulus Brooks and Strandtmann (1969), Hyland and Moorhouse (1970), Pence (1975), present study

Contopus virens Pence (1972; 1975)

Empidonax alnorum Hyland and Moorhouse (1970), Pence (1975)
Empidonax flaviventris Hyland and Moorhouse (1970), Pence (1975)
Empidonax minimus Brooks and Strandtmann (1969), Hyland and Moorhouse (1970), Pence (1975), Spicer (1987)
Empidonax trailli Hyland and Moorhouse (1970), Pence (1975)
Empidonax virescens Pence (1972; 1975)
Sayornis phoebe Pence (1972; 1975), present study
Sayornis saya Brooks and Strandtmann (1969), Hyland and Moorhouse (1970), Pence (1975)
Tyrannus melancholicus Hyland and Moorhouse (1970)

Diagnostic characteristics:
- three dorsal shields
- posterior margin of podosomal shield with a medial lobe and lacking lateral lobes
- opisthosomal shield is twice as long as wide
- lateral excavation of the posterior portion of the opisthosomal shield
- posterior margin of opisthosomal shield is rounded
- anterior margin of opisthosomal shield is straight
- st1 st2 and st3 off the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes with a rounded terminus
- four pairs of ventral opisthosomal setae
- three pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are as long or almost as long as the longest mesolateral setae
- dorsum of genu III with oblique row of four stout spine setae close together
- paranal setae anterior to anal opening, paranal and postanal setae are unequal in length

References:
Brooks, D.L., and R.W. Strandtmann. 1969. The nasal mites (Acarina) of some West Texas flycatchers (Tyrannidae). Journal of Parasitology **46**: 418-432.
Hyland, K.E., and A. Moorhouse. 1970. Nasal mites from Mexican birds. I. Rhinonyssidae (Mesostigmata) from the host family Tyrannidae. Acarologia **12**: 43-58.
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. 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 Texas Tech University **8**: 1-148.
Spicer, G.S. 1987. Prevalence and host-parasite list of some nasal mites from birds (Acarina: Rhinonyssidae, Speleognathidae). Journal of Parasitology **73**: 259-264.

Ptilonyssus hirsti **(Castro & Periera, 1947)**

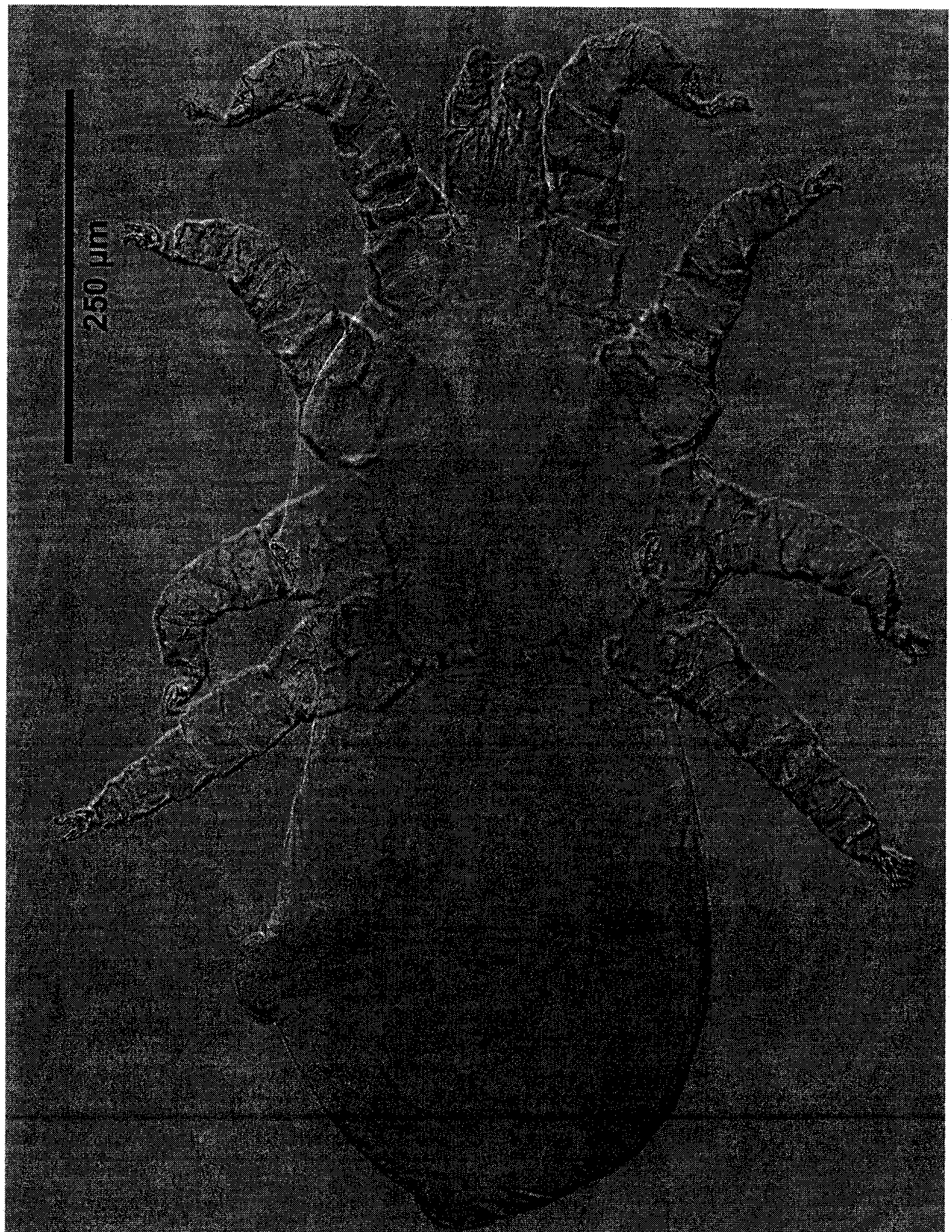


Figure 4.99. *Ptilonyssus hirsti* dorsal habitus.

North American host records:
Passeridae
Passer domesticus Porter and Strandtmann (1952), Fain and Hyland (1963), Wilson (1964), Pence (1975), present study

Diagnostic characteristics:
- three dorsal shields
- posterior margin of podosomal shield is straight
- opisthosomal shield is twice as long as wide
- opisthosomal shield without lateral excavation
- posterior margin of opisthosomal shield is rounded, occasionally it is invaginated forming an inverted V indent
- anterior margin of opisthosomal shield is straight
- st1 st2 and st3 off the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long filamentous spikes with long flexible tips
- six pairs of ventral opisthosomal setae
- four pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- minute subposterior pair of dorsal podosomal setae are as long or almost as long as the longest mesolateral setae
- paranal setae posterior to anal opening, paranal and postanal setae are unequal in length

References:
Fain, A., and K.E. Hyland. 1963. Deus nouveaux rhinonyssides communs aux faunes d'Amerique du Nord et de Belgique. Bulletin and Annales de la Societe Royale d'Entomologie de Belgique **99**: 375-386.

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

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 Texas Tech University **8**: 1-148.

Wilson, N. 1964. New records and descriptions of Rhinonyssidae, mostly from New Guinea (Acarina: Mesostigmata). Pacific Insects **6**: 357-388.

***Ptilonyssus icteridius* (Strandtmann and Furman, 1956)**

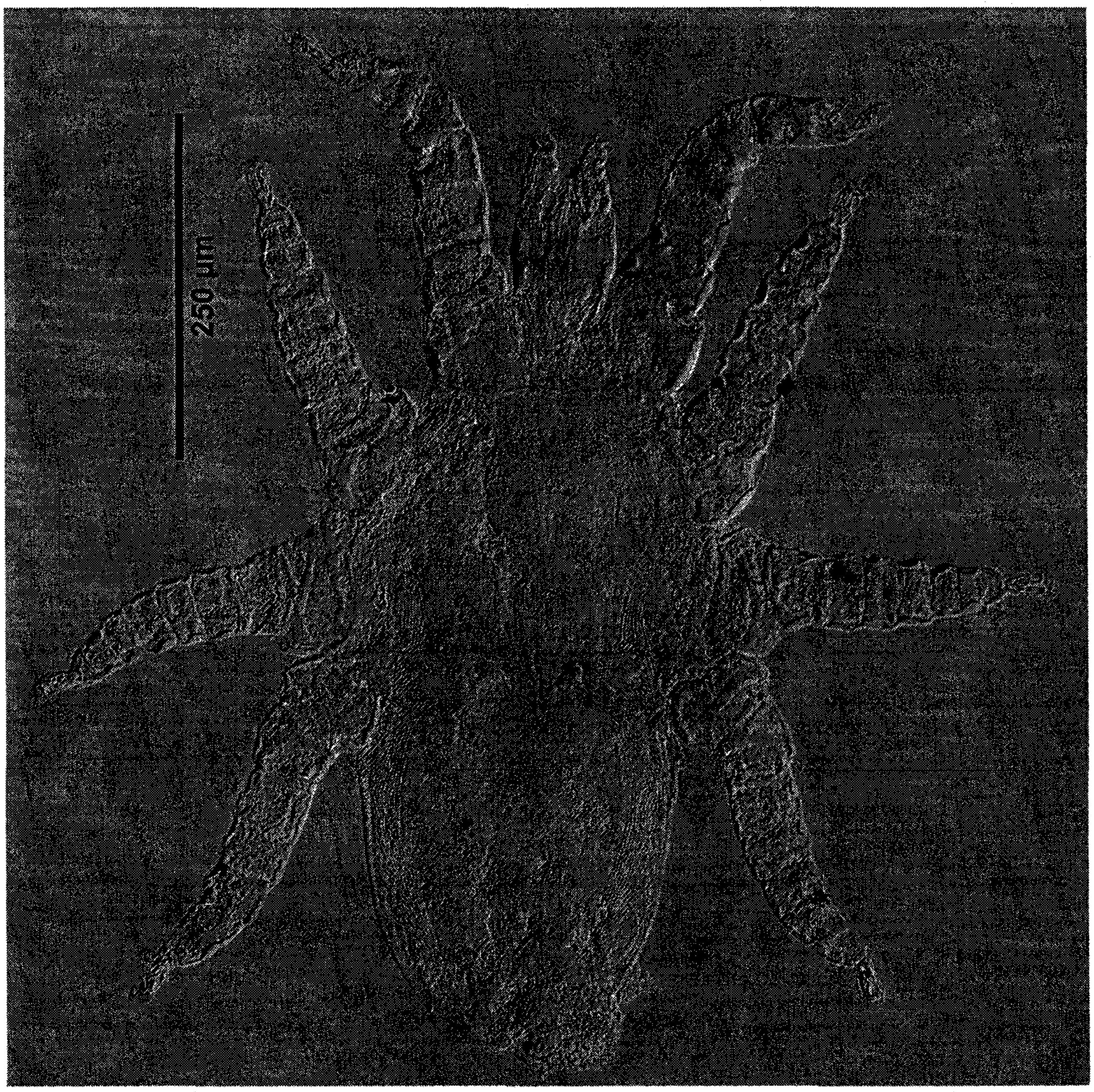


Figure 4.100. *Ptilonyssus icteridius* dorsal habitus.

North American host records:
Emberizidae:
Piranga ludoviciana Strandtmann and Furman (1956), Pence (1975)
Spiza americana Spicer (1977; 1987)
Sturnella magna Spicer (1987)

Icteridae:
Agelaius phoeniceus Strandtmann and Furman (1956), Wilson (1964), Pence (1972; 1975), present study
Agelaius tricolor Strandtmann and Furman (1956)
Euphagus carolinus Pence (1972; 1975)

Euphagus cyanocephalus Strandtmann and Furman (1956), Pence (1972; 1975), present study
Icterus galbula Pence (1972; 1975), present study
Molothrus ater Strandtmann and Furman (1956), Wilson (1964), Pence (1972; 1975), present study
Quiscalus quiscula Strandtmann and Furman (1956), Wilson (1964), Pence (1972; 1975), present study
Sturnella magna Strandtmann and Furman (1956), Pence (1972; 1975)
Sturnella neglecta Spicer (1978)
Xanthocephalus xanthocephalus Strandtmann and Furman (1956), Pence (1975)

Tyrannidae:
Myiarchus crinitus present study

Diagnostic characteristics:
- three dorsal shields
- posterior margin of podosomal shield is straight, occasionally a slight medial lobe is present
- opisthosomal shield is longer than wide, but not twice as long as wide
- opisthosomal shield without lateral excavation
- posterior margin of opisthosomal shield is invaginated forming an inverted V indent, occasionally it is rounded
- anterior margin of opisthosomal shield is straight
- st1 st2 and st3 off the sternal shield
- subapical ventral setal pair on tarsus IV are long heavyset inflated spikes
- six pairs of ventral opisthosomal setae
- four pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are as long or almost as long as the longest mesolateral setae
- paranal setae level with anal opening, paranal and postanal setae are equal or almost equal in length

References:
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. 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 Texas Tech University **8**: 1-148.
Spicer, G.S. 1977. New host records from avian nasal mites (Acarina: Rhinonyssinae, Speleognathinae). Journal of Medical Entomology **14**: 498.
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. 1987. Prevalence and host-parasite list of some nasal mites from birds (Acarina: Rhinonyssidae, Speleognathidae). Journal of Parasitology **73**: 259-264.

Strandtmann, R.W., and D.P. Furman. 1956. A new species of mite, *Paraneonyssus icteridius*, from the nasal cavities of blackbirds. Pan-Pacific Entomologist **32:** 167-173.

Wilson, N. 1964. New records and descriptions of Rhinonyssidae, mostly from New Guinea (Acarina: Mesostigmata). Pacific Insects **6**: 357-388.

***Ptilonyssus morofskyi* Hyland, 1962**

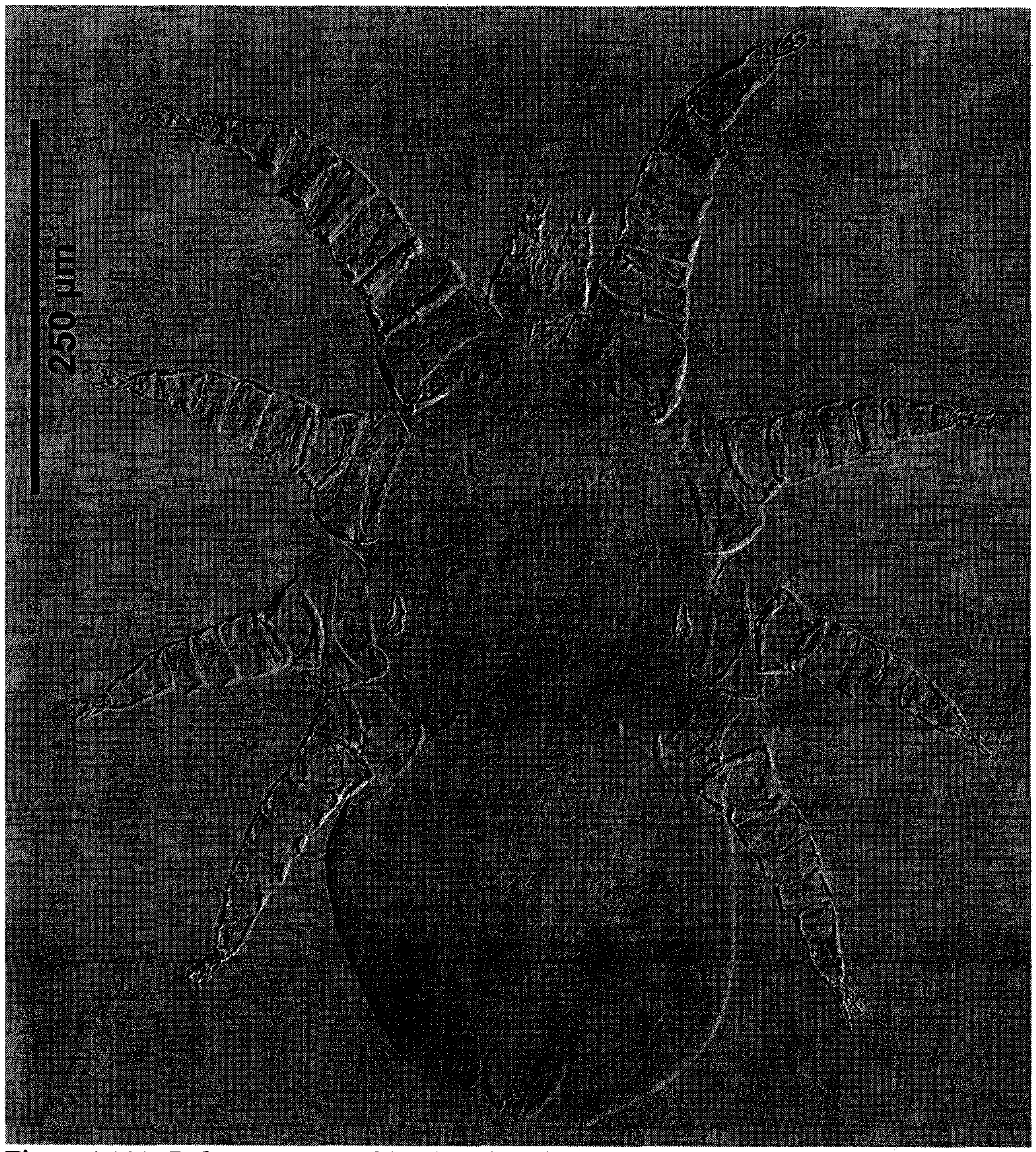


Figure 4.101. *Ptilonyssus morofskyi* dorsal habitus.

North American host records:
Emberizidae:
Ammodramus maritima Pence (1972; 1975)
Calamospiza melanocorys Spicer (1978)
Calcarius ornatus Spicer (1978)
Dendroica coronata Spicer (1987)
Junco hyemalis Pence (1975), Spicer (1978), present study

Melospiza georgiana Pence (1972; 1975)
Melospiza melodia Pence (1975)
Passerculus sandwichensis Hyland (1962), Pence (1975)
Passerella iliaca Pence (1975), present study
Pipilo erythrophthalmus Pence (1972; 1975)
Plectrophenax nivalis present study
Pooecetes gramineus Pence (1972; 1975)
Spizella pusilla Pence (1975)
Zonotrichia albicollis, Pence (1972; 1975), Spicer (1987)
Zonotrichia leucophrys Spicer (1978)
Zonotrichia querula Spicer (1977; 1987)

Fringillidae:
Carduelis flammea present study
Carduelis tristis Hyland (1962), Pence (1975), present study

Parulidae:
Dendroica coronata Pence (1972; 1975)
Dendroica pinus Pence (1972; 1975), present study
Geothlypis trichas Pence (1972; 1975)
Seiurus motacilla Pence (1972; 1975)
Setophaga ruticilla present study
Vermivora peregrina present study
Wilsonia pusilla Spicer (1978)

Diagnostic characteristics:
- three dorsal shields
- sternal shield wider than long
- posterior margin of podosomal shield is straight
- opisthosomal shield is longer than wide, but not twice as long as wide
- lateral excavation of the posterior portion of the opisthosomal shield
- posterior margin of opisthosomal shield is rounded
- anterior margin of opisthosomal shield is straight
- st1 st2 and st3 on the sternal shield
- subapical ventral setal pair on tarsus IV are one short filamentous spike and one short partially inflated bulb
- four pairs of ventral opisthosomal setae
- three pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are longer than mesolateral setae
- paranal setae level with anal opening, paranal and postanal setae are unequal in length

References:

Hyland, K.E. 1962. Two new nasal mites, *Ptilonyssus morofskyi*, n.sp., and *Sternostoma porteri* n.sp., from North American birds (Acarina; Rhinonyssidae). Bulletin of the Brooklyn Entomological Society **57**: 146-156.

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. 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 Texas Tech University **8**: 1-148.

Spicer, G.S. 1977. Two new nasal mites of the genus *Ptilonyssus* (Mesostigmata: Rhinonyssidae) from Texas. Acarologia **18**: 594-601.

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

***Ptilonyssus nivalis* sp. n.**

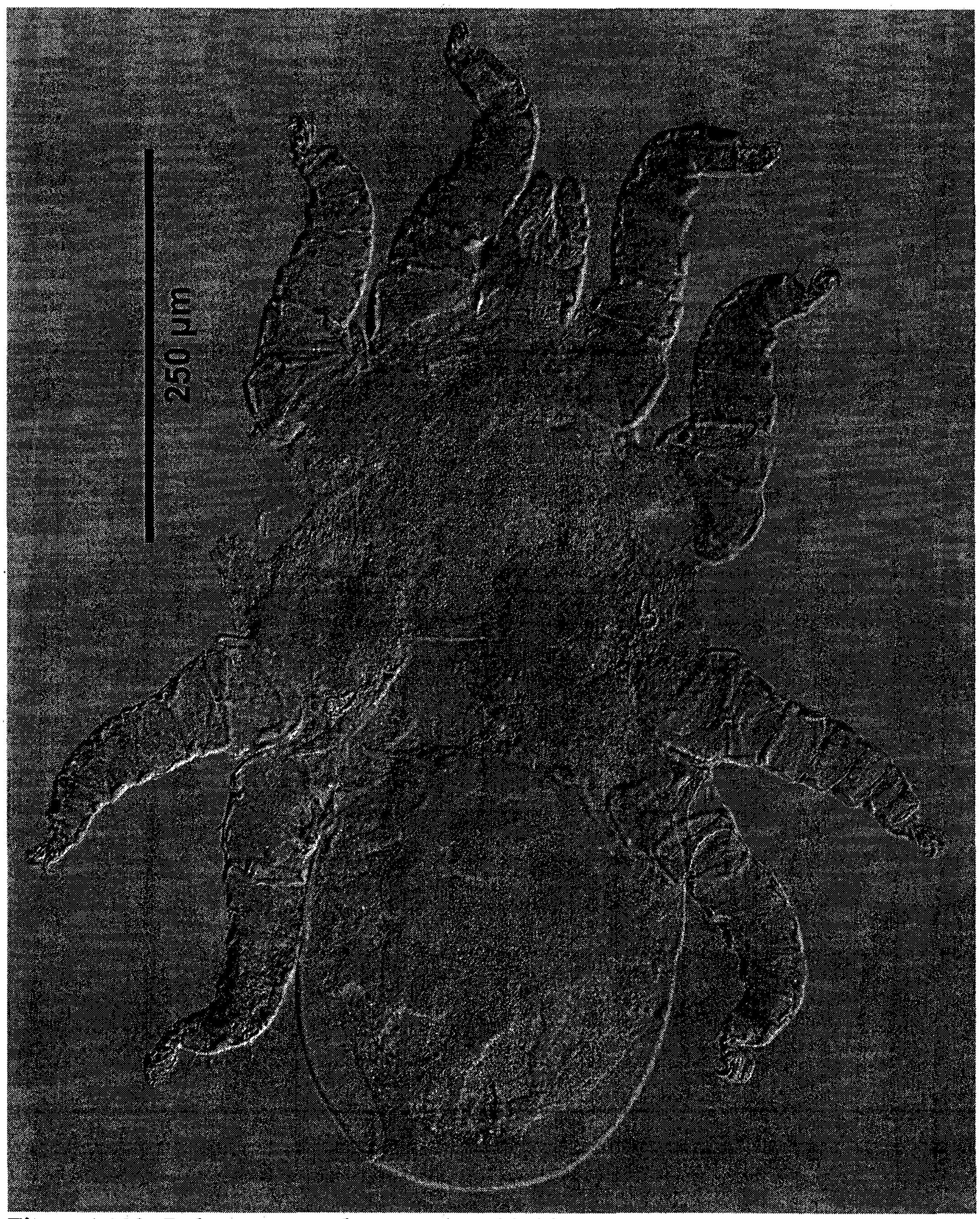


Figure 4.102. *Ptilonyssus nivalis* sp. n. dorsal habitus.

North American host records:
Emberizidae:
Plectrophenax nivalis present study

Diagnostic characteristics:
- three dorsal shields
- posterior margin of podosomal shield is trilobed
- opisthosomal shield is longer than wide, but not twice as long as wide
- lateral excavation of the posterior portion of the opisthosomal shield
- posterior margin of opisthosomal shield is invaginated forming an inverted V indent
- anterior margin of opisthosomal shield is straight
- st1 st2 and st3 on the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long, one strong spike and one filamentous spike
- six pairs of ventral opisthosomal setae
- three pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are less than half the length of the longest mesolateral setae
- paranal setae anterior to anal opening, paranal and postanal setae are unequal in length

Ptilonyssus pirangae **(Cerny, 1969)**

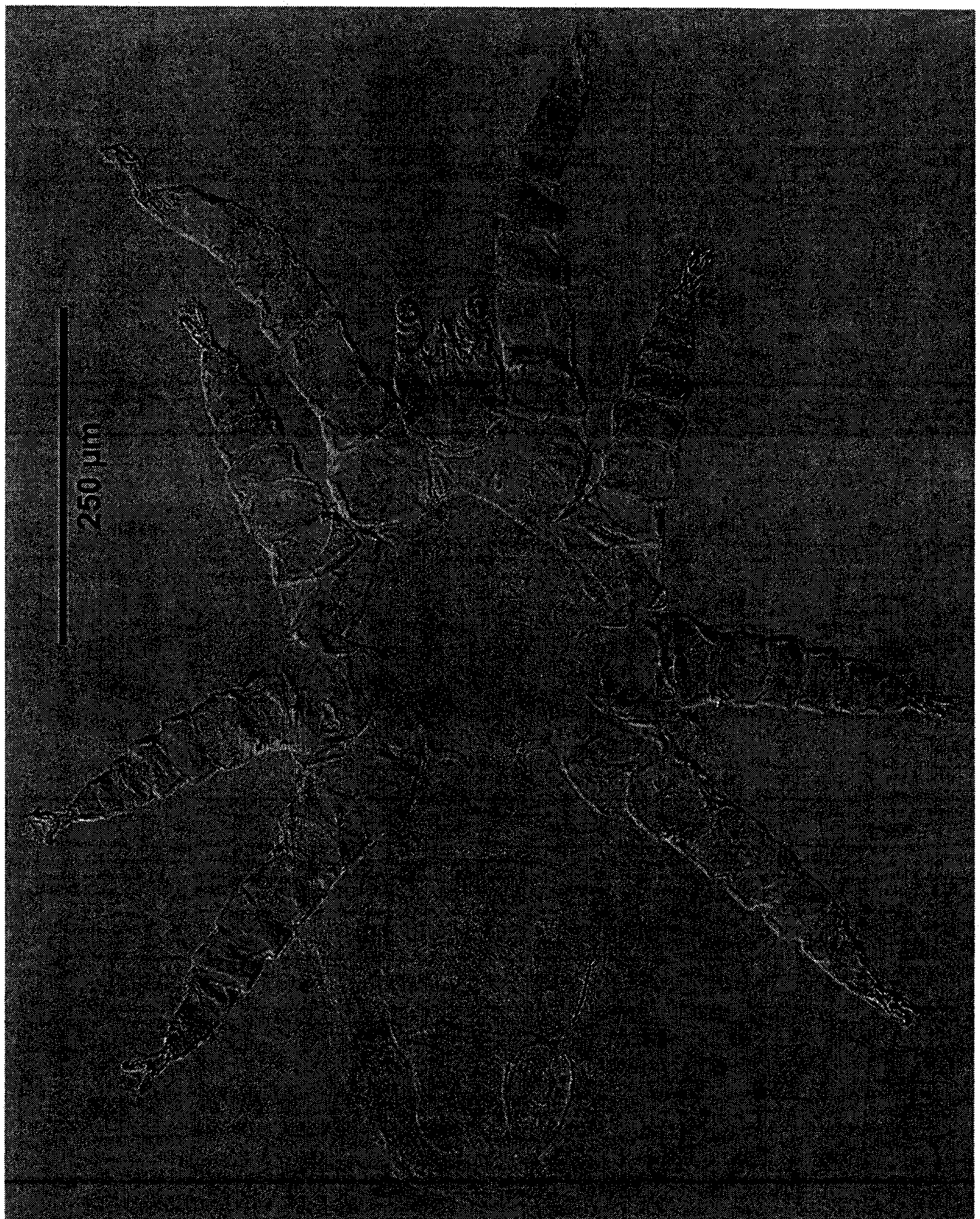


Figure 4.103. *Ptilonyssus pirangae* dorsal habitus.

North American host records:
Emberizidae:
Piranga ludoviciana present study
Piranga rubra Pence (1972; 1975)

Paridae:
Parus bicolor Pence (1972; 1975)

Diagnostic characteristics:
- three dorsal shields
- posterior margin of podosomal shield is straight
- opisthosomal shield is longer than wide, but not twice as long as wide
- lateral excavation of the posterior portion of the opisthosomal shield
- posterior margin of opisthosomal shield is invaginated forming an inverted V indent
- anterior margin of opisthosomal shield is straight
- st1 st2 and st3 on the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- five pairs of ventral opisthosomal setae
- four pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are less than half the length of the longest mesolateral setae
- paranal setae anterior to anal opening, paranal and postanal setae are equal or almost equal in length

References:
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. 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 Texas Tech University **8**: 1-148.

***Ptilonyssus carduelis* Fain, 1962**

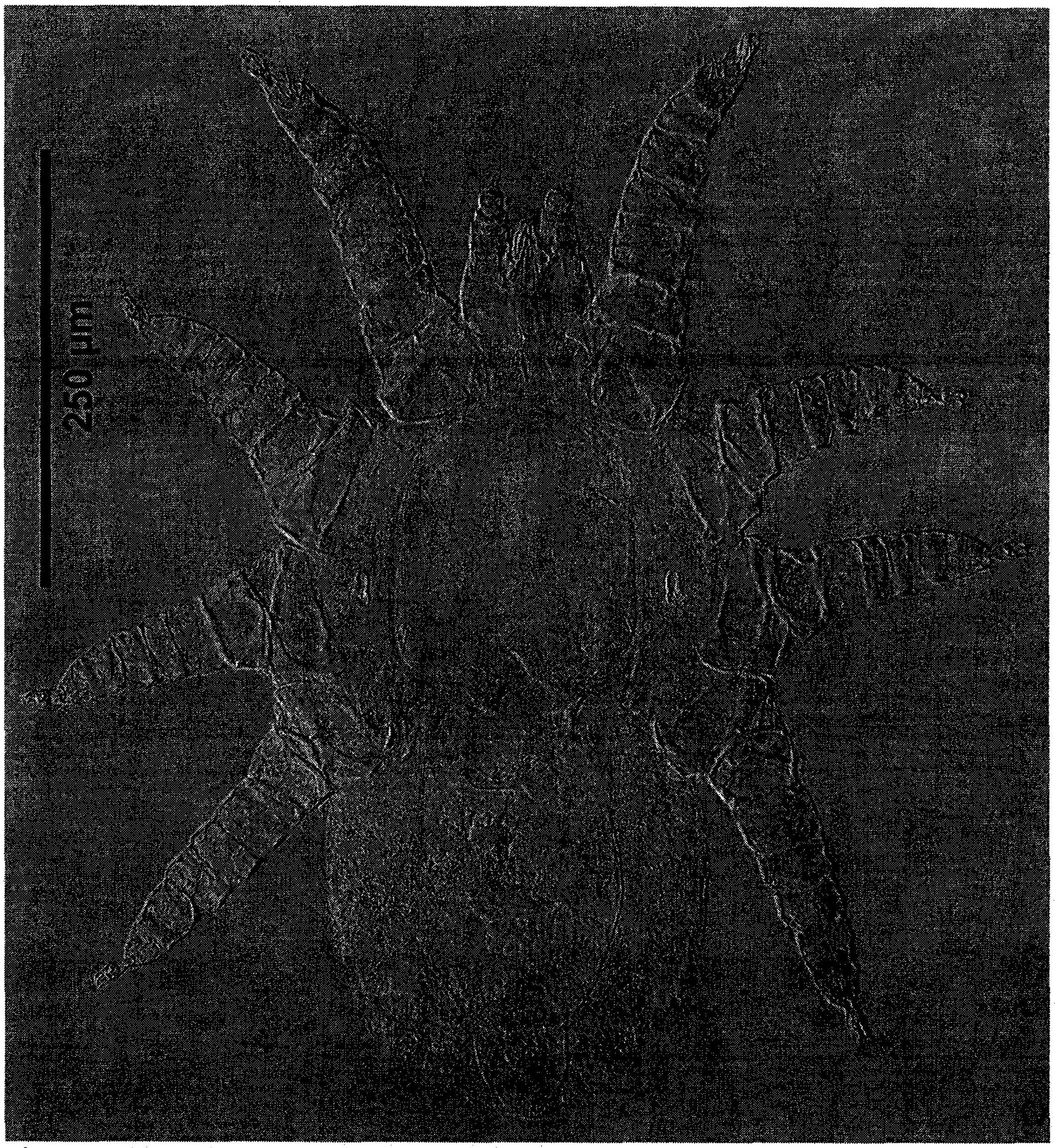


Figure 4.104. *Ptilonyssus carduelis* dorsal habitus.

North American host records:
Fringillidae:
Carduelis flammea Wilson and Haas (1980), present study
Loxia leucoptera present study

Diagnostic characteristics:
- three dorsal shields
- posterior margin of podosomal shield is trilobed

- opisthosomal shield is longer than wide, but not twice as long as wide
- opisthosomal shield without lateral excavation
- posterior margin of opisthosomal shield is rounded, occasionally it is invaginated forming an inverted V indent
- anterior margin of opisthosomal shield is medially straight with anterolateral projections
- st1 st2 and st3 on the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- five pairs of ventral opisthosomal setae
- four pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are as long or almost as long as the longest mesolateral setae
- paranal setae level with anal opening, paranal and postanal setae are almost equal in length

Refereneces:

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

***Ptilonyssus pinicola* sp. n.**

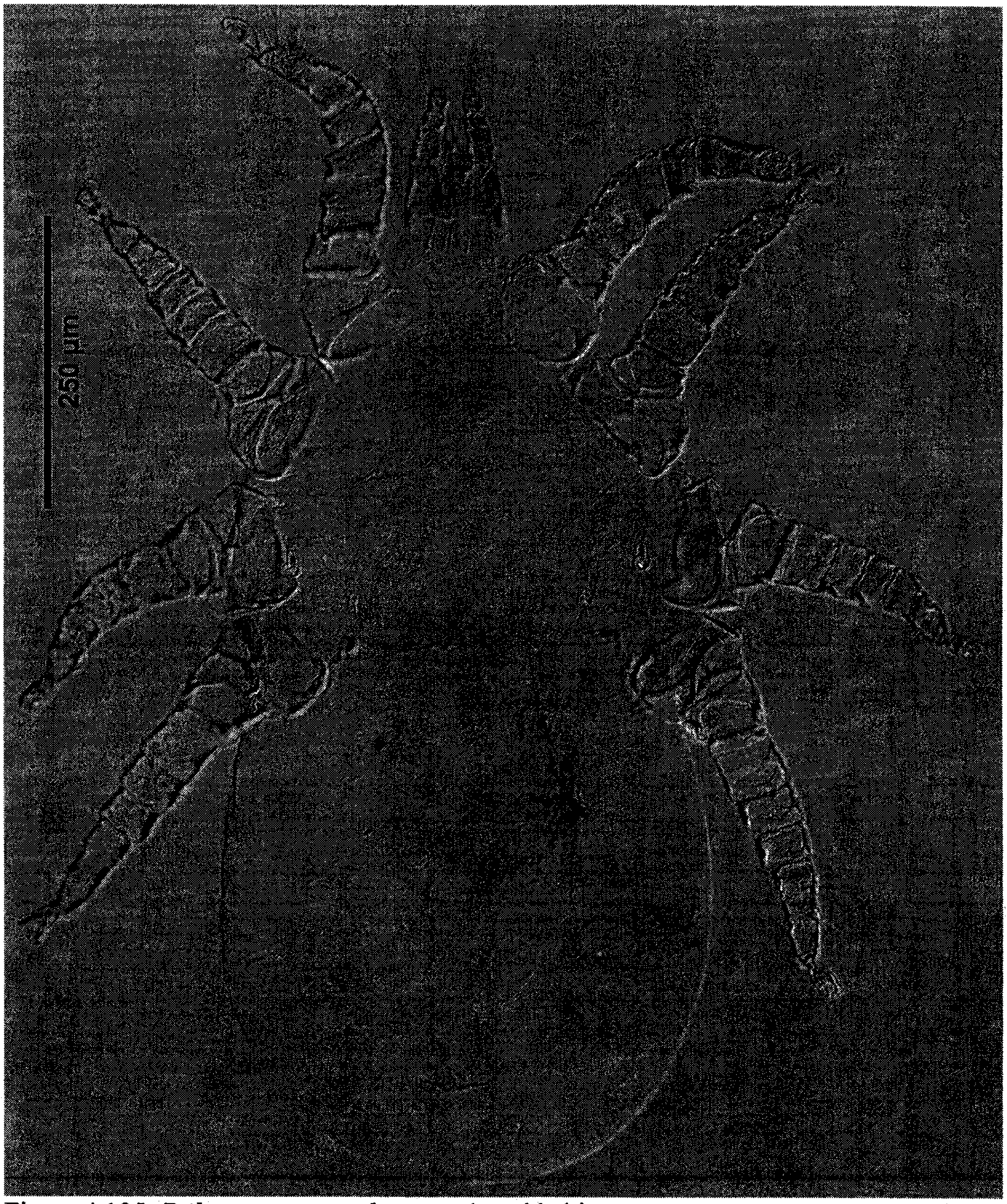


Figure 4.105. *Ptilonyssus pinicola* sp. n. dorsal habitus.

North American host records:
Fringillidae:
Pinicola enucleator present study

Diagnostic characteristics:
- three dorsal shields
- posterior margin of podosomal shield is trilobed
- opisthosomal shield is longer than wide, but not twice as long as wide
- opisthosomal shield without lateral excavation
- posterior margin of opisthosomal shield is rounded
- anterior margin of opisthosomal shield is medially straight with anterolateral projections
- st1 st2 and st3 on the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- six pairs of ventral opisthosomal setae
- four pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are longer than mesolateral setae
- paranal setae level with anal opening, paranal and postanal setae are unequal in length

Ptilonyssus perisorei **George, 1961**

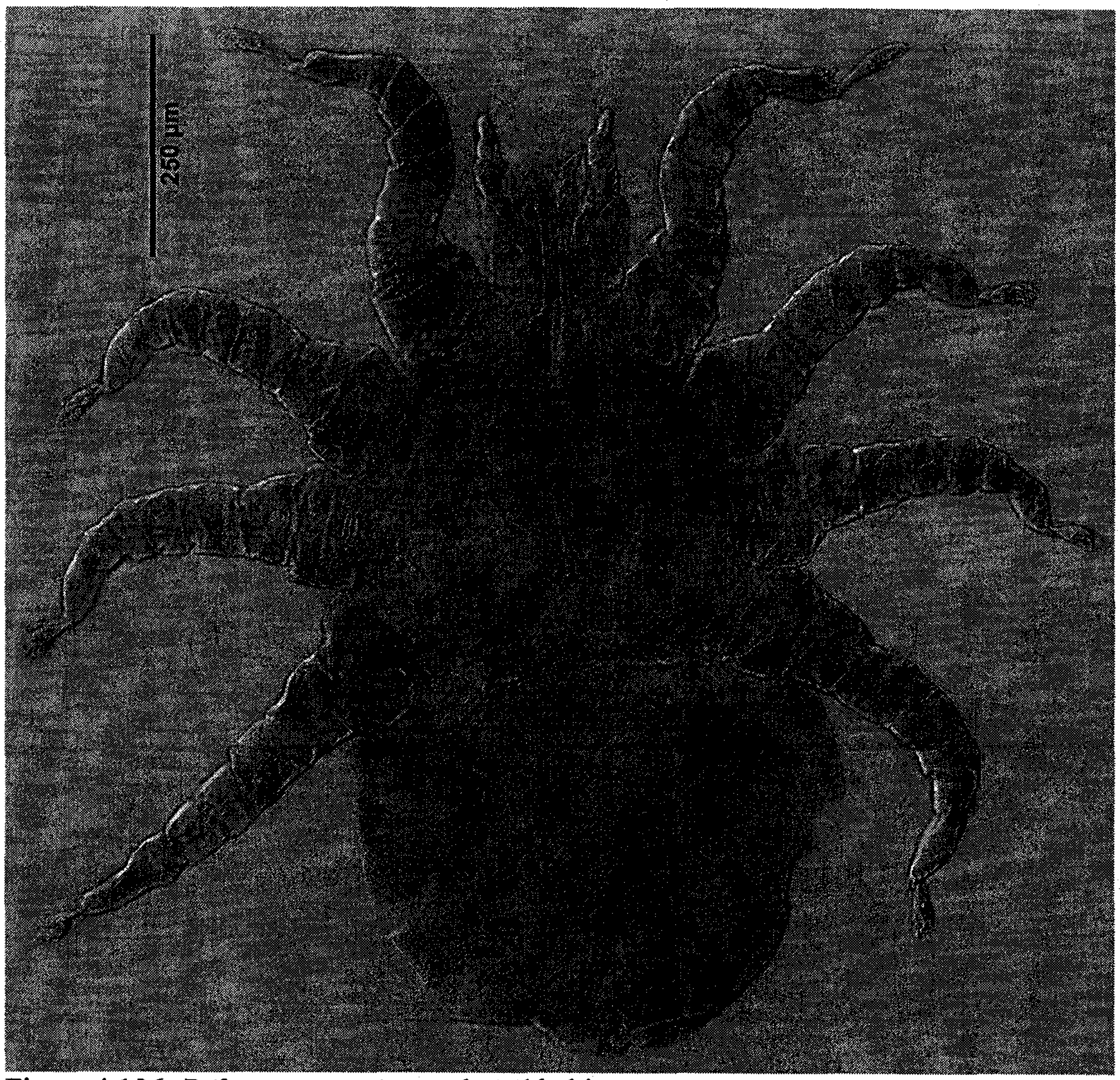


Figure 4.106. *Ptilonyssus perisorei* dorsal habitus.

North American host records:
Corvidae:
Aphelocoma coerulescens Spicer (1978)
Cyanocitta stelleri George (1961), Pence (1975)
Perisoreus canadensis George (1961), Pence (1975), Wilson and Haas (1980), present study

Diagnostic characteristics:
- two dorsal shields
- posterior margin of podosomal shield is trilobed
- either st2 on the sternal shield, with st1 and st3 off, or st1 and st2 on the shield, with st3 off
- subapical ventral setal pair on tarsus IV are relatively long strong spikes with a

rounded terminus
- four pairs of ventral opisthosomal setae
- three pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are as long or almost as long as the longest mesolateral setae
- long seta with frayed tip dorsally on tarsus I apical margin
- paranal setae posterior to anal opening, and postanal seta absent
- pygidial shield is sometimes entire and sometimes in two fragments with subposterior setal pair on the fragments

References:

George, J.E. 1961. The nasal mites of the genus *Ptilonyssus* (Acarina: Rhinonyssidae) occuring on some north american passerifrom birds. Kansas Entomological Society **34**: 105-132.

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 Texas Tech University **8**: 1-148.

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.

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

***Ptilonyssus echinatus* Berlese & Trouessart, 1889**

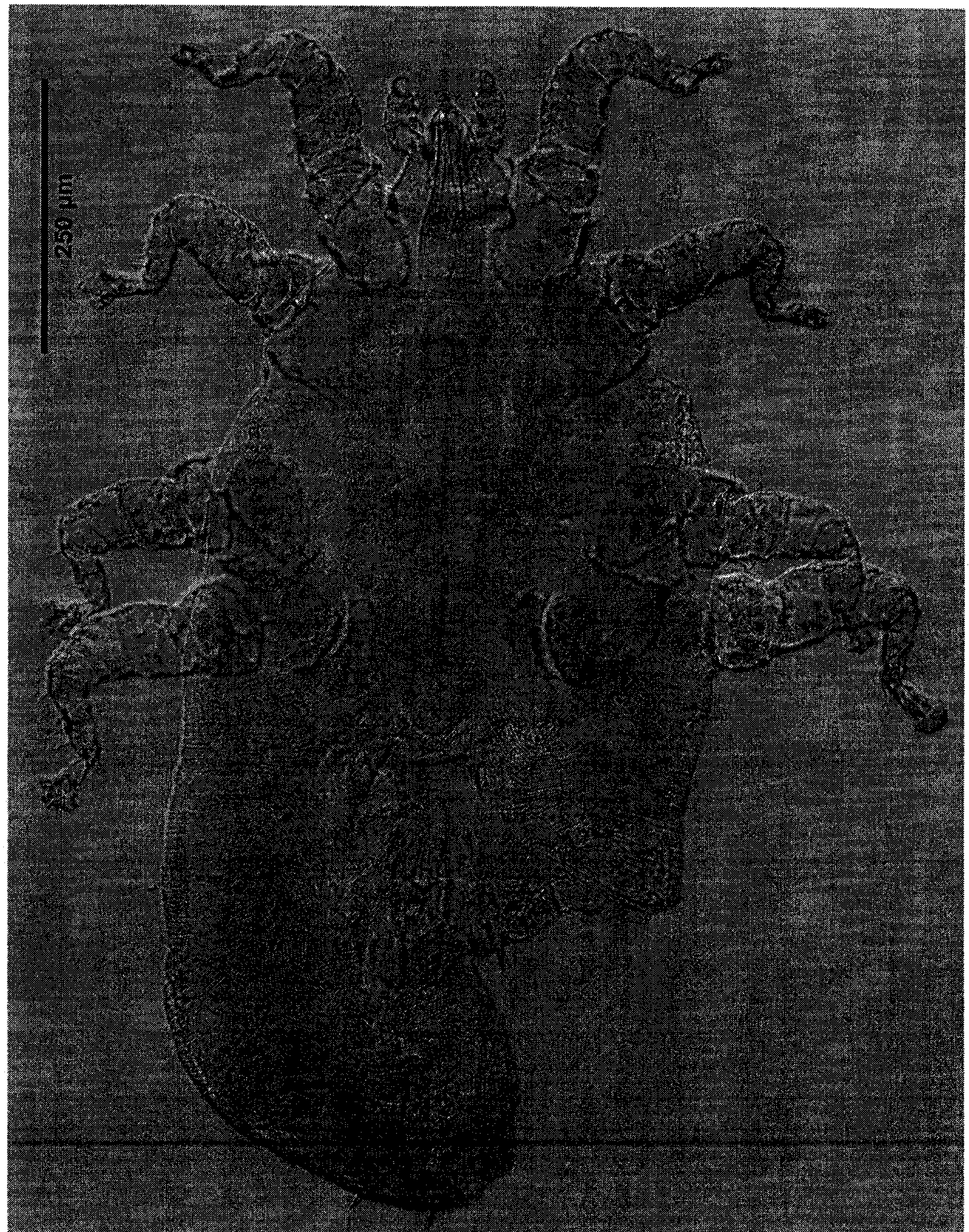


Figure 4.107. *Ptilonyssus echinatus* dorsal habitus.

North American host records:
Hirundinidae:
Hirundo pyrrhonota George (1961), Pence (1975), Spicer (1987)
Hirundo rustica George (1961), Pence (1972; 1975), Spicer (1987), present study
Petrochelidon pyrrhonota present study
Riparia riparia Wilson (1964), Pence (1975)
Tachycineta bicolor Pence (1975), present study

Diagnostic characteristics:
- two dorsal shields
- genital shield arrow-shaped, pointed terminus, 10 times longer than wide
- pygidial shield in two fragments with subposterior setal pair on the fragments
- sternal shield absent
- posterior margin of podosomal shield medially straight with lateral lobes, shield highly reduced
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- seven or more pairs of ventral opisthosomal setae
- six pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are as long or almost as long as the longest mesolateral setae
- paranal setae posterior to anal opening, paranal and postanal setae are equal or almost equal in length

References:
George, J.E. 1961. The nasal mites of the genus *Ptilonyssus* (Acarina: Rhinonyssidae) occuring on some north american passerifrom birds. Kansas Entomological Society **34**: 105-132.
Pence, D.B. 1972. The nasal mites of birds from Louisiana IV. The genus *Ptilonyssus* (Dermanyssidae: Rhinonyssinae) with a description of two new species. Journal of Parasitology **58:** 1162-1169.
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 Texas Tech University **8**: 1-148.
Spicer, G.S. 1987. Prevalence and host-parasite list of some nasal mites from birds (Acarina: Rhinonyssidae, Speleognathidae). Journal of Parasitology **73**: 259-264.
Wilson, N. 1964. New records and descriptions of Rhinonyssidae, mostly from New Guinea (Acarina: Mesostigmata). Pacific Insects **6**: 357-388.

Ptilonyssus cerchneis **Fain, 1957**

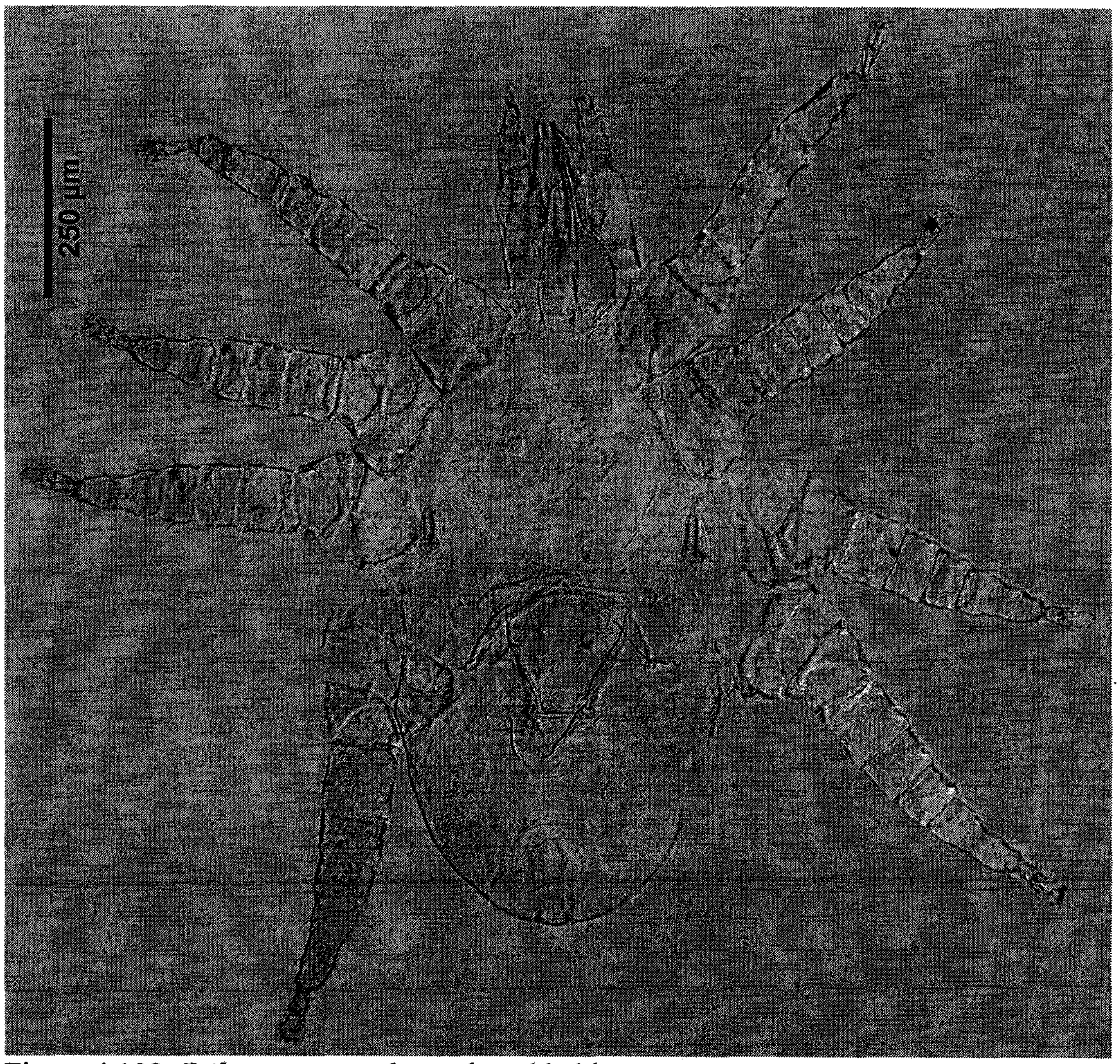


Figure 4.108. *Ptilonyssus cerchneis* dorsal habitus

North American host records:
Falconidae:
Falco sparverius Strandtmann (1962), Pence (1975), present study

Diagnostic characteristics:
- two dorsal shields
- pygidial shield in two fragments without subposterior setal pair on the fragments
- posterior margin of podosomal shield is trilobed
- dorsal opisthosoma with narrow area of thickened cuticle
- serrated deutosternal teeth in a single file
- st1 on with st2 and st3 off the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- six pairs of ventral opisthosomal setae

- three pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are longer than the longest mesolateral setae
- paranal setae posterior to anal opening, postanal seta absent

References:

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 Texas Tech University **8**: 1-148.

Strandtmann, R.W. 1962. A ptilonyssid mite from the sparrow hawk, *Falco sparverius*. Proceedings of the Entomological Society of Washington **64**: 100-102.

Ptilonyssus troglodytis **Fain, 1964**

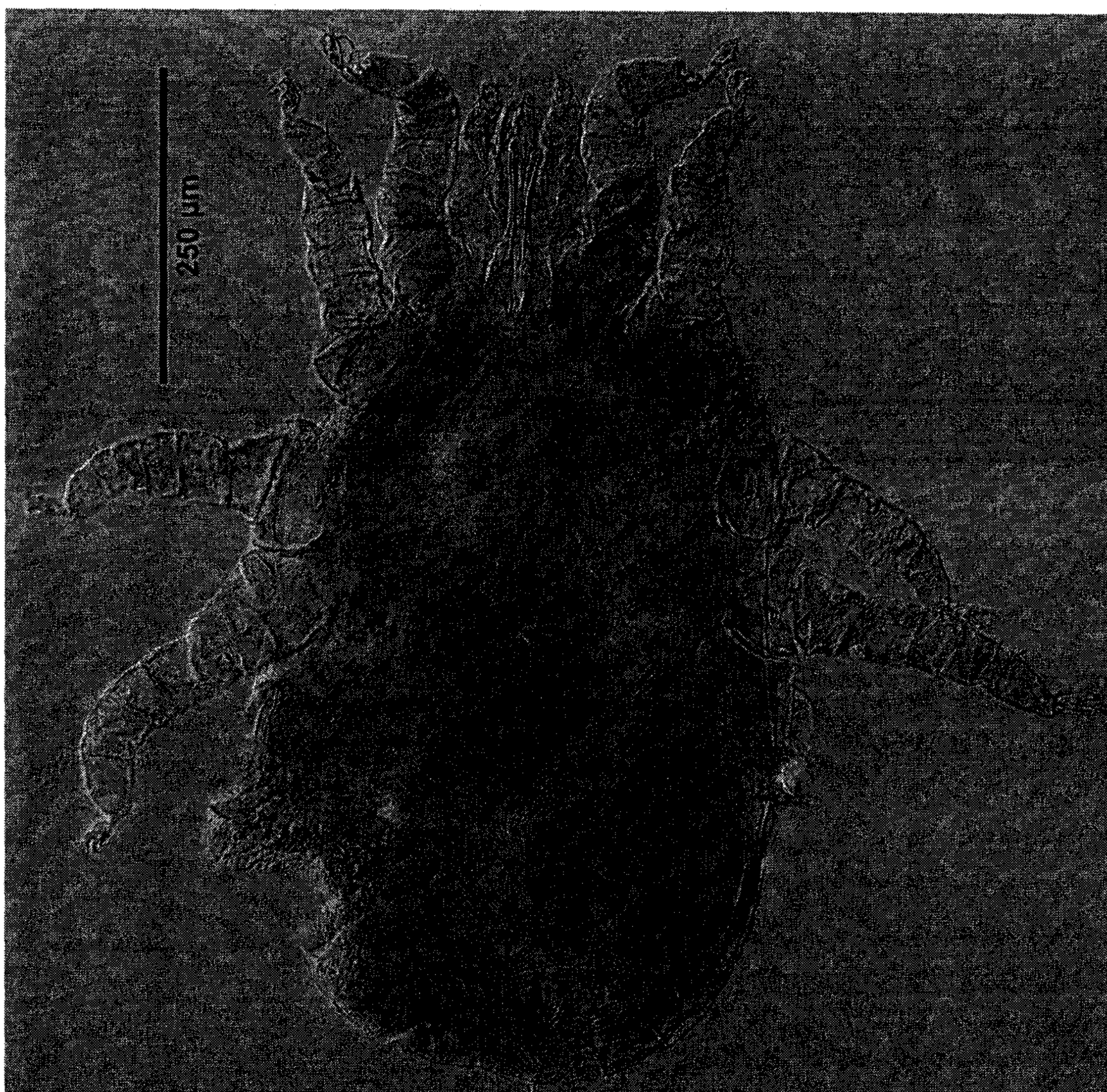


Figure 4.109. *Ptilonyssus troglodytis* dorsal habitus.

North American host records:
Troglodytidae:
Troglodytes troglodytes present study

Diagnostic characteristics:
- two dorsal shields
- pygidial shield in two fragments with subposterior setal pair on the fragments
- posterior margin of podosomal shield medially straight with lateral lobes, shield highly reduced
- st1 on sternal shield, st2 and st3 off shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- six pairs of ventral opisthosomal setae

- six pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are half as long as the longest mesolateral setae
- paranal setae level with anal opening, paranal and postanal setae are equal or almost equal in length

References:

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 Texas Tech University **8**: 1-148.

***Ptilonyssus nudus* Berlese & Trouessart, 1889**

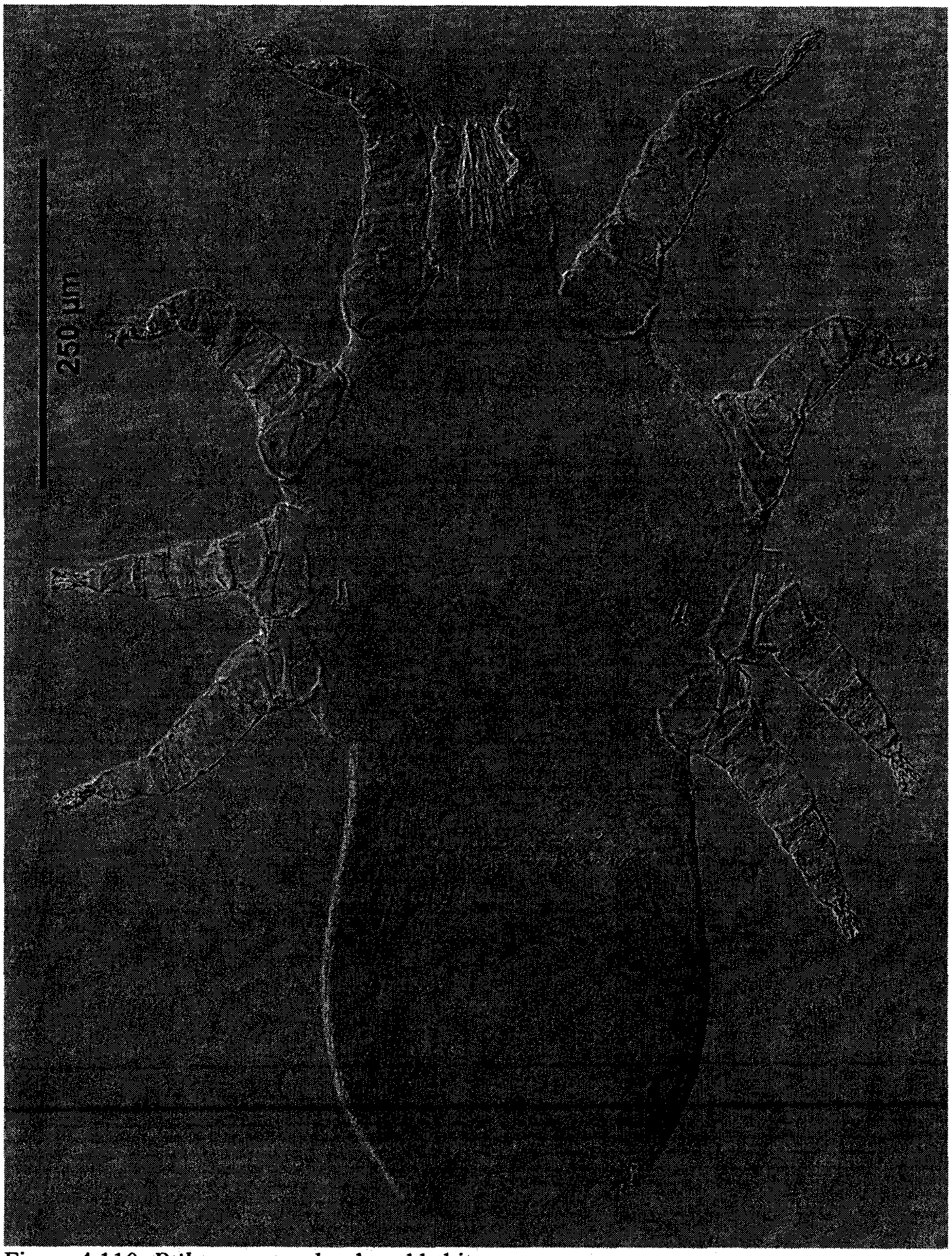


Figure 4.110. *Ptilonyssus nudus* dorsal habitus.

North American host records:
Hirundinidae:
Hirundo rustica Pence (1975)
Riparia riparia Pence (1975)

Paridae:
Parus atricapillus Pence (1975)

Passeridae:
Passer domesticus Porter and Strandtmann (1952), George (1961), Wilson (1964), Pence (1975), present study

Sturnidae:
Sturnus vulgaris Pence (1975)

Diagnostic characteristics:
- two dorsal shields
- posterior margin of podosomal shield is rounded
- st1 st2 and st3 on the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- six pairs of ventral opisthosomal setae
- four pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are less than half the length of the longest mesolateral setae
- anal shield terminates abruptly anterior to the anal opening
- paranal setae posterior to anal opening, paranal and postanal setae are equal or almost equal in length

References:
George, J.E. 1961. The nasal mites of the genus *Ptilonyssus* (Acarina: Rhinonyssidae) occuring on some north american passerifrom birds. Kansas Entomological Society **34**: 105-132.

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 Texas Tech University **8**: 1-148.

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

Wilson, N. 1964. New records and descriptions of Rhinonyssidae, mostly from New Guinea (Acarina: Mesostigmata). Pacific Insects **6**: 357-388.

***Ptilonyssus bombycillae* Fain, 1972**

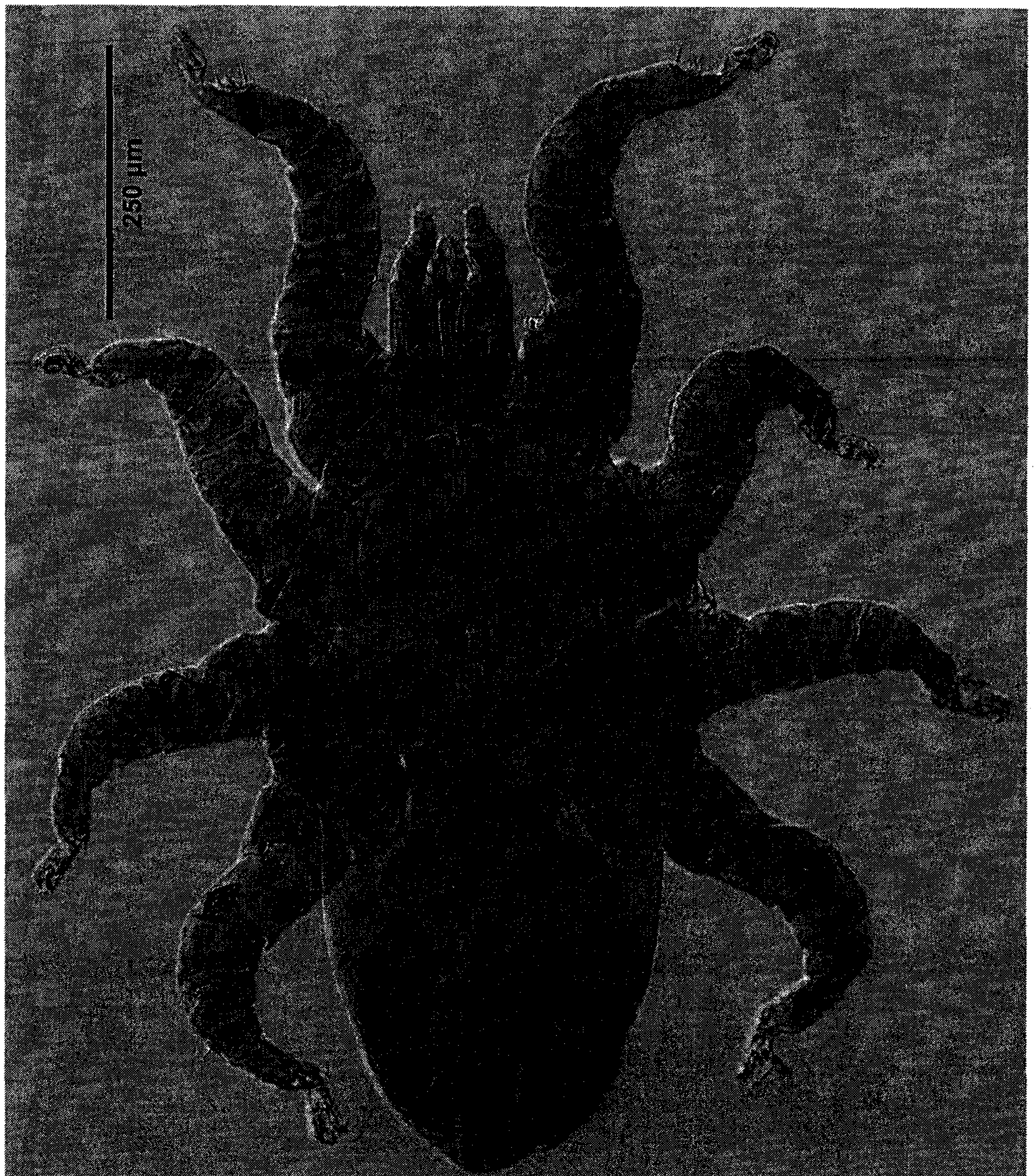


Figure 4.111. *Ptilonyssus bombycillae* dorsal habitus.

North American host records:
Bombycillidae:
Bombycilla cedrorum Pence (1973; 1975), present study
Bombycilla garrulus Spicer (1978), Canadian National Collection of Insects and Arachnids, present study

Diagnostic characteristics:
- two dorsal shields
- posterior margin of podosomal shield is trilobed
- st1 on sternal shield, st2 and st3 off shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- six pairs of ventral opisthosomal setae
- five pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are as long or almost as long as the longest mesolateral setae
- paranal setae posterior to anal opening, paranal and postanal setae are equal or almost equal in length

References:

Pence, D.B. 1973. The nasal mites of birds from Louisiana. VI. New and additional records of Dermanyssids (Rhinonyssinae) with description of a new species. Journal of Parasitology **59**: 359-362.

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 Texas Tech University **8**: 1-148.

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.

***Ptilonyssus calvaria* sp. n.**

Figure 4.112. *Ptilonyssus calvaria* sp. n. dorsal habitus.

North American host records:
Emberizidae:
Spizella passerina present study

Diagnostic characteristics:
- two dorsal shields
- posterior margin of podosomal shield is trilobed
- st1 on with st2 and st3 off the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- six pairs of ventral opisthosomal setae
- five pairs of mesolateral setae
- mesolateral setae all approximately equal in length, there are not two pairs of setae that are twice as long as another setal pair
- subposterior pair of dorsal podosomal setae are half as long as the longest mesolateral setae
- cribrum does not extend to posterior end of anal shield
- paranal setae level with anal opening, paranal and postanal setae are unequal in length

Ptilonyssus euroturdi Fain & Hyland, 1963

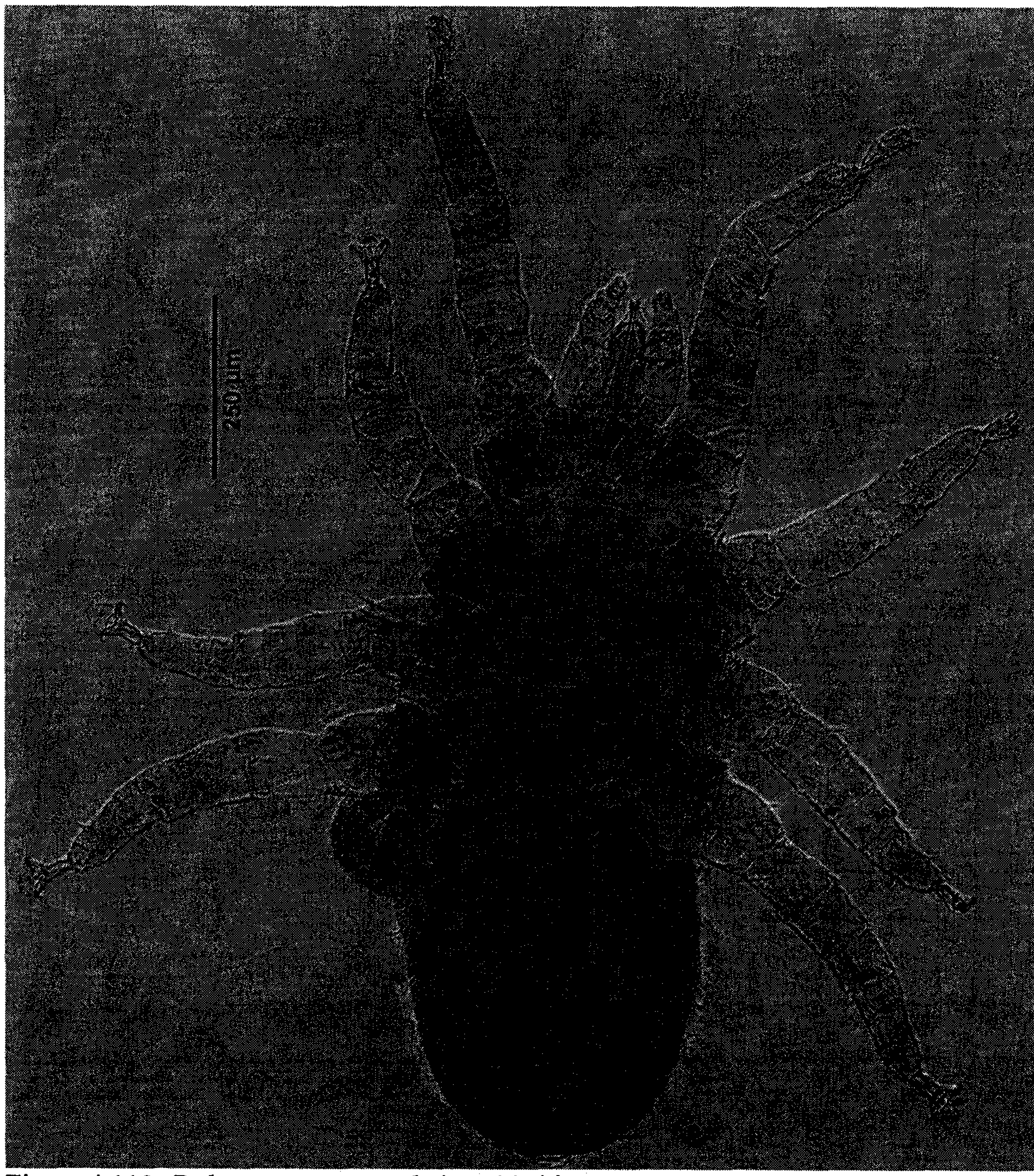


Figure 4.113. *Ptilonyssus euroturdi* dorsal habitus.

North American host records:
Mimidae:
Dumetella carolinensis Pence (1972; 1975), present study

Turdidae:
Turdus migratorius Spicer (1987)
Catharus mustelinus Pence (1972; 1975)

Diagnostic characteristics:
- two dorsal shields
- posterior margin of podosomal shield is medially straight with lateral lobes
- st1 on with st2 and st3 off the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- six pairs of ventral opisthosomal setae
- six pairs of mesolateral setae
- at least two pairs of mesolateral setae twice as long as other mesolateral setae
- subposterior pair of dorsal podosomal setae are as long or almost as long as the longest mesolateral setae
- paranal setae level with anal opening, paranal and postanal setae are unequal in length

References:

Pence, D.B. 1972. The nasal mites of birds from Louisiana IV. The genus *Ptilonyssus* (Dermanyssidae: Rhinonyssinae) with a description of two new species. Journal of Parasitology **58:** 1162-1169.

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 Texas Tech University **8**: 1-148.

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

Ptilonyssus acrocephali **Fain, 1964**

Figure 4.114. *Ptilonyssus acrocephali* dorsal habitus.

North American host records:
Regulidae:
Regulus calendula Pence (1972; 1975), Spicer (1987), present study

Diagnostic characteristics:
- two dorsal shields
- posterior margin of podosomal shield medially straight with lateral lobes, shield highly reduced

- st1 on sternal shield, st2 and st3 off shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- six pairs of ventral opisthosomal setae
- five pairs of mesolateral setae
- at least two pairs of mesolateral setae twice as long as other mesolateral setae
- subposterior pair of dorsal podosomal setae are as long or almost as long as the longest mesolateral setae
- paranal setae level with anal opening, paranal and postanal setae are equal or almost equal in length

References:

Pence, D.B. 1972. The nasal mites of birds from Louisiana IV. The genus *Ptilonyssus* (Dermanyssidae: Rhinonyssinae) with a description of two new species. Journal of Parasitology **58**: 1162-1169.

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 Texas Tech University **8**: 1-148.

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

***Ptilonyssus japuibensis* Castro, 1948**

Figure 4.115. *Ptilonyssus japuibensis* dorsal habitus.

North American host records:
Emberizidae:
Amphispiza bilineata Pence (1975)
Calamospiza melanocorys Pence (1975)
Chondestes grammacus Pence (1975)
Melospiza georgiana Pence (1972; 1975)
Melospiza lincolnii Pence (1975)
Passerculus sandwichensis Pence (1975)
Passerina cyanea Pence (1975)
Pipilo erythrophthalmus Pence (1972; 1973; 1975)
Pipilo fuscus Pence (1975)
Pooecetes gramineus Pence (1975)
Spizella pusilla Pence (1972; 1975)
Spizella passerina Pence (1975)
Zonotrichia albicollis Pence (1972; 1975)

Parulidae:
Dendroica auduboni George (1961)
Dendroica coronata George (1961)
Dendroica pinus George (1961)
Mniotilta varia George (1961)
Oporornis tolmiei George (1961)
Wilsonia citrina George (1961)
Wilsonia pusilla George (1961)

Tyrannidae:
Empidonax alnorum Hyland and Moorhouse (1970)

Diagnostic characteristics:
- two dorsal shields
- posterior margin of podosomal shield is trilobed
- st1 st2 and st3 off the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- six pairs of ventral opisthosomal setae
- four pairs of mesolateral setae
- at least two pairs of mesolateral setae twice as long as other mesolateral setae
- subposterior pair of dorsal podosomal setae are less than half the length of the longest mesolateral setae
- paranal setae level with anal opening, paranal and postanal setae are equal or almost equal in length

Note:
- *Ptilonyssus japuibensis* and *P. sairae* are members of the "*sairae*" species complex. The species boundaries between the members of the "*sairae*" complex are very indistinct.

References:

George, J.E. 1961. The nasal mites of the genus *Ptilonyssus* (Acarina: Rhinonyssidae) occurring on some north american passerifrom birds. Kansas Entomological Society **34**: 105-132.

Hyland, K.E., and A. Moorhouse. 1970. Nasal mites from Mexican birds. I. Rhinonyssidae (Mesostigmata) from the host family Tyrannidae. Acarologia **12**: 43-58.

Pence, D.B. 1972. The nasal mites of birds from Louisiana IV. The genus *Ptilonyssus* (Dermanyssidae: Rhinonyssinae) with a description of two new species. Journal of Parasitology **58**: 1162-1169.

Pence, D.B. 1973. The nasal mites of birds from Louisiana. VIII. Additional records and description of a new species (Acarina: Dermanyssidae, Ereynetidae, Epidermoptidae, and Cytoditidae). Journal of Parasitology **59**: 874-880.

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 Texas Tech University **8**: 1-148.

***Ptilonyssus sairae* Castro, 1948**

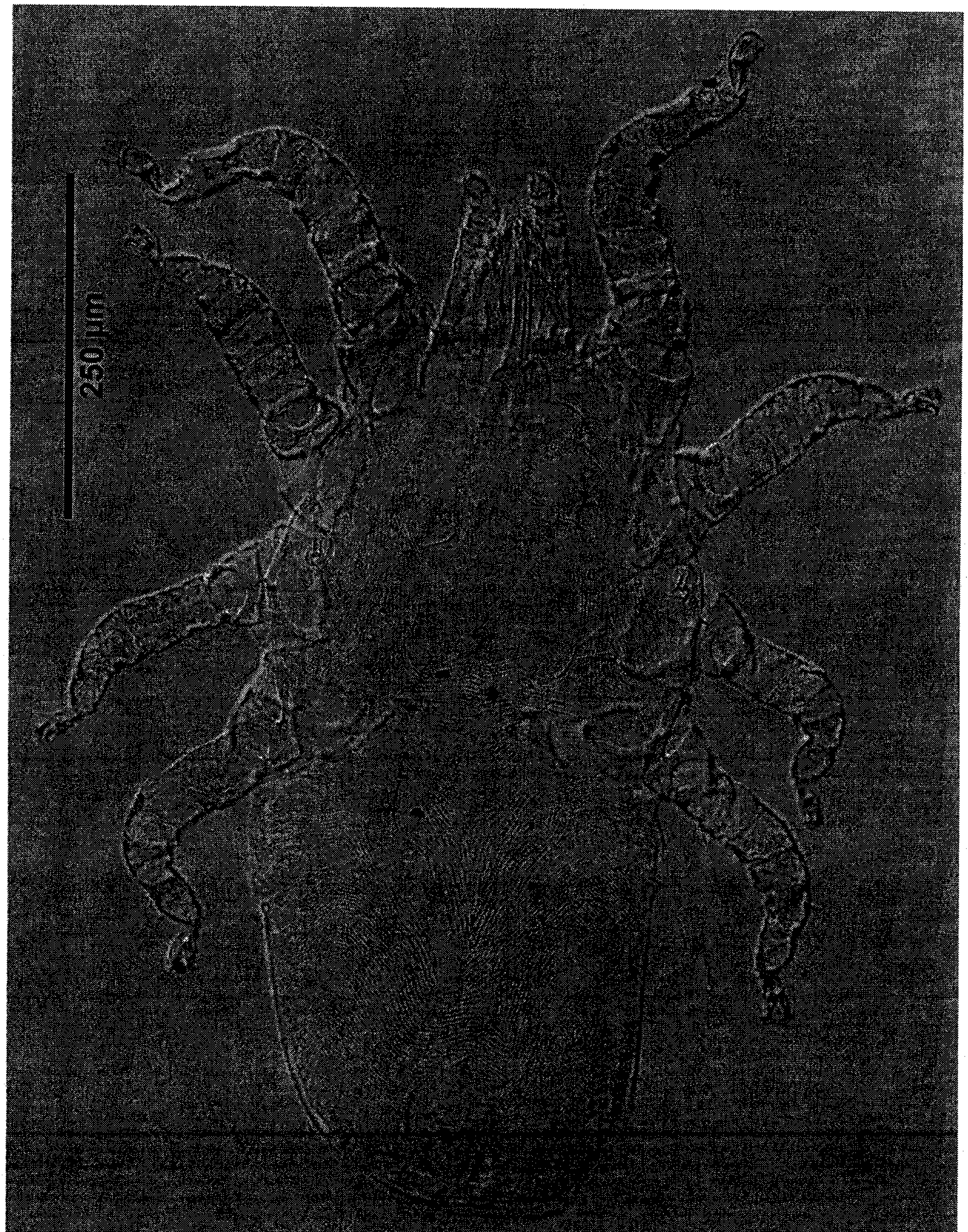


Figure 4.116. *Ptilonyssus sairae* dorsal habitus.

North American host records:
Emberizidae:
Aimophila ruficeps Spicer (1977a; 1987)
Ammodramus savannarum Spicer (1977a; 1987)
Amphispiza bilineata George (1961), Pence and Casto (1976)
Calamospiza melanocorys George (1961)
Chondestes grammacus George (1961), Spicer (1987)
Dendroica coronata Spicer (1987)
Dendroica erithachorides Spicer (1987)
Guiraca caerulea Spicer (1978)
Junco hyemalis Spicer (1978; 1987)
Melospiza lincolnii George (1961)
Melospiza melodia Spicer (1987)
Molothrus ater Spicer (1987)
Passerculus sandwichensis George (1961), Spicer (1987)
Passerina ciris Spicer (1977a; 1987)
Passerina cyanea George (1961)
Pheucticus melanocephalus Pence and Casto (1976)
Pipilo chlorura Spicer (1978)
Pipilo erythrophthalmus George (1961)
Pipilo fuscus George (1961), Pence and Casto (1976)
Piranga rubra Pence (1975), Pence and Casto (1976)
Pooecetes gramineus George (1961), Pence (1975), Spicer (1987)
Spizella passerina George (1961), Spicer (1987)
Spizella pusilla Spicer (1987)
Vermivora celata Spicer (1987)
Vermivora ruficapilla Spicer (1987)
Wilsonia pusilla Spicer (1987)
Zonotrichia querula Spicer (1977a; 1987)

Fringillidae:
Carduelis tristis Spicer (1977a; 1987)

Icteridae:
Dolichonyx oryzivorus Pence (1975), Pence and Casto (1976)
Euphagus cyanocephalus Spicer (1978)

Muscicapidae:
Polioptila albiloris Spicer (1987)

Paridae:
Parus carolinensis Pence (1972; 1975)

Parulidae:
Dendroica auduboni Pence (1975)
Dendroica caerulescens Pence and Casto (1976)

Dendroica cerulea Pence and Casto (1976)
Dendroica coronata Pence (1972; 1975), Wilson and Haas (1980)
Dendroica magnolia Pence (1972; 1975)
Dendroica petechia Spicer (1977b)
Dendroica pinus Pence (1972; 1973; 1975)
Dendroica striata Pence and Casto (1976)
Dendroica tigrina Pence and Casto (1976)
Geothlypis trichas Pence and Casto (1976), present study
Limnothlypis swainsonii Pence and Casto (1976)
Mniotilta varia Pence (1972; 1975), present study
Oporornis tolmiei Pence (1975)
Parula americana Pence (1972; 1975), Pence and Casto (1976)
Prothonotaria citrea Pence (1972; 1975)
Seiurus aurocapillus Pence and Casto (1976)
Setophaga ruticilla Pence (1972; 1975)
Vermivora celata Spicer (1977a)
Vermivora ruficapilla Spicer (1977a)
Wilsonia citrina Pence (1975)
Wilsonia pusilla Pence (1975)

Polioptilidae:
Polioptila albiloris Spicer (1977b)

Tyrannidae:
Empidonax flaviventris Pence (1972; 1975)

Diagnostic characteristics:
- two dorsal shields
- posterior margin of podosomal shield is straight
- st1 st2 and st3 off the sternal shield
- subapical ventral setal pair on tarsus IV are relatively long strong spikes
- six pairs of ventral opisthosomal setae
- five pairs of mesolateral setae
- at least two pairs of mesolateral setae twice as long as other mesolateral setae
- subposterior pair of dorsal podosomal setae are less than half the length of the longest mesolateral setae
- paranal setae level with anal opening, paranal and postanal setae are equal or almost equal in length

Note:
- *Ptilonyssus sairae* and *P. japuibensis* are members of the "*sairae*" species complex. The species boundaries between the members of the "*sairae*" complex are very indistinct.

References:

George, J.E. 1961. The nasal mites of the genus *Ptilonyssus* (Acarina: Rhinonyssidae) occuring on some north american passerifrom birds. Kansas Entomological Society **34**: 105-132.

Pence, D.B. 1972. The nasal mites of birds from Louisiana IV. The genus *Ptilonyssus* (Dermanyssidae: Rhinonyssinae) with a description of two new species. Journal of Parasitology **58**: 1162-1169.

Pence, D.B. 1973. The nasal mites of birds from Louisiana. VIII. Additional records and descritpion of a new species (Acarina: Dermanyssidae, Ereynetidae, Epidermoptidae, and Cytoditidae). Journal of Parasitology **59**: 874-880.

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 Texas Tech University **8**: 1-148.

Pence, D.B., and S.D. Casto. 1976. 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.

Spicer, G.S. 1977a. Two new nasal mites of the genus *Ptilonyssus* (Mesostigmata: Rhinonyssidae) from Texas. Acarologia **18**: 594-601.

Spicer, G.S. 1977b. New host records from avian nasal mites (Acarina: Rhinonyssinae, Speleognathinae). Journal of Medical Entomology **14**: 498.

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

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

Appendix 4.1. Character state matrix for Rhinonyssidae genera.

Character	Character state	*Ptilonyssus*	*Rallinyssus*	*Rhinoecius*	*Rhinonyssus*	*Sternostoma*	*Tinaminyssus*
posterior adhesive disk	present	0	1	0	0	0	0
	absent	1	0	1	1	1	1
cheliceral shaft and digits	chelicerae distally attenuated, digits minute	1	0	0	0	1	0
	chelicerae approximately uniform diameter, digits robust	0	1	1	1	0	1
number of cheliceral digits	two	1	1	0	1	1	1
	one	0	0	1	0	0	0
peritreme	present	1	1	1	0	0	1
	absent	0	0	0	1	1	0
stigmata placement	mesolaterally	1	0	1	1	1	1
	posterolaterally	0	1	0	0	0	0
host order and family	Passeriformes	1	0	0	0	1	0
	Gruiformes Rallidae	0	1	0	0	0	0
	Strigiformes Strigidae	0	0	1	0	0	0
	Anseriformes Anatidae	0	0	0	1	0	0
	Piciformes Picidae	0	0	0	0	1	0
	Columbiformes Columbidae	0	0	0	0	0	1
	Charadriiformes Scolopacidae	0	0	0	1	1	0
	Falconiformes Falconidae	1	0	0	0	0	0

Appendix 4.2. Character state matrix for *Ptilonyssus* species (na = character state does not apply; r. = character state is rare).

Character	Character state	*P. acrocephali*	*P. angrensis*	*P. bombycillae*	*P. callinectoides*	*P. calvaria sp. n.*	*P. carduelis*	*P. cerchneis*	*P. coccothraustis*	*P. echinatus*	*P. euroturdi*	*P. hirsti*	*P. icteridius*
number of dorsal shields, excluding mesosomal shieldlets	one (podosomal)	0	1	0	0	0	0	0	0	0	0	0	0
	two (podosomal and pygidial)	1	0	1	0	1	0	1	0	1	1	0	0
	three (podosomal, opisthosomal and pygidial, (pygidial and opisthosomal are fused))	0	0	0	1	0	1	0	1	0	0	1	1
podosomal shield posterior margin	trilobed	0	0	1	0	1	1	1	0	0	0	0	0
	straight	0	0	0	0	0	0	0	1	0	0	1	1
	lateral lobes present, medially straight	1	0	0	0	0	0	0	0	1	1	0	0
	medial lobe present, without lateral lobes	0	1	0	0	0	0	0	r.	0	0	0	r.
	rounded (convex)	0	0	0	1	0	0	0	0	0	0	0	0
podosomal shield	lateral winglike processes present	0	0	0	1	0	0	0	0	0	0	0	0
	without lateral winglike processes	1	1	1	0	1	1	1	1	1	1	1	1
subposterior setal pair on dorsal podosoma	off posterior margin of podosomal shield	0	0	1	0	1	0	1	0	1	1	0	0
	on posterior margin of podosomal shield	1	1	0	1	0	1	0	1	0	0	1	1
dorsal podosoma subposterior setal pair length	as long or almost as long as longest mesolateral setae	1	1	1	1	0	1	0	1	1	1	1	1
	half as long or less than half the length of longest mesolateral setae	0	0	0	0	1	0	0	0	0	0	0	0
	longer than mesolateral setae	0	0	0	0	0	0	1	0	0	0	0	0

Appendix 4.2. continued.

Character	Character state	*P. acrocephali*	*P. angrensis*	*P. bombycillae*	*P. callinectoides*	*P. calvaria sp. n.*	*P. carduelis*	*P. cerchneis*	*P. coccothraustis*	*P. echinatus*	*P. euroturdi*	*P. hirsti*	*P. icteridius*
mesolateral setae	3 pairs	0	0	0	0	0	0	1	0	0	0	0	0
	4 pairs	0	0	0	0	0	1	0	1	0	0	1	1
	5 pairs	1	0	1	0	1	0	0	0	0	0	0	0
	6 pairs	0	0	0	0	0	0	0	0	1	1	0	0
	2 pairs	0	1	0	1	0	0	0	0	0	0	0	0
mesolateral setae near podosomal shield	all approximately equal in length, no two pairs of setae are twice as long as mesolateral setae	0	1	1	1	1	1	1	1	1	0	1	1
	at least two pairs twice as long as other mesolateral setae	1	0	0	0	0	0	0	0	0	1	0	0
mesosomal shieldlets	present	1	1	1	1	1	0	0	0	1	1	1	1
	absent	0	0	0	0	0	1	1	1	0	0	0	0
anterior margin of opisthosomal shield	straight	na	na	na	1	na	0	na	0	na	na	1	1
	medially straight with anterolateral projections	na	na	na	0	na	1	na	1	na	na	0	0
	medial lobe present, without lateral lobes	na	na	na	0	na	0	na	0	na	na	0	0
opisthosomal shield length to width	twice as long as wide	na	na	na	1	na	0	na	0	na	na	1	0
	almost as wide as long	na	na	na	0	na	0	na	0	na	na	0	0
	longer than wide, but not twice as long as wide	na	na	na	0	na	1	na	1	na	na	0	1
shape of opisthosomal shield	lateral excavation of the posterior portion	na	na	na	1	na	0	na	0	na	na	0	0
	no lateral excavation	na	na	na	0	na	1	na	1	na	na	1	1
	lateral excavation at median of shield extending posteriorly	na	na	na	0	na	0	na	0	na	na	0	0

Appendix 4.2. continued.

Character	Character state	*P. acrocephali*	*P. angrensis*	*P. bombycillae*	*P. callinectoides*	*P. calvaria sp. n.*	*P. carduelis*	*P. cerchneis*	*P. coccothraustis*	*P. echinatus*	*P. euroturdi*	*P. hirsti*	*P. icteridius*
posterior margin of opisthosomal shield	invaginated forming an inverted V indent	na	na	na	0	na	r.	na	0	na	na	r.	1
	rounded	na	na	na	1	na	1	na	1	na	na	1	r.
pygidial plate	entire	1	na	1	na	1	na	0	na	0	1	na	na
	in two fragments with subposterior setal pair on fragments	0	na	0	na	0	na	0	na	1	0	na	na
	in two fragments with no setae on fragments	0	0	0	0	0	0	1	0	0	0	0	0
peritreme	present	1	0	1	1	1	1	1	1	1	1	1	1
	absent	0	1	0	0	0	0	0	0	0	0	0	0
genital shield	thumb-shaped, rounded terminus	1	1	1	1	1	1	1	1	0	1	1	1
	arrow-shaped, pointed terminus, 10 times longer than wide	0	0	0	0	0	0	0	0	1	0	0	0
sternal shield	present	1	0	1	1	1	1	1	1	0	1	1	1
	absent	0	1	0	0	0	0	0	0	1	0	0	0
sternal shield length to width	wider than long	0	na	0	0	0	0	0	0	na	0	0	0
	longer than wide	1	na	1	1	1	1	1	1	na	1	1	1
sternal setae (st1 st2 st3)	st1-3 on shield	0	0	0	0	0	1	0	1	0	0	0	0
	st1-3 off shield	0	1	0	0	0	0	0	0	1	0	1	1
	st1 on shield, st2 and st3 off shield	1	0	1	0	1	0	1	0	0	1	0	0
	st1 off shield, st2 and st3 on shield	0	0	0	1	0	0	0	0	0	0	0	0
	st2 on shield, st1 and st3 off shield	0	0	0	0	0	0	0	0	0	0	0	0
	st1 and st2 on shield, st3 off shield	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 4.2. continued.

Character	Character state	*P. acrocephali*	*P. angrensis*	*P. bombycillae*	*P. callinectoides*	*P. calvaria sp. n.*	*P. carduelis*	*P. cerchneis*	*P. coccothraustis*	*P. echinatus*	*P. euroturdi*	*P. hirsti*	*P. icteridius*
cribrum	extends to posterior end of anal shield	1	0	1	1	0	1	1	1	1	1	1	1
	does not extend to posterior end of anal shield	0	0	0	0	1	0	0	0	0	0	0	0
	absent or unnoticeable	0	1	0	0	0	0	0	0	0	0	0	0
paranal setae	anterior to anus	0	0	0	0	0	0	0	0	0	0	0	0
	posterior to anus	0	0	1	0	0	0	1	0	1	0	1	0
	level with anus	1	1	0	1	1	1	0	1	0	1	0	1
postanal seta	present	1	1	1	1	1	1	0	1	1	1	1	1
	absent	0	0	0	0	0	0	1	0	0	0	0	0
anal setae shape	constrict proximally near base forming a long filamentous tip	0	0	0	0	0	0	0	0	0	0	0	0
	taper distally, filamentous, spike, or short blunted peg setae	1	1	1	1	1	1	1	1	1	1	1	1
paranal and postanal setae	equal or almost equal length	1	1	1	0	0	1	na	0	1	0	0	1
	unequal length	0	0	0	1	1	0	na	1	0	1	1	0
ventral opisthosomal setae	4 pairs	0	0	0	1	0	0	0	0	0	0	0	0
	5 pairs	0	0	0	0	0	1	0	0	0	0	0	0
	6 pairs	1	0	1	0	1	0	1	1	0	1	1	1
	7 pairs or more	0	1	0	0	0	0	0	0	1	0	0	0
second cheliceral segment shape	prominently inflated proximally with marked constriction distally	1	0	1	0	1	0	1	0	1	1	0	0
	without marked inflation and constriction	0	1	0	1	0	1	0	1	0	0	1	1

Appendix 4.2. continued.

Character	Character state	*P. acrocephali*	*P. angrensis*	*P. bombycillae*	*P. callinectoides*	*P. calvaria sp. n.*	*P. carduelis*	*P. cerchneis*	*P. coccothraustis*	*P. echinatus*	*P. euroturdi*	*P. hirsti*	*P. icteridius*
ventral hypostomal setae	large bulbs or distally inflated bulb setae	0	0	0	0	0	0	0	1	0	0	0	0
	setae are not distally inflated	1	1	1	1	1	1	1	0	1	1	1	1
tarsus IV subapical ventral setal pair	relatively long strong spikes	1	0	1	0	1	1	1	0	1	1	0	0
	long heavyset inflated spikes	0	0	0	0	0	0	0	0	0	0	0	1
	relatively long filamentous spikes, long flexible tip	0	0	0	0	0	0	0	0	0	0	1	0
	relatively short spikes proximally inflated	0	1	0	0	0	0	0	0	0	0	0	0
	relatively long, one strong spike one filamentous spike	0	0	0	0	0	0	0	1	0	0	0	0
	relatively long strong spikes with rounded terminus	0	0	0	1	0	0	0	0	0	0	0	0
	one short filamentous spike and one short partially inflated bulb	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 4.2. continued.

Character	Character state	*P. japuibensis*	*P. morofskyi*	*P. nivalis sp. n.*	*P. nudus*	*P. perisorei*	*P. pinicola sp. n.*	*P. pirangae*	*P. plesiotypicus sp. n.*	*P. sairae*	*P. troglodytis*	*P. tyrannus*	*P. vireonis*
number of dorsal shields, excluding mesosomal shieldlets	one (podosomal)	0	0	0	0	0	0	0	0	0	0	0	0
	two (podosomal and pygidial)	1	0	0	1	1	0	0	0	1	1	0	0
	three (podosomal, opisthosomal and pygidial, (pygidial and opisthosomal are fused))	0	1	1	0	0	1	1	1	0	0	1	1
podosomal shield posterior margin	trilobed	1	0	1	0	1	1	0	1	0	0	0	0
	straight	0	1	0	0	0	0	1	0	1	0	0	0
	lateral lobes present, medially straight	0	0	0	0	0	0	0	0	0	1	0	0
	medial lobe present, without lateral lobes	0	0	0	0	0	0	0	0	0	0	1	1
	rounded (convex)	0	0	0	1	0	0	0	0	0	0	0	0
podosomal shield	lateral winglike processes present	0	0	0	0	0	0	0	0	0	0	0	0
	without lateral winglike processes	1	1	1	1	1	1	1	1	1	1	1	1
subposterior setal pair on dorsal podosoma	off posterior margin of podosomal shield	1	0	0	0	0	0	0	0	1	1	0	0
	on posterior margin of podosomal shield	0	1	1	1	1	1	1	1	0	0	1	1
dorsal podosoma subposterior setal pair length	as long or almost as long as longest mesolateral setae	0	0	0	0	1	0	0	0	0	0	1	1
	half as long or less than half the length of longest mesolateral setae	1	0	1	1	0	0	1	0	1	1	0	0
	longer than mesolateral setae	0	1	0	0	0	1	0	1	0	0	0	0

Appendix 4.2. continued.

Character	Character state	*P. japuibensis*	*P. morofskyi*	*P. nivalis sp. n.*	*P. nudus*	*P. perisorei*	*P. pinicola sp. n.*	*P. pirangae*	*P. plesiotypicus sp. n.*	*P. sairae*	*P. troglodytis*	*P. tyrannus*	*P. vireonis*
mesolateral setae	3 pairs	0	1	1	0	1	0	0	0	0	0	1	1
	4 pairs	1	0	0	1	0	1	1	1	0	0	0	0
	5 pairs	0	0	0	0	0	0	0	0	1	0	0	0
	6 pairs	0	0	0	0	0	0	0	0	0	1	0	0
	2 pairs	0	0	0	0	0	0	0	0	0	0	0	0
mesolateral setae near podosomal shield	all approximately equal in length, no two pairs of setae are twice as long as mesolateral setae	0	1	1	1	1	1	1	1	0	1	1	1
	at least two pairs twice as long as other mesolateral setae	1	0	0	0	0	0	0	0	1	0	0	0
mesosomal shieldlets	present	1	0	1	1	1	0	1	0	1	1	1	1
	absent	0	1	0	0	0	1	0	1	0	0	0	0
anterior margin of opisthosomal shield	straight	na	1	1	na	na	0	1	0	na	na	1	0
	medially straight with anterolateral projections	na	0	0	na	na	1	0	1	na	na	0	0
	medial lobe present, without lateral lobes	na	0	0	na	na	0	0	0	na	na	0	1
opisthosomal shield length to width	twice as long as wide	na	0	0	na	na	0	0	0	na	na	1	0
	almost as wide as long	na	0	0	na	na	0	0	0	na	na	0	1
	longer than wide, but not twice as long as wide	na	1	1	na	na	1	1	1	na	na	0	0

Appendix 4.2. continued.

Character	Character state	P. japuibensis	P. morofskyi	P. nivalis sp. n.	P. nudus	P. perisorei	P. pinicola sp. n.	P. pirangae	P. plesiotypicus sp. n.	P. sairae	P. troglodytis	P. tyrannus	P. vireonis
shape of opisthosomal shield	lateral excavation of the posterior portion	na	1	1	na	na	0	1	0	na	na	1	0
	no lateral excavation	na	0	0	na	na	1	0	1	na	na	0	0
	lateral excavation at median of shield extending posteriorly	na	0	0	na	na	0	0	0	na	na	0	1
posterior margin of opisthosomal shield	invaginated forming an inverted V indent	na	0	1	na	na	0	1	0	na	na	0	0
	rounded	na	1	0	na	na	1	0	1	na	na	1	1
pygidial plate	entire	1	na	na	1	1	na	na	na	1	0	na	na
	in two fragments with subposterior setal pair on fragments	0	na	na	0	1	na	na	na	0	1	na	na
	in two fragments with no setae on fragments	0	0	0	0	0	0	0	0	0	0	0	0
peritreme	present	1	1	1	1	1	1	1	1	1	1	1	0
	absent	0	0	0	0	0	0	0	0	0	0	0	1
genital shield	thumb-shaped, rounded terminus	1	1	1	1	1	1	1	1	1	1	1	1
	arrow-shaped, pointed terminus, 10 times longer than wide	0	0	0	0	0	0	0	0	0	0	0	0
sternal shield	present	1	1	1	1	1	1	1	1	1	1	1	1
	absent	0	0	0	0	0	0	0	0	0	0	0	0
sternal shield length to width	wider than long	0	1	0	0	0	0	0	0	0	0	0	0
	longer than wide	1	0	1	1	1	1	1	1	1	1	1	1

Appendix 4.2. continued.

Character	Character state	*P. japuibensis*	*P. morofskyi*	*P. nivalis sp. n.*	*P. nudus*	*P. perisorei*	*P. pinicola sp. n.*	*P. pirangae*	*P. plesiotypicus sp. n.*	*P. sairae*	*P. troglodytis*	*P. tyrannus*	*P. vireonis*
sternal setae (st1 st2 st3)	st1-3 on shield	0	1	1	1	0	1	1	1	0	0	0	0
	st1-3 off shield	1	0	0	0	0	0	0	0	1	0	1	0
	st1 on shield, st2 and st3 off shield	0	0	0	0	0	0	0	0	0	1	0	1
	st1 off shield, st2 and st3 on shield	0	0	0	0	0	0	0	0	0	0	0	0
	st2 on shield, st1 and st3 off shield	0	0	0	0	1	0	0	0	0	0	0	0
	st1 and st2 on shield, st3 off shield	0	0	0	0	1	0	0	0	0	0	0	0
cribrum	extends to posterior end of anal shield	1	1	1	1	1	1	1	1	1	1	1	1
	does not extend to posterior end of anal shield	0	0	0	0	0	0	0	0	0	0	0	0
	absent or unnoticeable	0	0	0	0	0	0	0	0	0	0	0	0
paranal setae	anterior to anus	0	0	1	0	0	0	1	0	0	0	1	1
	posterior to anus	0	0	0	1	1	0	0	0	0	0	0	0
	level with anus	1	1	0	0	0	1	0	1	1	1	0	0
postanal seta	present	1	1	1	1	0	1	1	1	1	1	1	1
	absent	0	0	0	0	1	0	0	0	0	0	0	0
anal setae shape	constrict proximally near base forming a long filamentous tip	0	0	0	0	0	0	0	1	0	0	0	0
	taper distally, filamentous, spike, or short blunted peg setae	1	1	1	1	1	1	1	0	1	1	1	1
paranal and postanal setae	equal or almost equal length	1	0	0	1	na	0	1	0	1	1	0	0
	unequal length	0	1	1	0	na	1	0	1	0	0	1	1

Appendix 4.2. continued.

Character	Character state	*P. japuibensis*	*P. morofskyi*	*P. nivalis sp. n.*	*P. nudus*	*P. perisorei*	*P. pinicola sp. n.*	*P. pirangae*	*P. plesiotypicus sp. n.*	*P. sairae*	*P. troglodytis*	*P. tyrannus*	*P. vireonis*
ventral opisthosomal setae	4 pairs	0	1	0	0	1	0	0	0	0	0	1	0
	5 pairs	0	0	0	0	0	0	1	0	0	0	0	0
	6 pairs	1	0	1	1	0	1	0	0	1	1	0	1
	7 pairs or more	0	0	0	0	0	0	0	1	0	0	0	0
second cheliceral segment shape	prominently inflated proximally with marked constriction distally	1	0	0	1	1	0	0	0	1	1	0	0
	without marked inflation and constriction	0	1	1	0	0	1	1	1	0	0	1	1
ventral hypostomal setae	large bulbs or distally inflated bulb setae	0	0	0	0	0	0	0	1	0	0	0	0
	setae are not distally inflated	1	1	1	1	1	1	1	0	1	1	1	1
tarsus IV subapical ventral setal pair	relatively long strong spikes	1	0	0	1	0	1	1	1	1	1	0	0
	long heavyset inflated spikes	0	0	0	0	0	0	0	0	0	0	0	1
	relatively long filamentous spikes, long flexible tip	0	0	0	0	0	0	0	0	0	0	0	0
	relatively short spikes proximally inflated	0	0	0	0	0	0	0	0	0	0	0	0
	relatively long, one strong spike one filamentous spike	0	0	1	0	0	0	0	0	0	0	0	0
	relatively long strong spikes with rounded terminus	0	0	0	0	1	0	0	0	0	0	1	0
	one short filamentous spike and one short partially inflated bulb	0	1	0	0	0	0	0	0	0	0	0	0

Appendix 4.3. Character state matrix for *Rhinoecius* species (na = character state does not apply).

Character	Character state	*R. aegolii*	*R. alifanovi*	*R. brikinboricus*	*R. cooremani*	*R. grandis*	*R. nycteae*
dorsal podosoma subposterior setal pair	on posterior margin of podosomal shield, very long (at least 70 µm long)	1	0	0	0	0	0
	off posterior margin of podosomal shield, short setae (less than < 70 µm long)	0	0	0	1	0	0
	on posterior margin of podosomal shield, short setae (less than < 70 µm long)	0	1	1	0	1	1
vestigial tritosternum	present	0	0	0	0	0	1
	absent	1	1	1	1	1	0
sternal shield	present	0	1	1	1	1	1
	absent	1	0	0	0	0	0
sternal shield anterior margin	shield extends far beyond st1	na	0	1	na	1	1
	shield does not extend far beyond st1	na	1	0	na	0	0
sternal shield shape	posteromedial projection present	na	0	1	0	1	0
	posterior margin straight	na	1	0	0	0	1
	sternal shield highly reduced	na	0	0	1	0	0
sternal setae st1 st2 st3	st1 st2 st3 not on shield	1	0	0	1	0	0
	st1 and st2 on shield, st3 off shield	0	1	1	0	1	1
paranal setae	anterior to anus	0	1	1	1	1	1
	level with anus	1	0	0	0	0	0
postanal seta	present	0	1	0	0	1	1
	absent	1	0	1	1	0	0
Host species	*Bubo virginianus* (Great Horned Owl)	0	0	0	0	1	0
	Aegolius funereus and *A. acadicus* (Boreal Owl or Northern Saw-whet Owl)	1	0	0	0	0	0
	Asio otus (Long-eared Owl)	0	0	1	0	0	0
	Strix nebulosa (Great Grey Owl)	0	0	0	1	0	0
	Nyctea scandiaca (Snowy Owl)	0	0	0	0	0	1
	Asio flammeus (Short-eared Owl)	0	1	0	0	0	0

Appendix 4.4. Character state matrix for *Rhinonyssus* species.

Character	Character state	*R. coniventris*	*R. rhinolethrum*
podosomal shield erosion	shield complete, without medial erosion	0	1
	medially eroded, often divided medially	1	0
number of ventral opisthosomal setae	5 pairs or less	1	0
	9 pairs or more	0	1

Appendix 4.5. Character state matrix for *Sternostoma* species.

Character	Character states	*S. boydi*	*S. cryptorhynchum*	*S. hylandi*	*S. lanorium*	*S. longisetosae*	*S. loxiae*	*S. porteri*	*S. sialiphilus*	*S. technaui*	*S. tracheacolum*	*S. setifer sp. n.*
number of dorsal shields, excluding mesosomal shieldlets	one (podosomal)	0	0	0	0	0	0	0	0	1	0	0
	two (podosomal and pygidial)	1	1	1	1	1	1	1	1	0	1	1
dorsal opisthosomal setae in integument	2 pairs	0	1	0	1	0	1	0	0	0	1	0
	3 pairs	0	0	1	0	0	0	1	0	0	0	0
	no setae in integument	1	0	0	0	1	0	0	0	0	0	0
	1 pair	0	0	0	0	0	0	0	1	0	0	0
	4 pairs or more	0	0	0	0	0	0	0	0	1	0	1
sternal setae	minute spines	1	1	1	1	1	1	1	1	0	1	1
	large proximally inflated blunt tipped spines	0	0	0	0	0	0	0	0	1	0	0
paranal setae present	posterior to anus	1	0	1	1	0	1	1	1	0	1	1
	level with anus	0	1	0	0	1	0	0	0	1	0	0
postanal seta	present	0	0	1	0	0	0	1	0	0	0	0
	absent	1	1	0	1	1	1	0	1	1	1	1
apical setal pair on palp tarsus	proximally inflated, medially constricted and distally flattened, resembling a T with an inflated base	0	0	0	0	1	0	0	0	0	0	0
	long spines, short spines, or short bulbs, does not resemble a T	1	1	1	1	0	1	1	1	1	1	1

Appendix 4.5. continued.

Character	Character states	*S. boydi*	*S. cryptorhynchum*	*S. hylandi*	*S. lanorium*	*S. longisetosae*	*S. loxiae*	*S. porteri*	*S. sialiphilus*	*S. technaui*	*S. tracheacolum*	*S. setifer sp. n.*
tarsi II - IV subapical ventral and ventrolateral setae	distally inflated asymmetrical setae	0	0	0	0	0	1	0	1	0	0	0
	distally inflated symmetrical setae	0	1	0	0	0	0	0	0	0	0	0
	hook-like short spines	0	0	0	1	0	0	0	0	0	0	0
	relatively long spines	0	0	0	0	1	0	0	0	0	0	1
	relatively short spines, compared to body setae	0	0	0	0	0	0	0	0	1	0	0
	subapical ventral setal pair are short blunt tipped spines	0	0	1	0	0	0	1	0	0	0	0
	minute spines, barely visible	0	0	0	0	0	0	0	0	0	1	0
	subapical ventral setal pair are short flattened setae with rounded tips	1	0	0	0	0	0	0	0	0	0	0
tarsus IV anterodorsal apical seta	long prominently swollen spike with flexible tip	0	0	0	0	0	0	1	0	0	0	0
	not swollen, long hair-like	1	1	1	1	1	1	0	1	1	1	1

Appendix 4.6. Character state matrix for *Tinaminyssus* species.

Character	Character state	*T. columbae*	*T. zenaidurae*	*T. melloi*
opisthosomal shield shape	occupying most of the dorsal opisthosoma, widest posteriorly	0	1	0
	widest anteriorly, posterior portion is less than 1/2 the width of the anterior portion	0	0	1
	widest anteriorly, posterior portion is almost half the width of the anterior portion	1	0	0
poststigmatal platelet	present	0	1	1
	absent	1	0	0
paranal setae	level with anus	0	1	0
	anterior to anus	1	0	1
ventral opisthosomal setae	5 pairs or less	1	0	0
	15 pairs or more	0	1	0
	approx. 10 pairs	0	0	1
leg setae	legs I-IV bear numerous long setae, longer or as long as ventral opithosomal setae	0	0	1
	legs I-IV bear long setae, but most are not as long as ventral opisthosomal setae	0	1	0
	most leg setae on legs I-IV are short setae	1	0	0

Chapter 5

[2]Host Records for the Northern Fowl Mite, *Ornithonyssus sylviarum* (Mesostigmata: Macronyssidae), from Birds of North America (Canada, USA, and Mexico).

Introduction

Birds are host to a broad diversity of symbiotic animals. Mites (Arachnida: Acari) are among the most diverse groups of these associates, with at least 40 families and approximately 3,000 described species known from avian hosts (Proctor and Owens 2000). Some species are highly detrimental parasites such as the nasal mite *Sternostoma tracheacolum* Lawrence, 1948 (Mesostigmata: Rhinonyssidae), while others are relatively benign such as most feather mites (Astigmata: Analgoidea: Pterolichoidea: Freyanoidea) (Proctor and Owens 2000). The northern fowl mite, *Ornithonyssus sylviarum* (Canestrini and Fanzago, 1877) (Mesostigmata: Macronyssidae), is an obligate hematophagous ectoparasite of domestic and wild birds in temperate regions worldwide. *Ornithonyssus sylviarum* spends the majority of its life cycle on the host (Sikes and Chamberlain 1954) but is often associated with nesting material when young birds are in the nest. With a short generation time of 5-7 days, *O. sylviarum* populations can build up rapidly, reaching upwards of 22,000 individuals in a single nest (Sikes and Chamberlain 1954, Masan and Orszaghova 1995). Humans are occasionally attacked by hungry mites when nests associated with man-made structures are abandoned after chicks fledge, and bitten humans may suffer pruritic dermatitis as a result (Orton et al.

[2] A version of this chapter has been published. W. Knee and H. Proctor 2007. Journal of Medical Entomology 44: 709-713.

2000). Heavy infestations in poultry houses can result in large blood losses and reduced egg production in domestic fowl (DeVaney 1979, DeLoach and DeVaney 1981). Currently it is not clear whether these mites can act as vectors for disease agents. Northern fowl mites have been found to harbor and mechanically transmit western equine encephalitis and St. Louis encephalitis viruses (Hammon and Reeves 1948, Mullen and OConnor 2002), but are not considered to be an important reservoir for either virus (Chamberlain and Sikes 1955, Reeves et al. 1955). Hofstad (1949) experimentally infected northern fowl mites with Newcastle virus by allowing them to feed on infected chickens, but the disease could not be transmitted by infected mites to uninfected chickens.

The most recent North American host list for *O. sylviarum* was published nearly 70 years ago (Cameron 1938). While surveying the mites associated with birds of Alberta, I became aware of a need for an updated host list for the northern fowl mite in North America, including the new records from Alberta.

Materials and Methods:

The laboratory of Heather Proctor at the University of Alberta had a collection of approximately 700 bird carcasses from Alberta, largely from the contributions of the Alberta Fish & 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, and for some I can only say that the birds were collected somewhere in Alberta. Bird bodies were maintained at -20°C until processing. Frozen birds were first thawed and then washed using the following method. The bird was placed in a suitably sized container, ranging from 4-18 L, with a drop of dish detergent, enough 95% ethanol to soak the plumage of the bird, and enough water to submerge it. The sealed container was then shaken vigorously for five minutes. 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 filter; 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 filter. The filtrate was stored in 30 mL scintillation and snap cap vials. Washings were examined using Leica MZ16 and MZ6 dissection microscopes at 20-25x magnification. Mites were removed, and cleared in 85% lactic acid for 1-24 hours depending on the degree of original opacity. Mites were mounted in a polyvinyl alcohol medium (PVA) from Bioquip Products Inc. USA (6371A). 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 DIC at 400x magnification, and identified *O. sylviarum* specimens using Baker (1999). Female *O. sylviarum* can be distinguished from female *O. bursa* (Berlese, 1888) by the absence of the Z5 dorsal opisthosomal setal pair in *O. sylviarum*. Although the extent of the sternal shield and placement of the third pair of sternal setae on or off the shield are often presented as diagnostic characters in keys, they are not sufficiently reliable to separate these two species; in fact, I have examined some *O. sylviarum* individuals in which one seta is on the shield and the other is off. *Ornithonyssus sylviarum* protonymphs and males also lack the Z5 setal pair. Male northern fowl mites can also be identified by the presence of a transversal line approximately where the ventral and anal shields meet (Cameron 1938). Literature searches were performed in Zoological Record (1978-2006) and Journal Storage

(JSTOR) (from the earliest records, in the 1800's for some journals, to 2003) databases. I did not confirm the identification for any of the mites recorded in the literature. Host taxonomy and authorities follow Clements (1991) provided by Andrew and McAllan (1998), selecting the 'Clements 1991-1996' taxonomy option in Nomina version 1.0. Voucher specimens have been deposited in the E.H. Strickland Entomological Museum at the University of Alberta (UASM 80530 - 80556).

Results and Discussion:

I examined 444 individual birds, representing 149 species from 16 orders. This sample represents 37% of Alberta's 402 species of birds (based on list from the Royal Alberta Museum 2005). *Ornithonyssus sylviarum* specimens were collected from 34 host individuals representing 4 orders, 11 families, 25 genera, and 26 species (Table 5.1). Sixteen of the 26 host species records from Alberta are new records for North America (Table 5.1). The northern fowl mites were primarily collected from passerines, which represented 18 of the 26 host species records. An average of 3-4 mites per host individual was observed, with the highest number being 20 mites on an American Robin, *Turdus migratorius* Linnaeus, 1766.

The literature search recovered 27 publications with records of northern fowl mites from North American hosts. Including the new host records from Alberta, *O. sylviarum* has been recorded from 9 orders, 26 families, 61 genera, and 72 species of North American birds (Table 5.2). The most novel additions to the list are the observations of northern fowl mites from raptors. One of the two North American strigiform species records, and all three of the falconiform species records were from the present study (Table 5.2). Given that there are several observations of northern fowl mites from raptor species in the Old World (Philips 2000), I feel that further examination of strigiform and falconiform birds in North America will result in more host records. This updated host list will be of use to workers in a broad range of fields such as ornithology, wildlife biology, and acarology.

Literature Cited

Andrew, P., and I. McAllan. 1998. Nomina: Global Bird Dictionary, Relational Taxonomies. CSIRO Publishing, Collingwood, Australia.

Baker, A.S. 1999. Family Macronyssidae *Ornithonyssus sylviarum* (Canestrini & Fanzago). *In* Mites and ticks of domestic animals an identification guide and information source, A.S. Baker (ed.). The Stationary Office, London, UK, p. 147-150.

Boyd, E.M. 1951. A survey of parasitism of the starling *Sturnus vulgaris* L. in North America. Journal of Parasitology **37**. 56-84.

Boyd, E.M., and A.E. Fry. 1971. Metazoan parasites of the eastern belted kingfisher, *Megaceryle alcyon alcyon*. Journal of Parasitology **57**: 150-156.

Boyd, E.M., R.L. Diminno, and C. Nesslinger. 1956. Metazoan parasites of the blue jay, *Cyanocitta cristata* L. Journal of Parasitology **42**: 332-346.

Briskie, J.V., and S.G. Sealy. 1989. Nest-failure and the evolution of hatching asynchrony in the least flycatcher. The Journal of Animal Ecology **58**: 653-665.

Brown, N.S., and G.I. Wilson. 1975. A comparison of the ectoparasites of the house sparrow (*Passer domesticus*) from North America and Europe American Midland Naturalist **94**: 154-165.

Cameron, D. 1938. The northern fowl mite (*Liponyssus sylviarum* C. & F., 1877). Canadian Journal of Research. Section D, Zoological Sciences **16**: 230-254.

Chamberlain, R.W., and R.K. Sikes. 1955. Laboratory investigations on the role of bird mites in the transmission of eastern and western equine encephalitis. American Journal of Tropical Medicine and Hygiene **4**: 106-118.

Clements, J.F. 1991. Birds of the World: A Checklist, 4th ed. Ibis Publishing, Vista, California.

DeLoach, J.R., and J.A. DeVaney. 1981. Northern fowl mite, *Ornithonyssus sylviarum* (Acari: Macronyssidae), ingests large quantities of blood from white leghorn hens. Journal of Medical Entomology **18**: 374-377.

DeVaney, J.A. 1979. The effects of the northern fowl mite, *Ornithonyssus sylviarum*, on egg production and body weight of caged White Leghorn hens. Poultry Science **58**: 191-194.

Dick, T.A. 1981. Ectoparasites of sharp-tailed grouse, *Pediocetes phasianellus*. Journal of Wildlife Diseases **17**: 229-235.

Estebanes-Gonzalez, M.L. 1997. Acarofauna en nidos de aves silvestres en Mexico. Acta Zoologica Mexicana **71**: 1-15.

Foulk, J.D., and J.G. Matthysse. 1965. *Ornithonyssus sylviarum* (Acarina: Mesostigmata) from wild birds and their nests. Journal of Parasitology **51**: 126-127.

Garvin, M.C., L.C. Scheidler, D.G. Cantor, and K.E. Bell. 2004. Abundance and temporal distribution of *Ornithonyssus sylviarum* Canestrini and Fanzago (Acarina: Mesostigmata) in gray catbird (*Dumatella carolinensis*) nests. Journal of Vector Ecology **29**: 62-65.

Halstead, J.A. 1988. American dipper nestlings parasitized by blowfly larvae and the northern fowl mite. Wilson Bulletin **100**: 507-508.

Hammon, W., and W.C. Reeves. 1948. Isolation from wild bird mites (*L. sylviarum*) of a virus or mixture of viruses from which St. Louis and western equine encephalitis viruses have been obtained. Science **23**: 91-92.

Hanson, H.C., N.D. Levine, C.W. Kossack, S. Kantor, and L.J. Stannard. 1957. Parasites of the mourning dove (*Zenaidura macroura carolinensis*) in Illinois. Journal of Parasitology **43**: 186-193.

Hofstad, M.S. 1949. Recovery of Newcastle disease (pneumoencephalitis) virus from mites *Liponyssus sylviarum* after feeding upon Newcastle infected chickens. American Journal of Veterinary Research **10**: 370-371.

Kellogg, F.E., and J.P. Calpin. 1971. A checklist of parasites and diseases reported from the bobwhite quail. Avian Diseases **15**: 704-715.

Masan, P., and Z. Orszaghova. 1995. Infestation and age structure of *Ornithonyssus sylviarum* (Acarina: Mesostigmata) and other mites occurrence in the *Hirundo rustica* nests. Biologia, Bratislava. **50**: 475-479.

McGroarty, D.L., and R.C. Dobson. 1974. Ectoparasite populations on house sparrows in Northwestern Indiana. American Midland Naturalist **91**: 479-486.

Mullen, G.R., and B.M. OConnor. 2002. Mites (Acari). *In* Medical and veterinary entomology, G. Mullen and L. Durden (eds.). Academic Press, New York, New York, p. 449-516.

Nelder, M.P., and W.K. Reeves. 2005. Ectoparasites of road-killed vertebrates in northwestern South Carolina, USA. Veterinary Parasitology **129**: 313-322.

Nolan, V.J. 1960. Breeding behavior of the bell vireo in Southern Indiana. The Condor **62**: 225-244.

Orton, D.I., L.J. Warren, and J.D. Wilkinson. 2000. Avian mite dermatitis. Clinical & Experimental Dermatology **25**: 129-131.

Peters, H.S. 1933. External parasites collected from banded birds. Bird Banding. **4**: 68-75.

Peters, H.S. 1936. A list of external parasites from birds of the Eastern part of the United States. Bird Banding. **7**: 9-27.

Philips, J.R. 2000. A review and checklist of the parasitic mites (Acarina) of the Falconiformes and Strigiformes. Journal of Raptor Research **34**: 210-231.

Phillis, W.A., H.L. Cromroy, and H.A. Denmark. 1976. New host and distribution records for the mite genera *Dermanyssus, Ornithonyssus* and *Pellonyssus* (Acari: Mesostigmata: Laelapoidea) in Florida. The Florida Entomologist **59**: 89-92.

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

Reeves, W.C., W. McD. Hammon, W.H. Doetschman, H.E. McClure, and G. Sather. 1955. Studies on mites as vectors of western equine and St. Louis encephalitis viruses in California. American Journal of Tropical Medicine and Hygiene **4**: 90-105.

Reeves, W.C., W. McD. Hammon, D.P. Furman, H.E. McClure, and B. Brookman. 1947. Recovery of western equine encephalomyelitis virus from wild bird mites (*Liponyssus sylviarum*) in Kern County, California. Science **105**: 411-412.

Rendell, W.B., and N.A.M. Verbeek. 1996a. Old nest material in nestboxes of tree swallows: effects on reproductive success. The Condor **98**: 142-152.

Rendell, W.B., and N.A.M. Verbeek. 1996b. Are avian ectoparasites more numerous in nest boxes with old nest material? Canadian Journal of Zoology **74**: 1819-1825.

Root, R.B. 1969. The behavior and reproductive success of the blue-grey gnatcatcher. The Condor **71**: 16-31.

Royal Alberta Museum. 2005. The Official List of the Birds of Alberta. http://www.royalalbertamuseum.ca/natural/birds/birdlist/taxon.htm (viewed 31 March 2006).

Sikes, R.K., and R.W. Chamberlain. 1954. Laboratory observations on three species of bird mites. Journal of Parasitology **40**: 691-697.

Stone, E.G., G. Montiel-Parra, and T.M. Perez. 2005. A survey of selected parasitic and viral pathogens in four species of Mexican parrots, *Amazona autumnalis, Amazona oratrix, Amazona viridigenalis,* and *Rhynchopsitta pachyrhyncha*. Journal of Zoo and Wildlife Medicine **36**: 245-249.

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

Willson, M.F. 1966. Breeding ecology of the yellow-headed blackbird. Ecological Monographs **36**: 51-77.

Wilson, N. 1958. Ectoparasites of the house sparrow, *Passer domesticus* (L.), in Kentucky. Journal of Parasitology **44**: 545.

Table 5.1. *Ornithonyssus sylviarum* host species records from birds of Alberta, and the status of these records in North America.

Host order	Host family	Host genus	Host species	Location and date of host collection	Status
Falconiformes	Accipitridae	*Accipiter*	*striatus* Vieillot	Barrhead, 24 September 1993	new record
		Pandion	*haliaetus* (Linnaeus)	no location, no date	new record
	Falconidae	*Falco*	*columbarius* Linnaeus	no location, 22 August	new record
Passeriformes	Corvidae	*Corvus*	*brachyrhynchos* Brehm	Edmonton, October 2006	previous record
		Cyanocitta	*cristata* (Linnaeus)	Edmonton, 19 September 2000	previous record
		Perisoreus	*canadensis* (Linnaeus)	Slave Lake, 10 October 2003	new record
	Emberizidae	*Pheucticus*	*ludovicianus* (Linnaeus)	Barrhead, 21 July 1999	new record
		Spizella	*passerina* (Bechstein)	no location, 1 July 2003	previous record
		Zonotrichia	*leucophrys* (Forster)	Barrhead, 6 September 1992, 1 October 1991, 21 July 1999	new record
	Fringillidae	*Carpodacus*	*purpureus* (Gmelin)	Barrhead, 22 June 1993	new record
	Icteridae	*Euphagus*	*cyanocephalus* (Wagler)	no location, no date	new record
		Icterus	*galbula* (Linnaeus)	Ministik Hills, no date	previous record
		Molothrus	*ater* (Boddaert)	Standard, 15 July 2002	previous record
		Quiscalus	*quiscula* (Linnaeus)	Devon, 10 July 2002	previous record
		Sturnella	*neglecta* Audubon	no location, no date	new record
	Parulidae	*Vermivora*	*peregrina* (Wilson)	University of Alberta, 11 August 2004	new record
	Turdidae	*Catharus*	*ustulatus* (Nuttall)	Ministik Hills, no date	new record
		Sialia	*currucoides* (Bechstein)	St. Paul, 05 August 2003	new record
		Turdus	*migratorius* Linnaeus	Ministik Hills, 02 September 1993; Millet, 18 July 1999	previous record
	Tyrannidae	*Empidonax*	*alnorum* Brewster	Barrhead, 9 June 1993	new record
		Tyrannus	*tyrannus* (Linnaeus)	Cardston, 9 Sept 2003	previous record
Piciformes	Picidae	*Colaptes*	*auratus* (Linnaeus)	Barrhead, no date	previous record
		Picoides	*pubescens* (Linnaeus)	St. Albert, July 2004	new record
		P.	*villosus* (Linnaeus)	Edmonton, 15 October 2002	previous record
		Sphyrapicus	*varius* (Linnaeus)	Edmonton, 3 October 2002	new record
Strigiformes	Strigidae	*Asio*	*otus* (Linnaeus)	no location, 20 August 2005	new record

Table 5.2. Known host species records for *Ornithonyssus sylviarum* collected from birds of North America.

Host order	Host family	Host genus	Host species and authority	Reference(s)
Apodiformes	Apodidae	*Chaetura*	*pelagica* (Linnaeus)	1, 2
Columbiformes	Columbidae	*Columba*	*livia* Gmelin	5
		Zenaida	*macroura* (Linnaeus)	8
Coraciiformes	Alcedinidae	*Megaceryle*	*alcyon* (Linnaeus)	2, 9
Falconiformes	Accipitridae	*Accipiter*	*striatus* Vieillot	present study
		Pandion	*haliaetus* (Linnaeus)	present study
	Falconidae	*Falco*	*columbarius* Linnaeus	present study
Galliformes	Odontophoridae	*Colinus*	*virginianus* (Linnaeus)	13
	Phasianidae	*Gallus*	*gallus* (Linnaeus)	1
		Tympanuchus	*phasianellus* (Linnaeus)	2, 15
Passeriformes	Cinclidae	*Cinclus*	*mexicanus* Swainson	17
	Corvidae	*Corvus*	*brachyrhynchos* Brehm	24, present study
		Cyanocitta	*cristata* (Linnaeus)	7, 20, 24, present study
		Perisoreus	*canadensis* (Linnaeus)	present study
	Emberizidae	*Cardinalis*	*cardinalis* (Linnaeus)	2
		Melospiza	*melodia* (Wilson)	23, 24
		Passerculus	*sandwichensis* (Gmelin)	24
		Passerella	*iliaca* (Merrem)	24
		Pheucticus	*ludovicianus* (Linnaeus)	present study
		P.	*melanocephalus* (Swainson)	25
		Pipilo	*erythrophthalmus* (Linnaeus)	24
		Spizella	*passerina* (Bechstein)	5, 23, 24, present study
		Zonotrichia	*albicollis* (Gmelin)	23, 24
		Z.	*leucophrys* (Forster)	present study
	Fringillidae	*Carpodacus*	*purpureus* (Gmelin)	present study
	Hirundinidae	*Hirundo*	*rustica* Linnaeus	1, 2, 23, 24, 25
		Progne	*subis* (Linnaeus)	1, 2
		Riparia	*riparia* (Linnaeus)	24
		Stelgidopteryx	*ruficollis* (Vieillot)	24

Table 5.2. continued.

Host order	Host family	Host genus	Host species and authority	Reference(s)
Passeriformes	Hirundinidae	*Tachycineta*	*bicolor* (Vieillot)	11, 26
	Icteridae	*Agelaius*	*phoeniceus* (Linnaeus)	24
		Euphagus	*cyanocephalus* (Wagler)	present study
		E.	*carolinus* (Müller)	1, 2
		Icterus	*galbula* (Linnaeus)	5, present study
		Molothrus	*ater* (Boddaert)	1, 2, 23, 24, present study
		Quiscalus	*quiscula* (Linnaeus)	1, 2, 23, 24, present study
		Sturnella	*neglecta* Audubon	present study
		S.	*magna* (Linnaeus)	2
		Xanthocephalus	*xanthocephalus* (Bonaparte)	6, 22
	Mimidae	*Dumetella*	*carolinensis* (Linnaeus)	1, 2, 3, 5, 24
		Mimus	*polyglottos* (Linnaeus)	7
		Toxostoma	*rufum* (Linnaeus)	7, 23, 24, 27
	Parulidae	*Dendroica*	*petechia* (Linnaeus)	1, 2
		Seiurus	*aurocapillus* (Linnaeus)	24
		Vermivora	*peregrina* (Wilson)	present study
	Passeridae	*Passer*	*domesticus* (Linnaeus)	1, 2, 4, 5, 18, 19
	Polioptilidae	*Polioptila*	*caerulea* (Linnaeus)	12
	Sittidae	*Sitta*	*carolinensis* Latham	2
	Sturnidae	*Sturnus*	*vulgaris* Linnaeus	1, 2, 5, 21, 24
	Troglodytidae	*Troglodytes*	*aedon* Vieillot	5, 23, 24
	Turdidae	*Catharus*	*occidentalis* Sclater	25
		C.	*ustulatus* (Nuttall)	present study
		Sialia	*currucoides* (Bechstein)	present study
		Turdus	*migratorius* Linnaeus	1, 2, 23, 24, 25, 27, present study
	Tyrannidae	*Contopus*	*virens* (Linnaeus)	2
		Empidonax	*alnorum* (Brewster)	present study
		E.	*minimus* (W.M. Baird & S.F. Baird)	10
		Myiarchus	*crinitus* (Linnaeus)	5, 23, 24

Table 5.2 continued.

Host order	Host family	Host genus	Host species and authority	Reference(s)
Passeriformes	Tyrannidae	*Sayornis*	*phoebe* (Latham)	5, 23, 24
		Tyrannus	*tyrannus* (Linnaeus)	1, 2, present study
		T.	*verticalis* Say	2
	Vireonidae	*Vireo*	*bellii* Audubon	14
		V.	*olivaceus* (Linnaeus)	2, 24
Piciformes	Picidae	*Colaptes*	*auratus* (Linnaeus)	1, 2, present study
		Picoides	*pubescens* (Linnaeus)	present study
		P.	*villosus* (Linnaeus)	1, 2, present study
		Sphyrapicus	*varius* (Linnaeus)	present study
Psittaciformes	Psittacidae	*Amazona*	*autumnalis* (Linnaeus)	16
		A.	*oratrix* Ridgway	16
		A.	*viridigenalis* (Cassin)	16
Strigiformes	Strigidae	*Asio*	*otus* (Linnaeus)	present study
		Strix	*varia* Barton	27

[1]Cameron 1938; [2]Wheeler and Threlfall 1989; [3]Garvin et al. 2004; [4]McGroarty and Dobson 1974; [5]Foulk and Matthysse 1965; [6]Reeves et al. 1947; [7]Phillis et al. 1976; [8]Hanson et al. 1957; [9]Boyd and Fry 1971; [10]Briskie and Sealy 1989; [11]Rendell and Verbeek 1996a; [12]Root 1969; [13]Kellogg and Calpin 1971; [14]Nolan 1960; [15]Dick 1981; [16]Stone et al. 2005; [17]Halstead 1988; [18]Wilson 1958; [19]Brown and Wilson 1975; [20]Boyd et al. 1956; [21]Boyd 1951; [22]Willson 1966; [23]Peters 1933; [24]Peters 1936; [25]Estenanes-Gonzalez 1997; [26]Rendell and Verbeek 1996b; [27]Nelder and Reeves 2005.

Chapter 6

General Discussion and Conclusions.

Birds are host to a widely variegated fauna of parasitic and commensal arthropods; one of the most species-rich group is mites (Arachnida: Acari) (Proctor and Owens 2000). Almost two decades ago Wheeler and Threlfall (1989) estimated that there are 6000-7000 species of avian-associated Acari in Canada, which does appear to be an overestimate, yet only a small fraction of that diversity having been surveyed. Avian nasal mites (Rhinonyssidae, Ereynetidae, Turbinoptidae, and Cytoditidae) have been recovered from hosts in every geographic location examined (Hyland 1963), but prior to the work in this thesis there were only four published and three unpublished species records from birds in Canada.

The two principal objectives of this thesis were to identify the species of nasal mites that occur in western Canada, and to determine how the diversity here compares to similar studies in North America. In Chapter 2 I present the findings from this survey, and expand the known number of species in Canada from seven to 58. Nasal mite prevalence in hosts from Alberta was similar to, but somewhat less than that observed in similar studies in North America (Pence 1973, Spicer 1987). The relatively high frequency of co-infestations of a single host by more than one species of nasal mite in Manitoba was unexpected, given the rarity of such records in the literature (Butenko and Stanyukovich 1999). Especially rare are reports of two congeneric mite species in a single host; however, I observed this in three hosts representing three species of Manitoban birds.

Nearly half of my rhinonyssid host-parasite species records are new for North America. The records reported here expand upon the known records from Canada from seven to 102 (a 14-fold increase). The largest proportion of novel records for North America was seen in the Strigiformes, with seven new records. Despite the diversity of mites reported here, here roughly three quarters of Canada's bird species remain to be examined. In Chapter 2 I used a species accumulation curve to estimate there to be at least 75 species of rhinonyssids in Canada, 19 more than I recovered from my survey.

I was surprised to have collected *Sternostoma tracheacolum* from Manitoba, since mites were collected via nasal flushings in Manitoba rather than by dissections, and *S. tracheacolum* reportedly rarely occurs in the nasal cavities of its host (Bell 1996a). In Canada *S. tracheacolum* is now known from two host species representing two families, Icteridae and Parulidae (Hood and Welch 1980, this thesis). The fact that this mite is reported from a broad range of hosts around the world, 37 species representing 11 families (Bell 1996b), the severe pathology sometimes caused by this mite, possibly indicating evolutionarily recent host associations, and the level of morphological variation within the species, all indicate that *S. tracheacolum* may be undergoing an incipient taxonomic radiation (Radovsky 1994). I was surprised that I did not recover any *Larinyssus* species from Albertan and Manitoban birds, since I examined three of several host species that *Larinyssus* has been reported from in North America (Pence 1975).

I collected speleognathines and turbinoptids infrequently, as has been reported in similar studies (Pence 1975, Spicer 1987). Prior to this survey speleognathines and turbinoptids had not been reported in Canada. Turbinoptid diversity in Canada was relatively low (one species), compared to records from the Southern USA (seven species) (Pence 1975). The difference in turbinoptid diversity is likely the result of differences in avian diversity.

I had expected that dissections would yield many more individual nasal mites than nasal flushings alone. For some host species bird washings may be as effective as dissections, and much more efficient in terms of time and energy. The main exception was Common Redpolls, in which many more mites were found in dissections. The structure of the nasal passage tissue can vary widely between species, especially members of separate orders (pers. obs.) and may play a role in the relative effectiveness of washing versus dissection.

In the course of the survey five new species of rhinonyssids and one new species of *Dermanyssus* were collected. I illustrated and described these new species in Chapter 3. *Dermanyssus diphyes* sp. n. was collected from the American Robin in Alberta. *Ptilonyssus calvaria* sp. n. was collected in Alberta and Manitoba from the Chipping Sparrow. *Ptilonyssus nivalis* sp. n. was collected in Manitoba from the Snow Bunting. *Ptilonyssus pinicola* sp. n. was collected from the Pine Grosbeak in Alberta and Manitoba. *Ptilonyssus plesiotypicus* sp. n. was collected from the Purple Finch in Alberta. *Sternostoma setifer* sp. n. was collected from the Least Flycatcher in Manitoba. Making thorough and accurate illustrations was very time-consuming; it is likely the rate-limiting step in species descriptions, which might explain why inadequate illustrations are very common in the taxonomic literature. Nevertheless, good drawings are of much greater value than photographs for illustrating rhinonyssids, whose lightly sclerotized cuticle and often minute setae are difficult to capture in light-microscope images.

During the survey I became aware of the need for a computer-based interactive key to rhinonyssids of Canada. The best key for nasal mites associated with North American birds to date is a dichotomous key by Pence (1975), but Pence's key lacks a number of Canadian nasal mite species. In Chapter 4 I provided a Lucid key to the female Rhinonyssidae of Canada, as well as HTML-based and hard-copy dichotomous keys to the female Rhinonyssidae of Canada. The keys provide species-level identifications of 47 species of rhinonyssids. These keys contain 116 figures of the various structures referred to in the key as well as dorsal habitus images. The Lucid key includes 51 characters and 151 character states. Occasionally within a species certain character states were inconsistent; for instances the presence of unpaired setae, the extent of dorsal or ventral shields, and the form of shield margins were variable at times. Intraspecific morphological variation can be quite common, and it must be taken into consideration while creating and using any key. Interactive keys provide a partial solution to the taxonomic impediment, by putting effective identification tools in the hands of those who need them most. Interactive keys do require much more effort to build, but for the user they are considerably more flexible than dichotomous keys.

In Chapter 5 I provide an updated North American host list for the northern fowl mite. The last host list for *Ornithonyssus sylviarum* in North America was published approximately 70 years ago (Cameron 1938). Host list records were compiled from the literature and from my records from Alberta. In Alberta, I collected *O. sylviarum* from 34 hosts representing 26 host species, sixteen of which are new host-parasite records for

North America. Including the new host records from Alberta and those from the literature, the northern fowl mite has been recorded from 72 host species representing 9 orders of North American birds. I believe with further examination of additional host species we will find that *O. sylviarum* is even more widespread than previously accepted.

Many questions about the diversity and biology of avian nasal mites that remain unanswered. The total diversity in Canada is far from completely determined; three quarters of Canada's avian fauna remains to be examined. In particular, non-passeriform orders need further examination. Some rhinonyssid species boundaries as defined by morphology are unclear, and molecular work may help us more clearly define them. Recent molecular work using cyt b (cytochrome b) and ITS (internal transcribed spacer) sequences have shown the presence of cryptic species in the *Ptilonyssus* "*sairae*" species complex (Carmichael 2007).

Our knowledge of the life history and ecology of nasal mites is scant. The transmission mechanisms of these mites, and specifically rhinonyssids, is not completely agreed upon. Rhinonyssids are likely transmitted through direct contact during courtship billing or feeding the young (Porter and Strandtmann 1952), but which life cycle stage is the transmissible stage is not known. Radovsky (1994) claims that the transmissible stage is the larva, while Bell (1996a) claims that the non-gravid female is the transmissible stage in *S. tracheacolum*; it is likely that the transmissible stage varies across genera. Finally, we do not understand the interaction between rhinonyssids and transmission of disease agents. In some host families there is very little host specificity, and if rhinonyssids transfer between species there is a chance that blood-borne pathogens could be transmitted across species. Intraspecific transmission is the most likely transmission path of rhinonyssids, but when multiple bird species are held in close contact (e.g. multi-species aviaries) or in the case of gregarious host species, like the Icteridae, it is possible that rhinonyssids can transfer across species (Strandtmann 1958). Although the research I present in this thesis does not directly examine the role of nasal mites in avian disease, by establishing host records and providing identification tools I have given other researchers the ability to recognize species invasions, and to evaluate the potential role of these mites in disease. This research provides the basis for all subsequent work on avian nasal mites in Canada, as it is a necessary precursor for answering ecological, evolutionary, and parasitological questions about these diverse and poorly understood mites.

Literature cited

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

Bell, P.J. 1996b. 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.

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

Cameron, D. 1938. The northern fowl mite (*Liponyssus sylviarum* C. & F., 1877). Canadian Journal of Research. Section D, Zoological Sciences **16**: 230-254.

Carmichael, A.D. 2007. Rates of evolution and cospeciation in birds and their parasitic mites. M.S. Thesis. San Francisco State University, San Francisco, California, 37 p.

Hood, D.E., and H.E. Welch. 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. 1963. Current trends in the systematics of acarines endoparasitic in vertebrates. *In* Advances in acarology, J.A. Naegele (ed.). Comstock Publishing Associates, Ithaca, New York, p. 365-373.

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 Texas Tech University **8**: 1-148.

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

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

Radovsky, F.J. 1994. The evolution of parasitism and the distribution of some dermanyssoid mites (Mesostigmata) on vertebrate hosts. *In* Mites: ecological and evolutionary analyses of life-history patterns, M.A. Houck (ed.). Chapman & Hall, New York, New York, p. 186–217.

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

Strandtmann, R.W. 1958. Host specificity of bird nasal mites (Rhinonyssidae) is a function of the gregariousness of the host. Proceedings of the 10th International Congress of Entomology **1**: 909-911.

Wheeler, T.A., and W. Threlfall. 1989. Synopsis of the parasites of vertebrates of Canada: ectoparasites of birds. Alberta Agriculture, Animal Health Division, Edmonton, Canada, 85 p.