Introduced Carabidae (Coleoptera) from Nova Scotia and Prince Edward Island: new records and ecological perspectives

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Abstract—Seven species of introduced Carabidae are newly reported in Nova Scotia and Prince Edward Island. *Trechus quadristriatus* (Schrank), *Amara ovata* (Fabricius), and *Harpalus rubripes* (Duftschmid) are newly recorded in Atlantic Canada as a whole. Possible modes of introduction of these species to the region are discussed. Several may have been introduced in association with dry ballast shipments. Some may have arrived via natural dispersion from neighbouring areas; others appear to have been present and undetected for a considerable time. The possible impact of such introductions is also discussed. Synanthropic environments have higher proportions of introduced species than relatively undisturbed, native habitats. Some adventive species do become widespread in native environments; however, negative impacts on native species may not be readily apparent.

Résumé—On signale sept espèces non indigènes de Carabidae pour la première fois en Nouvelle-Écosse et à l'Île-du-Prince-Édouard. Le *Trechus quadristriatus* (Schrank), l'*Amara ovata* (Fabricius) et le *Harpalus rubripes* (Duftschmid) sont signalés pour la première fois dans l'ensemble des provinces atlantiques du Canada. L'article aborde les voies d'introduction de ces espèces dans la région. Certaines espèces ont pu être introduites par le biais des matériaux secs utilisés pour le ballastage ou encore par voie de dispersion naturelle en provenance des régions avoisinantes, tandis que d'autres semblent avoir été présentes dans la région sans avoir été détectées pendant longtemps. L'article aborde également les conséquences envisageables de telles introductions. Les environnements synanthropiques décèlent de plus grandes proportions d'espèces non indigènes que ce que l'on pourrait normalement retrouver dans des habitats indigènes à l'état naturel. Certaines espèces adventives se répandent en effet dans des environnements indigènes, toutefois, les effets néfastes sur les espèces indigènes pourraient ne pas se révéler immédiatement.

Introduction

Introduced Carabidae have long been a subject of interest in the Maritime Provinces of Canada. Harrington (1892), Brown (1940, 1950, 1967), Lindroth (1954, 1957, 1963), Hieke (1990), Bousquet (1992), Majka and Klimaszewski (2004), and Majka (2005) have all contributed to the sizeable list of Palearctic species known to have been introduced to the region. Bousquet (1992) listed 45 taxa of exotic Carabidae established in northeastern North America. Of these, 32 have been collected in the Maritimes and 15 were first recorded in

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North America from the region. The present study adds records of introduced carabids from Prince Edward Island and Nova Scotia.

Methods and conventions

In the course of ongoing research on the biodiversity of Coleoptera in the Maritime Provinces, new records of introduced species were noted. Codens of collections referred to in this study are as follows:

ACNS Agriculture and Agri-Food Canada, Kentville, Nova Scotia
ACPE Agriculture and Agri-Food Canada, Charlottetown, Prince Edward Island
CGMC Christopher G. Majka collection, Halifax, Nova Scotia
JCC Joyce Cook collection, North Augusta, Ontario
NSAC Nova Scotia Agricultural College, Bible Hill, Nova Scotia
NSMC Nova Scotia Museum, Halifax, Nova Scotia
NSNR Nova Scotia Department of Natural Resources Insectary, Shubenacadie, Nova Scotia
SMU Saint Mary's University, Halifax, Nova Scotia
UMNB Université de Moncton, Moncton, New Brunswick

The number of specimens is indicated in parentheses; if not specified, it is assumed to be one. Specimen records are given only for new jurisdictional records. The collection locations of all specimens examined from the Maritime Provinces are plotted on the range maps (Figs. 1–3).

Results

Three species of adventive Carabidae, *Notiophilus biguttatus* (Fabricius), *Carabus granulatus hibernicus* Lindroth, and *Ophonus puncticeps* (Stephens), are newly recorded from Prince Edward Island. Four species, *Trechus quadristriatus* (Schrank), *Porotachys bisulcatus* (Nicolai), *Amara ovata* (Fabricius), and *Harpalus rubripes* (Duftschmid), are newly recorded from Nova Scotia. Of these, *T. quadristriatus*, *A. ovata*, and *H. rubripes* are newly recorded for Atlantic Canada as a whole. Specific details follow.

Notiophilus biguttatus (Fabricius, 1779)

PRINCE EDWARD ISLAND. Queens Co.: St. Patricks, 17.viii.2002, C.G. Majka, (2), mixed forest, CGMC; St. Patricks, 25.vi.2003, C.G. Majka, mixed forest, CGMC; Millvale, 15.viii.2004, C.G. Majka, (3), along river, CGMC; Springfield, vii.2003, K. MacNeil, (2), potato field, pitfall trap, ACPE.

Newly recorded on Prince Edward Island. Widely distributed in Nova Scotia (Fig. 1). Lindroth (1957) collected the species at Dartmouth, Appledore, Fremington, and Barnstaple — four of eight principal sites in southwestern England where dry ballast destined for Atlantic Canada originated. First recorded in North America in St. John's, Newfoundland, in 1923 (Brown 1950).

Carabus granulatus hibernicus Lindroth, 1956

NOVA SCOTIA. Cape Breton Co.: Sydney, 25.vi.1951, H.-F.M.R., NSAC. **PRINCE EDWARD ISLAND.** No locality indicated, 12.ix.1987, M. Bernard, UMNB; **Kings Co.:** Rollo Bay, 25.vii.2001, C. Noronha, (34), pitfall trap, ACPE; Rollo Bay, 8.viii.2001, C. Noronha, (4), pitfall trap, ACPE.

Newly recorded on Prince Edward Island (Fig. 2). Rollo Bay is located near the port of Souris, one of the main timber-exporting and ship-building ports on the island from the time of the Napoleonic Wars until the end of the 19th century (Townshend 1986). It was precisely this transatlantic commerce that was singled out by Brown (1950) and Lindroth (1957) as responsible for many of the dry-ballast-related introductions of Coleoptera. Although Lindroth (1954) reported that *C. g. hibernicus* had not been found on Cape Breton Island, there is a specimen that was collected in Sydney in 1951. The species is now abundant in the greater Sydney area, although it appears not to have spread to other portions of the island. First recorded in North America in New Brunswick in 1890 (Harrington 1892).

Trechus quadristriatus (Schrank, 1781)

NOVA SCOTIA. Kings Co.: Kentville, 22.viii.2000, S. Westby, raspberry plot, ACNS.

Fig. 1. Collection sites of *Notiophilus biguttatus* in the Maritime Provinces.

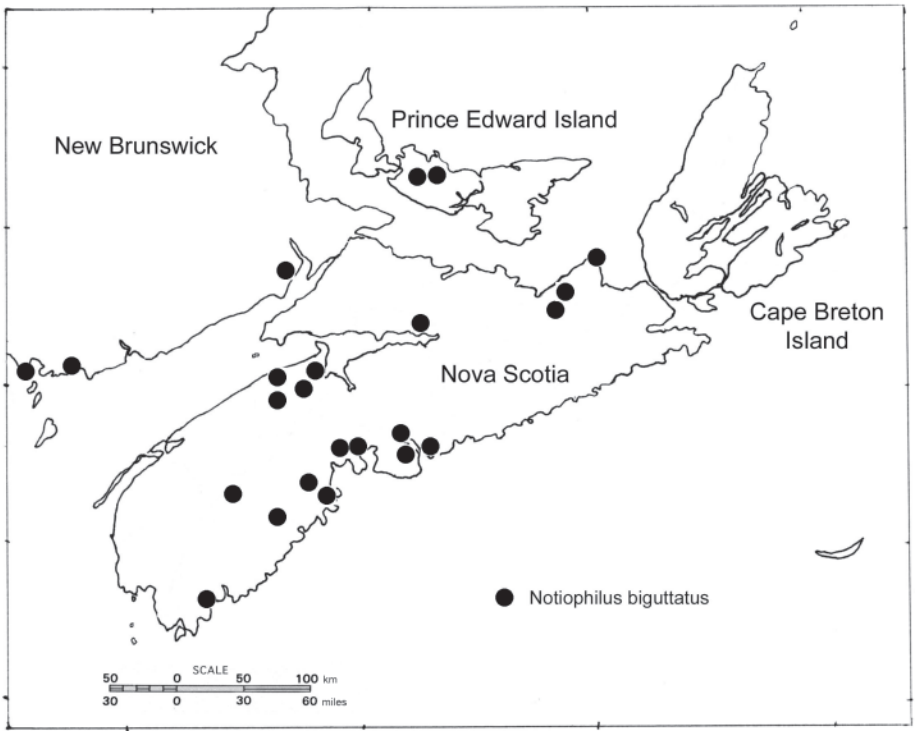


Fig. 2. Collection sites of *Amara ovata*, *Carabus granulatus hibernicus*, and *Ophonus puncticeps* in the Maritime Provinces.

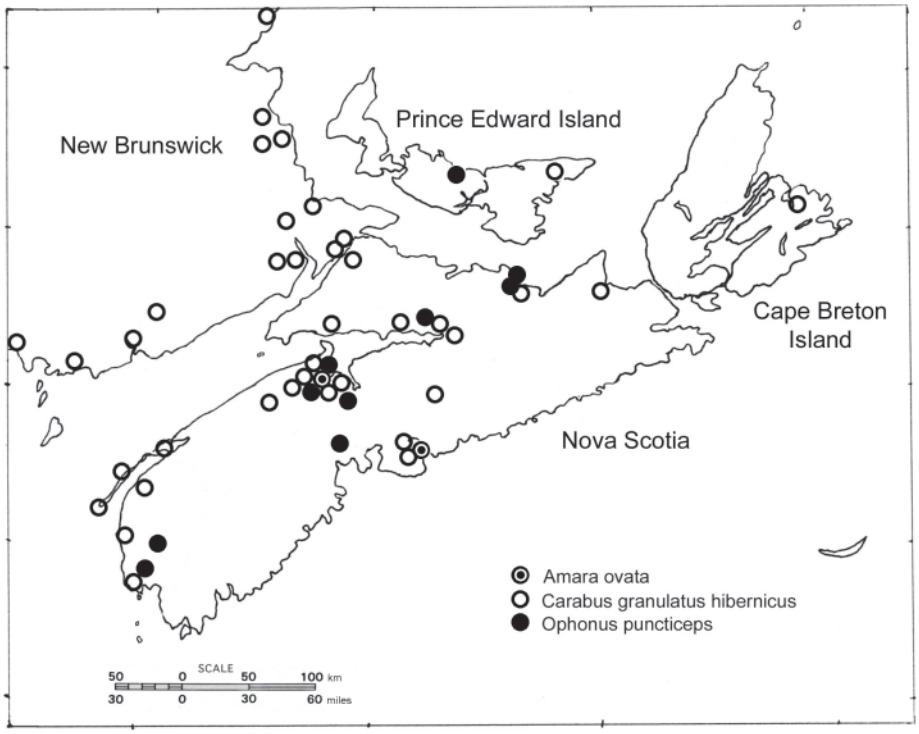
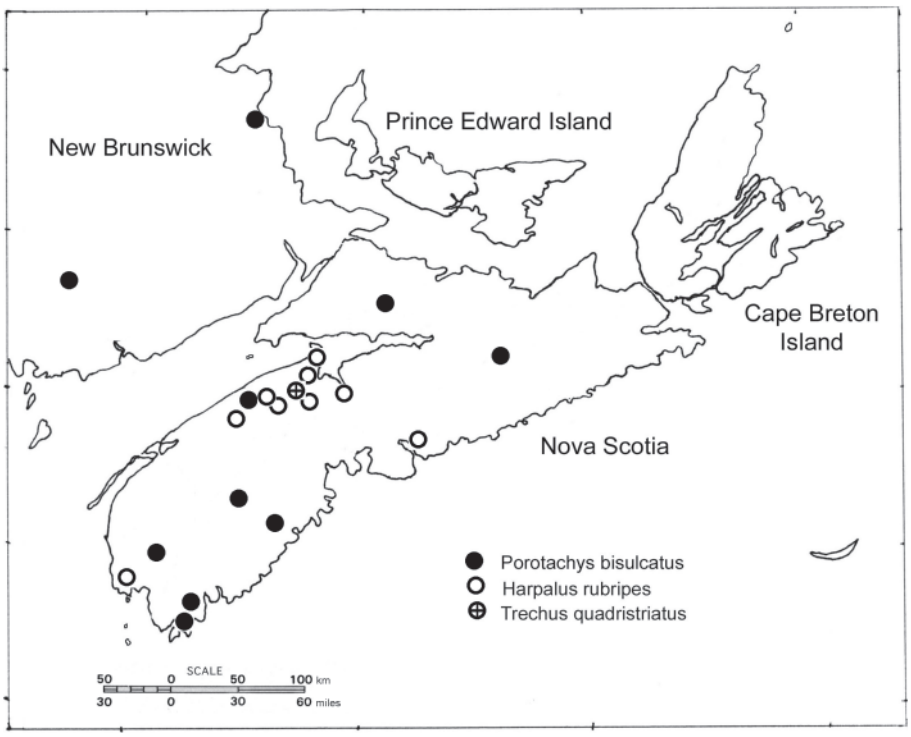


Fig. 3. Collection sites of *Porotachys bisulcatus*, *Harpalus rubripes*, and *Trechus quadristriatus* in the Maritime Provinces.



Newly recorded in Nova Scotia and in Atlantic Canada as a whole (Fig. 3). Further research is required to determine its status in the province and whether its presence there represents a separate introduction or is due to natural dispersion. Lindroth (1957) collected it at ballast sites in Topesham and Appledore, England. Many collection sites in Ontario and Michigan (Bousquet *et al.* 1984) are adjacent to the St. Lawrence River, Lakes Ontario, Erie, and Huron, and Georgian Bay, possibly indicating an association with shipping in the Great Lakes region. First recorded in North America in Ontario in 1965–1981 and in Michigan in 1977 (Bousquet *et al.* 1984).

Porotachys bisulcatus (Nicolai, 1822)

NOVA SCOTIA. Annapolis Co.: Melvern Square, 24.vi.1992, E. Georgeson, NSNR. **Cumberland Co.:** Westchester-Londonderry, 20.vii.1992, S. and J. Peck, (4), forest road, car net, JCC. **Guysborough Co.:** Trafalgar, 19.vii. 1992, S. and J. Peck, (6), car net, JCC. **Queens Co.:** Caledonia, 25.vii.1992, J. and F. Cook, (5), car net, JCC; Medway River Road, 13.vii. 1993, J. and T. Cook, (3), car net, JCC. **Shelburne Co.:** Clyde River Road, 16.vii.1992, S. and J. Peck, car net, JCC. **Yarmouth Co.:** Carleton: Perry Road, 18.vii.1993, J. and T. Cook, (3), car net, JCC; Oak Park Road, 27.viii.1992, J. and F. Cook, (6), car net, JCC.

Newly recorded in Nova Scotia. Although this species was not found in Nova Scotia by Lindroth (1954), the extent of its distribution in the province would appear to indicate that it has been present for a considerable period of time (Fig. 3). Its original habitat was under the bark of trees (Lindroth 1966). It may have been introduced in association with tree nursery stock or the shipment of wood products, as may be the case with *Dromius fenestratus* (Fabricius, 1794) (Majka and Klimaszewski 2004). First recorded in North America prior to 1900 in Massachusetts (Bousquet 1992).

Amara ovata (Fabricius, 1792)

NOVA SCOTIA. Halifax Co.: south-end Halifax, 6.vii.2002, C.G. Majka, garden, CGMC. **Kings Co.:** Starr's Point, May–

December 1991, I. Pearsall, organic apple orchard, NSMC.

Newly recorded in Nova Scotia and Atlantic Canada as a whole (Fig. 2). The specimen from Starr's Point was collected by Pearsall and Walde (1994) but was not correctly determined until recently. Lindroth (1957) collected specimens at ballast sites in Topesham, Plymouth, and Barnstaple, England. First recorded in North America in Toronto, Ontario, in 1928 (Hieke 1990).

Ophonus puncticeps (Stephens, 1828)

PRINCE EDWARD ISLAND. Queens Co.: North Rustico, 17.viii.2002, C.G. Majka, under rock, CGMC.

Newly recorded in Prince Edward Island; widely distributed in Nova Scotia (Fig. 2). In Nova Scotia, specimens have been collected from the shoreline at Caribou at the terminal where ferries destined for Prince Edward Island originate, suggesting a possible conduit for the species. Lindroth (1957) collected it at ballast sites in Plymouth, Appledore, and Fremington. First recorded in North America on Long Island, New York, in 1954 (Dietrich 1957).

Harpalus rubripes (Duftschmid, 1812)

NOVA SCOTIA. Annapolis Co.: Middleton, 20.vii.2004, S. Westby, near stream, ACNS. **Halifax Co.:** Burnside, 28.v.2003, C. Cormier, field: on decomposing pig, SMU. **Hants Co.:** Quarry Lake, 9.vi.2004, S. Westby, gypsum near water, ACNS. **Kings Co.:** Kentville, 30.v.2000, 20.vi.2000, 27.vi.2000, 4.vii.2000, S. Westby, raspberry plot, ACNS; Upper Canard, 28.vi.2000, 5.vii.2000, 2.vii.2001, 20.vi.2002, 8.viii.2002, and 3.vii.2003, S. Westby, pear and apple orchards, ACNS; Morristown, 24.v.2002, S. Westby, apple orchard, ACNS; Houston Beach, 12.v.2004, S. Westby, beach, ACNS; Aylesford, 30.vi.2005, R. Smith, apple orchard, ACNS; Sunken Lake, 8.v.2005, E. Burke, lakeshore, NSMC. **Yarmouth Co.:** Wellington, 12.vii.1997, J. Cook, ultraviolet light trap, JCC.

Newly recorded in Nova Scotia and Atlantic Canada as a whole. A specimen collected at carrion in Burnside may indicate predation on dipteran larvae. The extent of its distribution in Nova Scotia would appear to indicate that it has been present for a considerable period of time (Fig. 3). Although it was not found by Lindroth (1954), it may have been introduced via dry ballast shipments and may have persisted undetected. Lindroth (1957) collected specimens at ballast sites in Poole, Topesham, Appledore, and Barnstaple, England. First recorded in North America in New Hampshire in 1981–1983 (Bell and Davidson 1987).

Discussion

Establishing the historical origins of introduced species is fraught with uncertainty. It is noteworthy, however, that five of the seven species discussed herein were collected at multiple sites in southwestern England where dry ballast (bulky rock, sand, and soil) destined for Atlantic Canadian ports originated (Lindroth 1957). Brown (1950) and Lindroth (1957) both advanced the idea that ships' dry ballast was a probable source of entry of many adventive ground-dwelling Coleoptera. Brown (1950) noted that large quantities of dry ballast were unloaded at Atlantic ports during the Napoleonic Wars (1799–1815) by British merchants in search of timber when Baltic ports were closed to Britain. This practice continued until the end of World War I, providing many opportunities for introductions.

Although the flightless beetle *C. g. hibernicus* is not amongst the taxa reported by Lindroth, its presence (and that of *Amara communis* (Panzer, 1797) (Majka 2005)) at Rollo Bay near the port of Souris and that town's historical role in relation to timber and shipbuilding commerce on Prince Edward Island would suggest a dry-ballast-associated introduction for both of these species, the more so since neither species has been found on other portions of the island.

The presence of *T. quadristriatus*, *A. ovata*, and *H. rubripes* in Nova Scotia appears to represent separate introduction events because these populations are markedly disjunct from those previously reported in North America. The presence of *H. rubripes* is puzzling because its discovery at multiple sites in southern Nova Scotia would appear to indicate that it has been established in the province for some time, despite a dearth of earlier records. *Ophonus puncticeps* is rapidly expanding its range in North America and, being an adept flier, may have made its way to Prince Edward Island

through natural dispersion; however, its presence at the ferry terminal at Caribou, Nova Scotia, may indicate human-mediated dispersion.

The present additions increase the introduced carabid fauna of Nova Scotia to 35 species (12.3% of the 285 species) and that of Prince Edward Island to 24 species (15.1% of 159 species). This is slightly less than the overall proportion of adventive species of Coleoptera found in Nova Scotia (14.6%) and Prince Edward Island (18.2%) (C.G. Majka, unpublished data). The impact of these introductions on native faunas and the environment has been little investigated in the Maritime Provinces.

In some instances introduced species occupy synanthropic environments, which did not exist prior to European colonization. In British Columbia Spence and Spence (1988) listed 20 species of adventive carabids, 4.1% of the BC fauna. They reported weak (but statistically significant) evidence that introduced species may reduce the diversity of the native fauna in anthropogenic habitats. In British Columbia Smith *et al.* (2004) reported that 13 of 44 Carabidae (29.5%) found in apple orchards were introduced species, while in Nova Scotia Pearsall and Walde (1994) found that 11 of 35 species (31.4%) in apple orchards were nonnative.

Spence and Spence (1988) found little evidence that introduced species were colonizing undisturbed forests in British Columbia, and this appears equally true in eastern Canada. In a study of Carabidae in yellow birch (*Betula alleghaniensis* Britt.; Betulaceae) forests in southeastern Quebec, Klimaszewski *et al.* (2005) found that only 4 of 38 species (and 0.2% of individuals) were nonnative. Bertrand (2005), in a study of Carabidae in deciduous and coniferous forests in northwestern New Brunswick, found that only 2 of 54 species (*Clivina fossor* (L., 1761) and *Pterostichus melanarius* (Illiger, 1798)) and 2% of individuals were introduced. D'Orsay (2005) found only 14 native species of Carabidae in forested communities on Cape Breton Island, Nova Scotia. In a study of forest-floor Coleoptera in deciduous and coniferous forests in Kejimkujik National Park, Nova Scotia, only 14 native species of Carabidae were found (C.G. Majka and T. Rossolimo, unpublished data). In nine mixed coniferous forest stands in southwestern Nova Scotia, Dollin (2004) found that only one of 17 species (*Harpalus affinis* (Schrank, 1781)) of Carabidae and 0.2% of individuals were nonnative.

Lindroth (1963), however, pointed out that in Newfoundland adventive species such as *Agonum muelleri* (Herbst, 1784), *Amara familiaris* (Duftschmid, 1812), *Bembidion bruxellense* Wesmael, 1835, and *H. affinis* have become broadly distributed. This seems true of *N. biguttatus*, *O. puncticeps*, and *P. bisulcatus* in the Maritimes. Spence and Spence (1988) noted that in British Columbia several introduced species (particularly *Carabus g. granulatus* L., 1758, *Carabus nemoralis* Müller, 1764, and *P. melanarius*) have invaded a broad range of early and intermediate successional habitats. In a study of Coleoptera of Point Pleasant Park, Nova Scotia, a much disturbed successional forest (see Majka and Klimaszewski 2004), 11 of 40 species of Carabidae (27.5%) and 29.8% of individuals were nonnative (C.G. Majka, unpublished data), an indication that introduced species have made substantially greater inroads in disturbed habitats than in undisturbed ones.

The effect of such exotic species on native environments may not be straightforward. Niemelä and Spence (1991) found no discernible impact of *P. melanarius* on native carabid assemblages in Alberta, nor were there any negative pairwise associations between this species and any of the abundant native species. This was true in both synanthropic urban environments and relatively undisturbed deciduous forests. They argued that this supports the view of Ricklefs (1987) and Hengeveld (1989) that biological communities are unsaturated aggregations of species, the compositions of which are to a great extent determined by regional and historical processes such as migration. In their view, the lack of a discernible impact of *P. melanarius* also supports the idea that not all invasions of exotic species need threaten the biological diversity of the recipient fauna.

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