New records of mites (Arachnida: Acari) from Sable Island, Nova Scotia, Canada

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Abstract—The first investigations of the mite fauna of Sable Island, Nova Scotia, Canada, are reported. Fourteen species have been found. *Uropoda orbicularis* (Müller) (Uropodidae) and *Scarabaspis inexpectatus* (Oudemans) (Eviphididae) are newly recorded for North America, *Macrocheles nemerdarius* Krantz and Whitaker (Macrochelidae) is newly recorded for Canada, and *Trichoribates striatus* Hammer (Ceratozetidae) is recorded for the first time south of the subarctic zone. Colonization, dispersal, and the zoogeographic origins of the fauna are discussed in the context of the biological, geological, and human history of the island.

Résumé—Cet article présente les premières investigations de la faune acarienne de l'Île de Sable en Nouvelle-Écosse au Canada. On a trouvé 14 espèces. On signale le *Uropoda orbicularis* (Müller) (Uropodidae) et le *Scarabaspis inexpectatus* (Oudemans) (Eviphididae) pour la première fois en Amérique du Nord, le *Macrocheles nemerdarius* Krantz et Whitaker (Macrochelidae) pour la première fois au Canada et le *Trichoribates striatus* Hammer (Ceratozetidae) pour la première fois au sud de la zone subarctique. La colonisation, la dispersion et les origines zoogéographiques de cette faune sont abordées dans le contexte de l'histoire biologique, géologique et humaine de l'île.

Introduction

Sable Island (44°N, 60°W) is a 45 km long sand bar located near the edge of the continental shelf, 160 km from the nearest point of land (Fig. 1). Rising no more than 25 m in height, it is covered by heathland and a variety of grasses. In the widest areas (approximately 1.5 km) there are shallow brackish and freshwater ponds. The island was ice-covered during the last phase of

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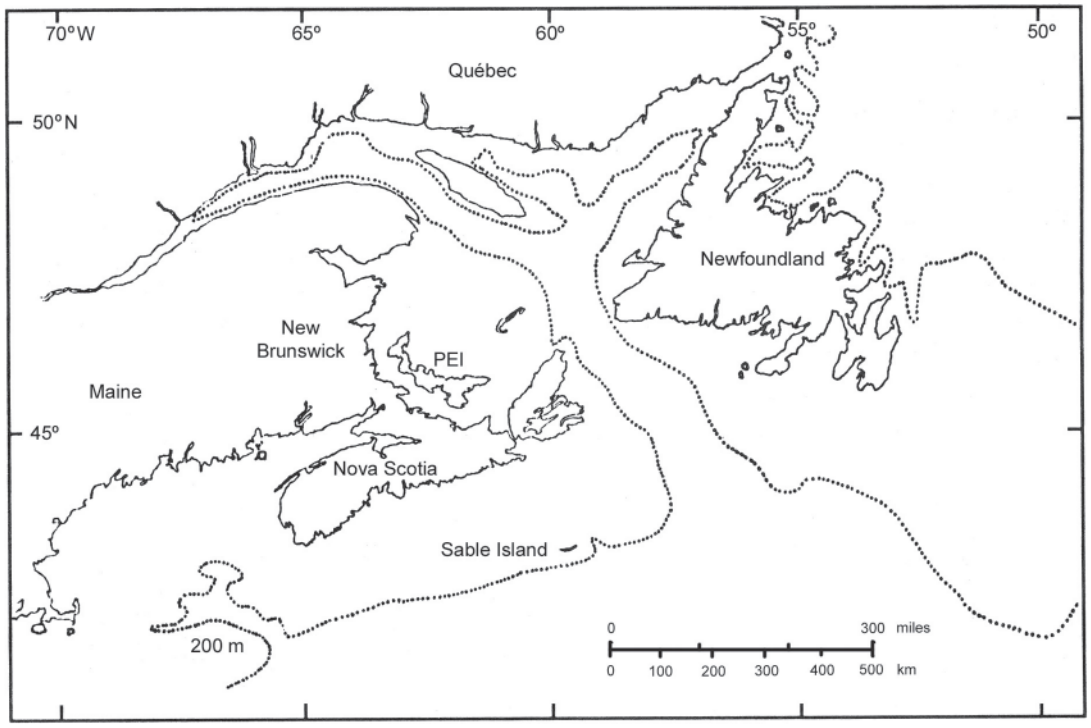
Fig. 1. Map of Atlantic Canada and the continental shelf, indicating the position of Sable Island.



the Wisconsinian glaciation and became ice-free approximately 14 500 years ago (King 2001). Humans visited and lived on the island sporadically during the 1600s and 1700s, and it has been continuously inhabited since 1801 (Campbell 1974).

Because of its geographical situation, environmental vulnerability, long history of human activities, and unique fauna, Sable Island has been the focus of considerable scientific interest. Several endemic species have been described from the island, including *Koerneria mulveyi* Ebsary (Nematoda), *Aequipecten irradians sablensis* Clarke (Mollusca: Bivalvia), *Tricholochmaea sablensis* (Brown) (Coleoptera: Chrysomelidae), *Orgyia leucostigma sablensis* Neil (Lepidoptera: Lymantriidae), *Agrotis arenarius* Neil (Lepidoptera: Noctuidae), a still undescribed species of *Papaipema* Smith (Lepidoptera: Noctuidae), as well as the well-known Ipswich sparrow (*Passerculus sandwichensis princeps* Maynard) (Aves) (Wright 1989).

Biological investigations of the island began in the middle of the nineteenth century (Gilpin 1858). Contemporary studies of its arthropod fauna began with Howden *et al.* (1970). Wright (1989) published a comprehensive treatment of the island's fauna (reporting 561 arthropod species of which 486 are insects). He recorded 28 species of spiders (Arachnida: Araneae) and 2 species of opilionids (Arachnida: Opiliones), but no Acari have been reported. This paper reports the results of preliminary investigations of the island's acarine fauna.

Materials and methods

Since 2004, Z. Lucas has been collecting insects on Sable Island. Methods have included sweep-netting, dip-netting, pitfall-trapping, and Berlese-funnel extractions, but collection has relied primarily on manual searching. Specimens of Acari have been collected incidentally by means of all these techniques and voucher specimens deposited with the following institutions:

NSMC Nova Scotia Museum, Halifax, Nova Scotia, Canada
OSU Oregon State University, Corvallis, Oregon, United States of America
UMMZ University of Michigan Museum of Zoology, Ann Arbor, Michigan, United States of America

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Examination of specimens at the following institutions has yielded additional records:

CNC Canadian National Collection of Insects, Arachnids, and Nematodes, Ottawa, Ontario, Canada

NSMC Nova Scotia Museum, Halifax, Nova Scotia, Canada

SUNY State University of New York, Albany, New York, United States of America

Classification follows Krantz and Walter (2008).

Results

Fourteen species of mites have been found on Sable Island. Table 1 lists them and summarizes information on their bionomics and distribution. Brief notes on the Sable Island fauna follow.

Acari: Parasitiformes: Mesostigmata: Monogynaspida

Uropodina: Uropodidae

***Uropoda orbicularis* (Müller, 1776)**

Deutonymphs were found on the scarab beetles *Aphodius fimetarius* (L.), *Aphodius subterraneus* (L.), and *Onthophagus nuchicornis* (L.), which are associated with horse dung (NSMC). *Aegialia arenaria* (F.) (Scarabaeidae), *Cercyon haemorrhoidalis* (F.), *Cercyon pygmaeus* (Illiger), and *Cryptopleurum minutum* (F.) (Hydrophilidae), all Palearctic beetles also associated with horse dung on Sable Island, were not found to host *U. orbicularis*, although *C. haemorrhoidalis* has been recorded as a host in Europe (Bajerlein and Przewoźny 2005). *Aphodius* spp. and *O. nuchicornis* are known hosts of *U. orbicularis* in Europe (Bajerlein and Błoszyk 2004). Although specimens of this species from Alberta and Newfoundland exist (CNC; E.E. Lindquist, personal communication), this is the first published report of its occurrence in North America.

Gamasina: Parasitidae

***Parasitus fimetorum* (Berlese, 1903)**

A single deutonymph was recovered from horse manure (OSU). The species is common in small-mammal nests, rotting vegetation, dung, and compost. Specimens have also been taken from the nests of birds, and occasionally from leaf litter or open grasslands (Hyatt 1980; Hennessey and Farrier 1988). Deutonymphs of *P. fimetorum* may be phoretic on a wide range of arthropods, including dung and carrion beetles (*Aphodius*, *Geotrupes*, *Hister*, *Nicrophorus* spp.) and bumblebees (Holzmann 1969; Richards and Richards 1976).

Gamasina: Eviphididae

***Scarabaspis inexpectatus* (Oudemans, 1903)**

Deutonymphs were taken from the gular region of the dung beetle *O. nuchicornis* (OSU). The species has been collected from cattle dung in Europe (Karg 1993). These collections represent the first records of *S. inexpectatus* in North America. Its occurrence on Sable Island is noteworthy also in light of records from other insular sites in Europe (Borkum Island in the East Frisian Islands chain, Isles of Scilly) (Oudemans 1903; Evans 1957).

Gamasina: Macrochelidae

***Macrocheles perglaber* Filipponi and Peggazano, 1962**

Found associated with horse dung and with dung beetles (*Aphodius* spp.) (OSU). A common Holarctic phoretic species found in domestic animal dung, where it preys on fly eggs and larvae (Filipponi 1959; Krauss 1970; Glida *et al.* 2003). It is considered a potentially useful biological agent for controlling muscine pests (Krantz 1983).

***Macrocheles nemerdarius* Krantz and Whitaker, 1988**

Collected from beneath dead seabirds (OSU). The species was described from rodent nests in Maryland and Florida (Krantz and Whitaker 1988), where it was probably feeding on nematodes and other nidicolous microfaunal species. The female specimens from Sable Island deviate from the original description in having somewhat more robust idiosomatic setae than those found in type specimens. Prolonged isolation of the Sable Island population may have contributed to the expression of this anomaly. However, the widely disparate distributions and substrates of the Sable Island collections compared with those of the type collections suggest that males of this insular population should be sought to confirm the species' identity.

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Table 1. Acari found on Sable Island, Nova Scotia, Canada.

Species	Sable Island bionomics	Preferred habitats	Biology and ecology	Known distribution
Superorder: Parasitiformes				
Order: Mesostigmata				
Suborder Monogynaspida				
Cohort Uropodina				
Family Uropodidae				
*Uropoda orbicularis**	Phoretic on *Aphodius* spp. and *Onthophagus nuchicornis* on horse dung	Dung environments	Feeds on fungal hyphae; phoretic on dung beetles	Widely distributed in Europe; adventive in North America
Cohort Gamasina				
Family Parasitidae				
*Parasitus fimetorum**	Horse manure	Decomposing environments	Predaceous; phoretic on many arthropods, including dung and carrion insects	Widely distributed in Europe; adventive in North America
Family Eviphididae				
*Scarabaspis inexpectatus**	Phoretic on *O. nuchicornis* on horse manure	Dung environments	Predaceous on eggs and larvae of Diptera associated with dung and dung beetles	Insular/coastal in Europe; newly recorded in North America
Family Macrochelidae				
Macrocheles perglaber†	Phoretic on *Aphodius* spp. on horse manure	Dung environments	Predaceous on eggs and larvae of Diptera on dung and carrion; phoretic on dung beetles	Widely distributed Holarctic species
Macrocheles nemerdarius	Dead seabirds	Rodent nests	Predaceous on nematodes	Southeastern USA
Family Ascidae				
*Cheiroseius curtipes**	Pond margins	Swamps, marshes, ponds	Predaceous	Widely distributed in Europe; adventive in North America
Order: Trombidiformes				
Suborder Prostigmata				
Cohort Parasitengonina				
Family Erythraeidae				

Table 1 (*concluded*).

Species	Sable Island bionomics	Preferred habitats	Biology and ecology	Known distribution
Leptus species A	Small brackish ponds	Aquatic and semi-aquatic	Parasitic on insects and arachnids	Unknown
Family Pionidae				
Piona sp. near *rotunda*	Small brackish ponds	Aquatic and in wetlands	Parasitic on chironomids	Widely distributed in North and Central America
Superorder: Acariformes				
Order: Sarcoptiformes				
Suborder Oribatida				
Cohort Nothrina				
Family Nothridae				
Trhypochthoniellus setosus canadensis	Beach drift	Aquatic and semi-aquatic	Particle-feeding mycophage	Alaska, northern Canada, and the Maritime Provinces
Family Camisiidae				
Platynothrus punctatus†	Small brackish ponds	Aquatic and semi-aquatic	Particle-feeding saprophage and mycophage	Widely distributed Holarctic species
Cohort Brachypylina				
Family Ceratozetidae				
Trichoribates striatus	Found on oily porpoise skull	Decomposing environments	Particle-feeding saprophage and mycophage; possibly an opportunistic predator	Subarctic (Alaska, Yukon, and northern Manitoba)
Family Hydrozetidae				
Hydrozetes species A	Small brackish ponds	Aquatic	Surface-grazing microphage	Unknown
Cohort Astigmatina				
Family Histiostomatidae				
Pelzneria species A	On *Creophilus maxillosus* and *Thanatophilus lapponicus* in decomposing environments	Decomposing and dung environments	Filter-feeding microphage phoretic on Silphidae and Staphylinidae	Widely distributed?
Spinanoetus species A	On *C. maxillosus* and *T. lapponicus* in decomposing environments	Decomposing and dung environments	Filter-feeding microphage phoretic on Silphidae and Staphylinidae	Widely distributed?

*Palearactic species.
†Holarctic species.

Gamasina: Ascidae

***Cheiroseius* (*Posttrematus*) *curtipes* (Halbert, 1923)**

A single female was collected from the muddy edge of a coastal pond on 26–28 August 1979 by Eric Mills (OSU). Like most other platyseiine ascids, *C.* (*P.*) *curtipes* is commonly encountered in humus and moss from damp habitats such as swamps, marshes, wetlands, and watercourse banks in Europe and North and Central America (Schweizer 1949; Karg 1993). Its feeding habits are unknown, although the cheliceral morphology suggests that it is predatory (Lindquist and Evans 1965).

Trombidiformes: Prostigmata: Parasitengonina

Parasitengonina: Erythraeidae

***Leptus* species A**

Specimens of an undescribed species in the genus *Leptus* were collected in association with small brackish ponds (NSMC and CNC). Postlarval instars of the worldwide genus *Leptus* are predators in litter and herbaceous plant habitats (Walter *et al.* 2008). Larvae parasitize a wide range of arthropods including insects and arachnids, providing regular opportunities for the mites to disperse on their hosts. There appear to be numerous species of *Leptus* in North America, including some that are morphologically similar to species living in Eurasia. Species identities and nomenclature remain uncertain pending a revision of the genus for the Holarctic region.

Parasitengonina: Pionidae

***Piona* sp. *near rotunda* (Kramer, 1979)**

A number of specimens of this water mite were collected by Paul Catling in 1981 in a brackish pond (CNC). Adults and deutonymphs of the worldwide genus *Piona* are predators of cladocerans (Branchiopoda: Cladocera) and other small arthropods in standing-water habitats (Cook 1974; Smith *et al.* 2001). Larval *Piona* spp. are typically ectoparasites of adult chironomids (Diptera: Chironomidae), which provide the primary dispersal mechanism for the mites as well as the nourishment for their developing larvae (Smith 1976; Smith and Oliver 1986). Populations of the *Piona rotunda* species complex are widely distributed in ponds and lakes throughout the Holarctic region (Cook 1960; Viets 1987), and although several species names are available, none can be used with certainty until the group is revised.

Acariformes: Sarcoptiformes: Oribatida

Nothrina: Nothridae

***Trhypochthoniellus setosus canadensis* Hammer, 1952**

J.E.H. Martin collected large numbers on 8 July 1965 in beach drift (CNC and SUNY). It has a subarctic and boreal distribution throughout the Nearctic region and has been recorded from Alaska, Yukon, Northwest Territories, Nunavut, Alberta, New Brunswick, and Nova Scotia (Marshall *et al.* 1987; Behan-Pelletier and Eamer 2004). It is among the few oribatid mites found in aquatic and semi-aquatic habitats in Canada. *Trhypochthoniellus* spp. can complete their life cycle while submerged and are truly aquatic (Seniczak *et al.* 1998). *Trhypochthoniellus s. canadensis* is a particle-feeding mycophage involved in decomposition processes.

Nothrina: Camisiidae

***Platynothrus punctatus* (L. Koch, 1879)**

Collected by Eric Mills from the margins of ponds on 26–28 August 1979 (CNC). Widely distributed throughout the Holarctic region and in Canada known from the Yukon, Northwest Territories, Nunavut, Manitoba, and Newfoundland (Marshall *et al.* 1987; Behan-Pelletier and Eamer 2004). It is also among the few oribatid mites found in aquatic and semi-aquatic habitats.

Brachypylina: Ceratozetidae

***Trichoribates striatus* Hammer, 1952**

Collected by Z. Lucas in large numbers on 23 July 2004, 30–31 August 2004, and 1–5 September 2004 on an oily porpoise skull (NSMC and CNC). This species has a subarctic distribution and is known from the Kenai Peninsula, Alaska, the Yukon, and Churchill, Manitoba. Most species of *Trichoribates* are particle-feeding saprophages and mycophages, possibly preying opportunistically on nematodes and other microfaunal species. They are also scavengers on small dead arthropods (necrophages).

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These specimens represent the first records of this species south of the subarctic zone.

Brachypylina: Hydrozetidae

Hydrozetes species A

Specimens of an undescribed species of *Hydrozetes* were collected by Eric Mills on 26–28 August 1979 from pond margins (CNC). The genus *Hydrozetes* is in need of revision. Species are found throughout the world in aquatic situations, generally in association with plants (Krantz and Baker 1982). Among Oribatida only adult *Hydrozetes* spp. exhibit levitation, *i.e.*, move upwards in the water column because of an air bubble that forms in the midgut when they are agitated, when the light changes from high to low intensity (Newell 1945), or when adults are dislodged (Fernandez and Athias-Binche 1986).

Astigmatina: Histiostomatidae

Pelzneria species A

Several specimens of this undescribed species were collected as deutonymphs phoretic on the beetles *Creophilus maxillosus* (L.) (Coleoptera: Staphylinidae) and *Thanatophilus lapponicus* (Herbst) (Coleoptera: Silphidae) associated with dead seabirds (UMMZ). Species of *Pelzneria* are restricted to carrion habitats, where they can be found inhabiting carcasses in association with beetles of the genus *Nicrophorus* (Coleoptera: Silphidae). They are filter-feeders on microorganisms. Though both *Pelzneria* and *Spinanoetus* (see below) have been studied in Europe (Scheucher 1957), they have not been formally examined in North America. B. OConnor has collected *Pelzneria* species A from *Nicrophorus* sp. in northern lower Michigan.

Spinanoetus species A

Specimens of this undescribed species were collected as deutonymphs phoretic on *C. maxillosus* in horse manure and on *T. lapponicus* on dead seabirds (UMMZ). Species of *Spinanoetus* typically inhabit vertebrate carrion but have not been studied outside Europe. Feeding stages filter microorganisms from fluid with their highly modified chelicerae. B. OConnor has collected all stages of this species from deer carcasses in Michigan and found the deutonymphs phoretic on *C. maxillosus* and on species of *Oiceoptoma* and *Necrodes* (Coleoptera: Silphidae) in Michigan, New York, and Pennsylvania.

Discussion

Given the remote location of Sable Island, the origins of its fauna are of interest. Different components of the mite fauna may have employed several modes of dispersal and colonization.

Dispersal via postglacial continental-shelf bridges

Howden *et al.* (1970), Wright (1989), and Klimaszewski *et al.* (2006) have all discussed the possibility that postglacial emergent island chains served as conduits for species from refugia on George's Bank to Sable Island. Such pathways of colonization are well established in the case of the coastal-plain flora of southwestern Nova Scotia (Keddy and Wisheu 1989). Mites such as *M. nemerdarius*, *T. striatus*, *Pelezneria* species A, and *Spinanoetus* species A could have been transported to Sable Island via beach-drift materials, wind, water, or sea ice, or over existing land bridges. *Camisia anomia* Colloff, an oribatid in the cohort Nothrina, tolerated experimental submersion in seawater for 14 days, with a survival rate of 75% (Coulson *et al.* 2002). The authors noted that this length of time is sufficient to permit ocean-current transport for approximately 700 km.

Parasitic mites such as *Piona* sp. near *rotunda* and *Leptus* species A could have been transported in association with their hosts.

It is noteworthy that subarctic mites such as *T. striatus* and *T. s. canadensis* are present on Sable Island. Miller and Elias (2000) have established from postglacial paleontological evidence that between 13 760 and 12 730 years BP, beetle assemblages in Nova Scotia consisted of tundra and tree-line species. These disappear in younger sediments and are replaced by typical boreal assemblages that flourished as the climate warmed and trees began to appear. Subarctic mites could have arrived on Sable Island via continental-shelf land bridges behind the retreating glaciers and might represent a surviving relict of the former subarctic fauna of the Maritime Provinces.

Bird-mediated colonization

Alternatively, oribatids may have been transported to Sable Island from the mainland in association with birds. Krivolutsky and Lebedeva (2004*a*, 2004*b*) have collected species of *Trichoribates* from the feathers of both passeriform

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and non-passeriform birds in Russia, and *Trhypochthoniellus setosus* (Willmann) was taken from the feathers of a mallard. Those authors suggested that the mites feed on fungi associated with the feathers and that transport on birds may be an important means of oribatid dispersal to islands. Avian transport may be particularly relevant in the case of aquatic and semi-aquatic Oribatida (*T. s. canadensis*, *P. punctatus*, and *Hydrozetes* species A) found on Sable Island. Fifteen species of birds regularly breed on Sable Island, including four ducks, three shorebirds, two gulls, and three terns (Lucas 2002). These species frequent aquatic environments and could serve as a conduit for mite dispersal.

Introduced taxa and human-mediated dispersal

Four introduced Palearctic species of mites are found on Sable Island: *U. orbicularis*, *P. fimetorum*, *S. inexpectatus*, and *C.* (*P.*) *curtipes*. The Holarctic *M. perglaber* may also be an introduced species. All are associated with dung environments and are phoretic on dung beetles. All dung-associated beetles found on Sable Island are introduced Palearctic species. There are no native terrestrial mammals on Sable Island and the horse (*Equus caballus* L.) is the only introduced mammal that persists. It therefore seems probable that dung beetles were inadvertently introduced in association with the importation of livestock, which commenced in 1553 when Portuguese fisherman landed cattle and pigs to serve as a source of fresh meat (Elstracke 1625). Forty-four species of Coleoptera (Howden *et al.* 1970; Wright 1989) and 69 species of vascular plants on Sable Island are introduced (Catling *et al.* 1984).

Insular evolution

Also of interest are the collections of *M. nemerdarius*, whose modification of the substrate and idiosomatic setal anomaly (see above) suggest that the Sable Island population has diverged from continental mainland populations in response to the special environmental circumstances of this isolated offshore location.

Conclusion

This account clearly represents but a first step towards identifying and cataloguing the mite fauna of Sable Island. There is every indication that more comprehensive collecting efforts will yield additional species, as well as further information regarding the origins and bionomics of the Sable Island acarine fauna.

What is the size of this fauna? Exact parallels are difficult to find; however, on the sub-Antarctic Prince Edward Islands (46.5°S, 37.5°E), Marshall *et al.* (1999) reported 60 species of mites, while on Heard Island (53°S, 73.5°E) Marshall and Chown (2002) reported 45 species. Although there are differences between these volcanic islands and Sable Island (44°N, 60°W) in terms of size, geology, geological history, distance from nearest land, *etc.*, they do lie at similar latitudes, have similar climates, are relatively remote, provide a very limited range of habitats, and have a combination of native and introduced faunas. Therefore, those numbers may serve as an indicator of the scale of the Sable Island acarine fauna.

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