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Introduced leaf beetles of the Maritime Provinces, 8: *Gastrophysa polygoni* Linnaeus (Coleoptera: Chrysomelidae)

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Abstract

The taxonomy, nomenclature, identification, introduction history, biology (reproduction, phenology, parasites, predators, host plants), biocontrol potential, susceptibility to pesticides, and economic importance of *Gastrophysa polygoni* (Linnaeus) in North America are reviewed. This information is part of continuing surveys and research on the adventive leaf beetles of Canada with particular reference to the Maritime Provinces. Known provincial records are confirmed and new locality records are reported for the widely distributed *G. polygoni*. The introduction timelines and dispersal of the beetle in North America are discussed. Clearly *G. polygoni* must have been established early in the settlement of North America because reports from the first half of the 19th century already indicated that the species was widely established and common in many locations in the northeastern United States and eastern Canada. *Gastrophysa polygoni* is beneficial when it feeds on weeds such as *Polygonum* spp, *Fallopia* spp, or *Rumex* spp. It can be a minor pest of cultivated buckwheat (*Fagopyrum* spp.)

Key words*:* Coleoptera, Chrysomelidae, *Gastrophysa polygoni*, Canada, Maritime Provinces, introduced species, adventive beetles, *Fallopia*, *Polygonum*, *Rumex*

Introduction

Gastrophysa polygoni (Linnaeus, 1758) is widely distributed throughout the Palearctic region from Europe east to Siberia, China, and Turkistan. An immigrant species in North America (Jolivet 1951a), it has been recorded across Canada from British Columbia to the Maritimes Provinces, but has not been found in Newfoundland and Labrador (LeSage 1991). In the United States it is found from Maine south to New Jersey and West Virginia, and west to Kansas, Nebraska, Wyoming, and Montana (Riley *et al.* 2003). From a biocontrol perspective *G. polygoni* can be considered beneficial when it feeds on weeds (*Fallopia* spp., *Polygonum* spp., *Rumex* spp.) or harmful when it damages cultivated buckwheat (*Fagopyrum* spp.).

Most of the information on the biology of *G. polygoni* in current publications is based on observations made in the 1980's in southern England (Sotherton 1982a, b; Sotherton *et al.*1985). The present contribution includes an extensive literature review of Canadian, American, and European publications, and new information obtained from newly examined voucher specimens on the distribution of *G. polygoni* in the Maritime Provinces of Canada. Specifically, the early life history work by Whitehead (1919) in Nova Scotia and other studies by Johnson & Carrick (1950) and Chevin (1964, 1968) are reviewed.

Methods and conventions

Abbreviations of collections (following Evenhuis 2009) referred to in the text are:

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ACNS	Agriculture and Agri-Food Canada, Kentville, Nova Scotia, Canada
ACPE	Agriculture and Agri-Food Canada, Charlottetown, Prince Edward Island, Canada
CBU	Cape Breton University, Sydney, Nova Scotia, Canada
CNC	Canadian National Collection of Insects, Arachnids, and Nematodes, Ottawa, Ontario, Canada
JOC	Jeffrey Ogden Collection, Truro, Nova Scotia, Canada
NBM	New Brunswick Museum, Saint John, New Brunswick, Canada
NSAC	Nova Scotia Agricultural College, Bible Hill, Nova Scotia, Canada
NSMC	Nova Scotia Museum Collection, Halifax, Nova Scotia, Canada
STFX	St. Francis Xavier University, Antigonish, Nova Scotia, Canada
UMNB	Université de Moncton, Moncton, New Brunswick, Canada
UPEI	University of Prince Edward Island, Charlottetown, Prince Edward Island, Canada

The botanical nomenclature used follows *The Flora of North America*. Further details are given below in the host plant section.

Information on localities, habitats, host plants, and ecology was compiled from voucher specimens of *G. polygoni* collected in the Maritime Provinces and housed in the reference collections listed above. The number of specimens examined is indicated in parentheses together with the collection abbreviation.

Nomenclature

Gastrophysa polygoni was described by Linnaeus (1758) within the genus *Chrysomela*. This genus was subsequently split into more precisely defined genera. Although not described as such in the second edition of the Dejean's (1836) catalogue, the genus *Gastrophysa* Chevrolat was valid because it used valid specific names described under it (ICZN 1999, Article 12.2.5). The absence of generic authorships in Dejean's catalogues created nomenclatorial problems in many groups, although Dejean (1837) declared in the preface of the third edition that the generic divisions employed for the Chrysomelidae were those of M. Chevrolat. Generic characters of *Gastrophysa* were given later by Chevrolat (1843, 1845).

The catalogues were published in several fascicles and released at different dates with the result that users often disagreed on the publication dates of genera. The publication date of 1837 was adopted by Seeno and Wilcox (1982) in their world catalogue, however, Madge (1988) demonstrated that the correct publication date should be 1836.

Hope (1840) described the genus *Gastreoidea* (generally misspelled *Gastroidea*) with *Gastrophysa polygoni* as the type species. Weise (1916) employed this generic name until Barber & Bridwell (1940) demonstrated that *Gastrophysa* was valid and had priority over *Gastreoidea* (Jolivet 1952). *Phaedon rubripes* Philippi & Philippi should also be added to the synonyms listed by Riley *et al.* (2003). This synonymy was established by Askevold (1991) who concluded that the original description was based either on a mislabeled specimen or on an accidental introduction.

The etymology of the generic name *Gastrophysa* (venter + inflated) refers to the markedly distended abdomen of gravid females (Fig. 2). The genus is currently divided into two subgenera, *Gastrophysa sensu stricto*, and *Exiguipenna* Jolivet which includes two brachypterous species restricted to the Iberian Peninsula and Bosnia (Jolivet 1951b).

Identification

Although relatively small (4–5 mm), adults of *G. polygoni* are easily recognized in the field by their orange-reddish prothorax, legs, and abdomen contrasting with the metallic blue or green head and elytra, a color pattern uncommon in the Canadian fauna (Figs. 1, 2). *Gastrophysa polygoni* can be confused with *Oulema*

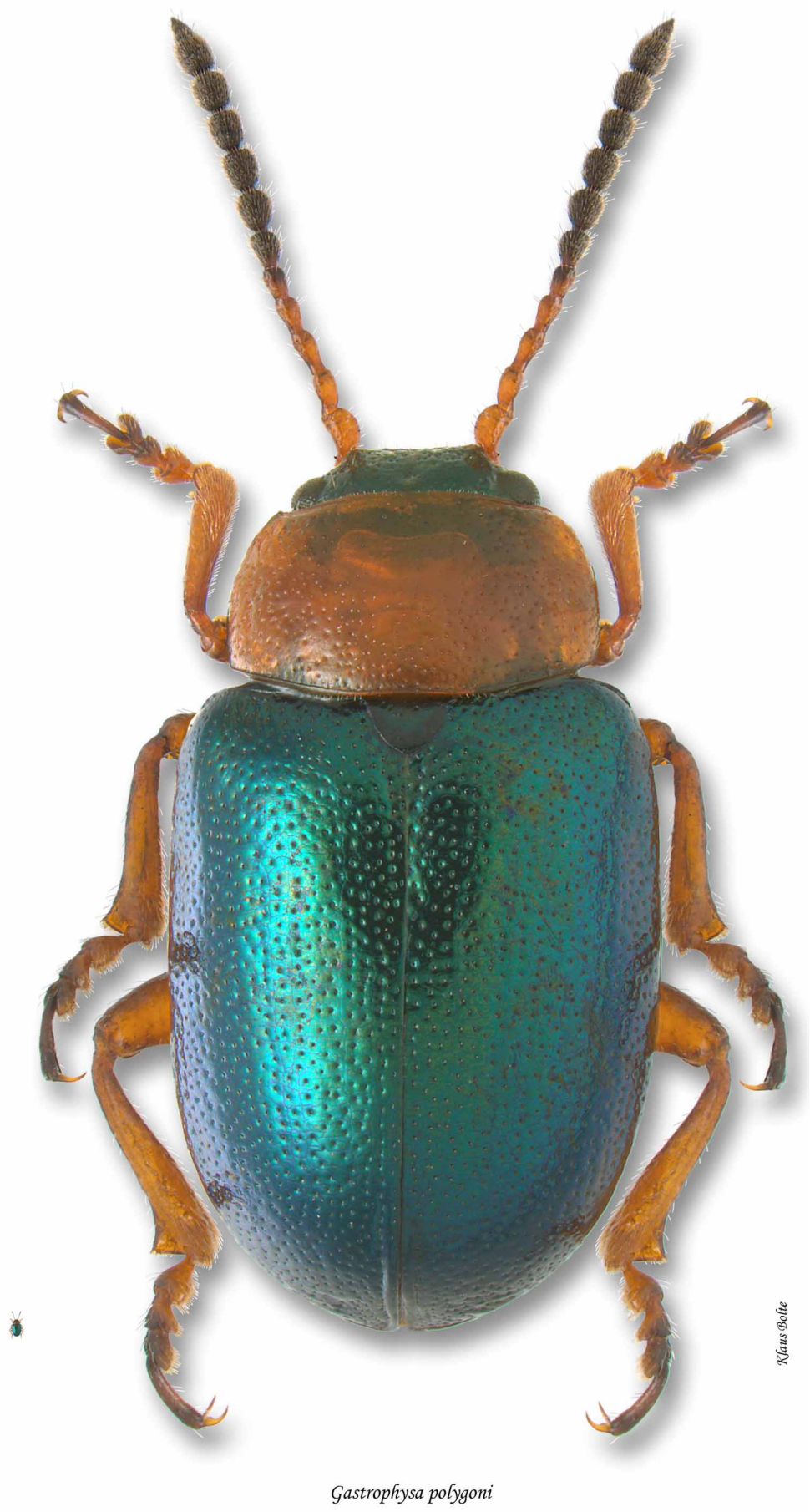

FIGURE 1. *Gastrophysa polygoni*, habitus of male, dorsal view.

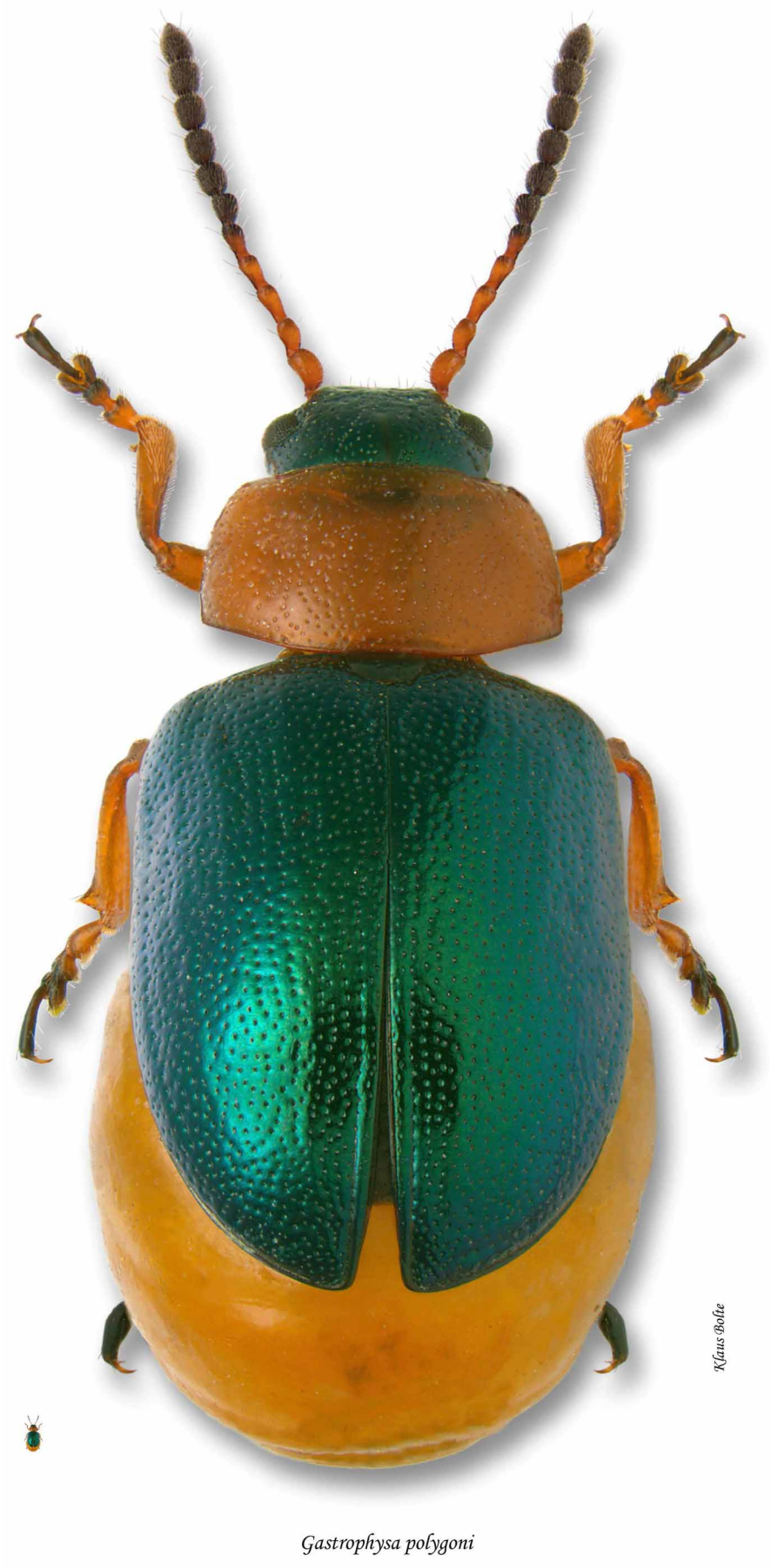

FIGURE 2. *Gastrophysa polygoni*, habitus of female, dorsal view.

melanopus (Linnaeus, 1758) as they occur in the same habitats and are superficially similar. However, *G. polygoni* possesses a distinct lateral bead on the pronotum and confused elytral punctures (Figs. 1, 2) whereas the sides of the pronotum are rounded in *O. melanopus* and its elytral punctures are arranged in regular rows (LeSage *et al.* 2007, Fig. 1). The internal and external sexual characters were discussed and illustrated by Jolivet (1951a). The male genitalia show relationships between *Gastrophysa* and *Plagiodera* (Powel 1941).

Eggs are bright yellow, cylindrical (1.44 x .44 mm), and deposited in compact groups on the underside of leaves. Line drawings of the egg habitus are available in Whitehead (1919) and Jolivet (1951a), but detailed illustrations of the chorion microsculpture are still needed to enable identification at the species level.

Larvae are eruciform, largely yellowish except the darker dorso-lateral sclerites. A lateral habitus of the mature larva is illustrated by Whitehead (1919) and Jolivet (1951a). The most important larval morphological characters are, the first eight abdominal segments without any ambulatory warts, anal opening ventrally placed in the middle of a sucking disk on the tenth abdominal segment, labial palpus two-segmented, front with four setae, labrum deeply notched, sclerites light yellow (Bøving & Craighead 1931; Jolivet 1951a; Medvedev & Zaitsev 1978). Illustrations of the chaetotaxy of the head, mouthparts, body sclerites, and legs are found in Paterson (1931) and Medvedev & Zaitzev (1978). Identification keys are available in Bøving & Craighead (1931), Paterson (1931), Jolivet (1951a), Medvedev & Zaitsev (1978), and Cox (1982). The egg bursters of first instars are located on the meso- and metathorax (Cox 1988, 1994a).

The pupa of was described by Paterson (1931) and Jolivet (1951a). A lateral view is provided by Paterson (1931), a ventral view by Whitehead (1919). The pupa is yellow and bears nine pairs of marginal setae on the pronotum. The meso- and metathorax are devoid of setae. There are two rows of median setae on abdominal segment I–VI and paired lateral setae. Spiracles are present on segments I–VI. Steinhausen (1998) divided the chrysomeline pupae into five groups according to the morphological differences of the 9th abdominal segment. *Gastrophysa* falls within the Chrysomelini (group 3) since there is no projection on the 9th abdominal segment.

Historical review

Gastrophysa polygoni is one of the first beetles to have been described or reported in North America. Say (1826) described it from Indiana under the name *Chrysomela caeruleipennis* as, "a beautiful and rare species, an inhabitant of the North West Territory. I received a specimen from Mr. John P. Brace of Litchfield [Connecticut], and another from Dr. T.W. Harris." Harris (1833) included it in the first edition of his catalogue of the insects of Massachusetts under the name *C. caeruleipennis*, but in subsequent editions stated that it was identical to the European *C. polygoni* and that it was the most common leaf beetle in New England (Harris 1833, 1842, 1852, 1862). Dr. MacCulloch and Captain Hall found it in Nova Scotia in approximately 1827 (Kirby 1837, as *Phaedon polygoni*). Rogers (1856) reported it from the southern and central American states. Couper (1864) was the first entomologist to collect it in Québec City. Provancher (1877) treated it in his textbook on the Québec fauna and pointed out that it was very common on knotweed. Subsequent authors reported it from various parts of North America; Hubbard & Schwarz (1878) from the Lower Peninsula of Michigan, Dury (1879, 1902) from Cincinnati (Ohio), LeConte (1881) from Lower Fort Gary (Manitoba), Zesch & Reinecke (1882) from Buffalo (New York), Hayward & Savage (1883) from the Green Mountains (Vermont), Harrington (1883) from Ottawa (Ontario), and Bowditch (1896) on the summit of Mount Washington (New Hampshire). Fauvel (1889) stated that it was common and abundant from Nova Scotia to Mississippi.

Little biological information exists on *G. polygoni* in North America, although it has been known for almost two centuries on this continent. Whitehead (1919) reported observations on its biology. Gorham (1928) noted damage to rhubarb. MacNay (1955a, b, 1956a, b, 1957) discussed its potential as a biocontrol agent.

Biology

Gastrophysa polygoni is one of the commonest leaf beetles in cereal fields where it feeds on knotweeds (*Polygonum* spp., *Fallopia* spp.) or docks (*Rumex* spp.) (Whitehead 1919; Johnson & Carrick 1950; Chevin 1964; Potts & Vickerman 1974; Sotherton 1982a). The overwintered adults leave their winter shelters in late April or early May in southern England (Sotherton 1982a), but not so early in the Maritimes. The earliest specimens collected in the region were from June 2 in Fredericton (New Brunswick). The earliest specimen preserved in the Canadian National Collection was caught on May 9 at Niagara Falls in southern Ontario.

Adults mate a few days after emergence, three days in France (Chevin 1964), usually eight in England (Johnson & Carrick 1950). They feed by eating the margins of leaves (Johnson & Carrick 1950). No noticeable weight increase is observed in the male, but females gain considerable weight. Females can live 20+ days more than males, especially if they are feeding on *Fallopia convolvulus* or *Polygonum dumetorum* (Chevin 1968).

Medvedev & Pavlov (1988) studied the mating behavior of several chrysomelids including *G. polygoni*. In most species, all tarsi of the male are clasped on the elytra of the female, the hind pair usually placed at the outer margins. This is the case in *G. polygoni* during the initial period of pairing when the male inserts its aedeagus into the female, but during the peak of mating activity he will stand upright on the enlarged abdomen of the female, vigorously shake his forelegs, and vibrate his antennae.

Egg laying begins after a pre-oviposition period of 6–11 days. The oviposition period lasts about 44 days, begins in early May, peaking at the end of the month. The eggs are enveloped with a glutinous matter, and laid in batches on the underside of leaves. The number of eggs laid in a batch varies; 20–35 (Whitehead 1919), 25–40 (Jolivet 1951a), 17–31 (Chevin 1964), 23–98 (Sotherton 1982a). Between two and four batches could be laid per day. Although never specifically described for *G. polygoni*, the oviposition process should be very similar to that described in detail for *G. viridula* [as *G. raphani* Herbst, 1783], by Osborne (1880) and Remaudière (1948). Eggs are deposited on their sides, in rows, the ends of some fitting into the intervals between the ends of the preceding ones.

Fecundity measured in the field varied from 835 to 1016 eggs per female in the first generation, to 587 to 1028 eggs in the second (Sotherton 1982a). In the laboratory, Chevin (1964) obtained 2085–2930 eggs under a photoperiod of light of 18 hours and 1837–2776 eggs with 12 hours of lighting per day. This author also estimated that the weight of eggs inside a gravid female represented almost 30 times its initial weight. The oviposition period lasts 43–45 days in the first generation, 19–33 days in the second. A partial third generation may occur in some years. The number of generations is not fixed and these develop continuously one after the other over the year (Remaudière 1963).

No parasites or pathogens were found attacking the eggs. Egg mortality attributed to waterlogging (0 %), infertility (5 %), and cannibalism (2 %) was not important (Sotherton 1982b). Predation, however, was important. Both eggs and larvae of *Gastrophysa cyanea* are chemically protected by substantial quantities of oleic acid that deters ants. They owe their bright yellow color primarily to beta-carotene (Howard *et al*. 1982).

The three larval instars of *G. polygoni* were described and keyed by Henriksen (1927). First instars feed on the egg chorion before feeding on the plant, and unhatched eggs are occasionally cannibalized by neonate larvae (Chevin 1964). First instars fenestrate the leaves, remaining on those on which they hatch, whereas second and third instars chew holes through the leaves and tend to move from plant to plant. When fully developed, they enter the soil where they pupate in an earthen cell. Under laboratory conditions, Chevin (1964) obtained a complete life cycle in 19 days at 27° C, 24 days at 23° C, and 29 days at 20° C.

Blum *et al*. (1978) first reported methylcyclopentanoid monoterpenes in the larval secretions of *G. cyanea*. Chrysomelidial was identified as the active repellent in the Japanese *Gastrophysa atrocyanea* Motschulsky, 1860 (Sugawara *et al.* 1979). These secretions are very efficient deterrents against small predators such as ants. In a larger context, the chemical ecology of defense and its evolution in arthropods and leaf beetles was reviewed by Pasteels *et al.* (1982, 1983, 1984, 1989, 1990).

Pupae (5.0–5.5 mm long) are yellow with brown setae arranged in regular rows. Adults of the first generation emerged from the soil in late June and early July in southern England (Sotherton 1982a). The total duration of the development of the first generation varied from 35 to 69 days, that of the second generation from 31 to 53 days.

In Germany adult diapause may be induced by low temperatures, decreasing day lengths and food shortage during the first two days after emerging from the pupa (Hilterhaus 1965). In contrast, *G. atrocyanea* undergoes obligatory diapause that is not induced by environmental conditions but genetically controlled; electrophoresis showed that a specific glycoprotein present during diapause disappears upon completion (Ichimori *et al.* 1987, 1990). Male longevity is about 42 (21–59) days; that of the female is 57 (42–72) days (Chevin 1964, 1968).

Simonsen *et al.* (1999) studied the gene flow of *G. polygoni* from four Danish localities. The level of heterozygosity was of the same magnitude for all populations studied. The estimated gene flow corresponded to 3–4 reproducing individuals per generation which indicates that genetic exchange between the populations does occur. *Gastrophysa polygoni* has a modal number of $2n = 24$ chromosomes and Xy_p sex–system (Petitpierre 1978).

Parasites

Egg parasitoids are unknown in *G. polygoni* (Sotherton *et al.* 1985) and have not been found in the native *G. cyanea* (Girault 1908). Only one tachinid fly (*Meigenia* sp.) was reared from 4170 eggs and 2040 larvae collected in the field in southern England (Sotherton 1982a).

In the Diptera, the parasitic tachinid genus *Meigenia* Robineau-Desvoidy is associated with *Gastrophysa* spp. larvae (Lundbeck 1927; Van Emden 1950; Cox 1994b). Jolivet (1946, 1948, 1949, 1950) listed *M. floralis* Fallén, 1810 and *M. mutabilis* Fallén, 1810 as larval endoparasites of *G. polygoni* in France. Lundbeck (1927) observed that only one parasite developed in each larval host.

In the Hymenoptera, the braconid *Microbracon fuscipennis* (Wesmael, 1838) parasitizes the larvae of *G. polygoni* in France (Thompson 1943; Jolivet 1950). In North America, the braconid *Microctonus gastrophysae* (Ashmead, 1889) was reared from larvae of *G. cyanea* and from those of *G. formosa* Say, 1824 [misidentified as *G. viridula fide* Jolivet & Théodoridès (1951)] in the District of Columbia, Virginia, and South Carolina (Muesebeck 1936; Thompson 1943, 1951; Krombein *et al.* 1979).

Phoretic deuteronymphs of *Histiostoma* sp. (Acarina, Histiostomatidae) were found under the elytra of *G. cyanea* and *G. formosa* (*sub G. viridula*) (Jolivet 1954).

Larvae of *G. cyanea* were the intermediate host in the life cycle of the trematod, *Brachylecithrum americanum* Denton, a liver fluke of several passerine birds (Denton 1945). This very unusual infestation was induced experimentally by spreading cercariae of the trematod on the leaves of *Rumex* on which *G. cyanea* larvae fed (Jolivet & Théodoridès 1950).

An unidentified fungal pathogen was found once in *G. polygoni* (Sotherton 1982a). *Nosema gastroideae* Hostounský & Weiser, 1973 (Microsporidia, Nosematidae) was described from infected *G. polygoni* and *Leptinotarsa decemlineata* (Say, 1824) (Hostounský & Weiser 1973).

Predators

Weed-dwelling insects such as *G. polygoni* constitute an important component of the diet of the grey partridge (*Perdrix perdrix* Linnaeus, 1758) (Vickerman and O'Bryan 1979). Third instar larvae are favoured by chicks (Sotherton 1978). The decline of the grey partridge after the Second World War can be explained in terms of decreased chick survival, which in turn, can be related to the decline of weeds in cereals (Potts 1970). Thus, weeds help support biodiversity within agroecosystems (Marshall *et al.* 2003).

The most important invertebrate predators of *G. polygoni* are polyphagous climbing species in the Coleoptera and Dermaptera. Surprisingly, Coccinellidae (Coleoptera), Syrphidae (Diptera), Nabidae (Heteroptera), and Anthocoridae (Heteroptera) did not feed on eggs or larvae of *G. polygoni* in laboratory tests (Sotherton 1982b). On the other hand, eggs and first instar larvae were preyed upon by the carabids *Agonum dorsale* (Pontappidan, 1763), *Demetrias atricapillus* (Linnaeus, 1753), and *Nebria brevicollis* (Fabricius, 1792), and the staphylinids *Philonthus cognatus* (Stephens, 1832), *P. laminatus* (Creutzer, 1799), and *Tachyporus hypnorum* (Fabricius, 1775). Second and third instar larvae were mainly attacked by the carabids *Pterostichus madidus* (Fabricius, 1775), and *P. melanarius* (Illiger, 1798), and undetermined staphylinids (*Philonthus* spp.). The common earwig, *Forficula auricularia* (Linnaeus, 1758), also preyed on eggs and larvae. Lesne (1927, 1928) and Jolivet (1950) listed the histerid beetle *Saprinus virescens* (Paykull, 1798) as a predator of the larvae of *G. polygoni* in France on the basis of an old observation by Léveillé (1881) who thought the beetles were feeding on the larvae under the leaves of *Polygonum maritimum* L.

Host plants

The true host plants of *G. polygoni* are found in the plant family Polygonaceae, mainly in the genera *Polygonum*, *Fallopia*, and *Rumex*, although a considerable number of unrelated, secondary, or incidental hosts have been reported (Remaudière 1963; Clark *et al.* 2004). In Europe, the preferred host is *Polygonum aviculare* L. and to a lesser extent *Fallopia convolvulus* (Remaudière 1963; Chevin 1968; Sotherton 1982a, 1982b). According to Force (1966), *G. cyanea* preferentially feeds on *Rumex crispus* L. and is attracted by substances produced by the plant. A similar attraction is probable in *G. polygoni*, but such attractants have not been identified.

Little information is available on the host plant preferences of *G. polygoni* in North America. For the Maritimes the only study is that of Whitehead (1919) who found eggs on *F. convolvulus* and reared the beetle on this weed. In Manitoba, the "normal" host was *P. aviculare* (Handford 1939). In Québec, Provancher (1877) reported it on *Polygonum* sp. and Chagnon (1938, 1940) and Chagnon & Robert (1962) recorded it from *P. aviculare*. In Alberta, Hocking (1957) stated that *G. polygoni* was the most conspicuous chrysomelid in the province on rhubarb, radish, and cabbage but pointed out that these vegetables were not the normal hosts. During the summers 1956 and 1957, *G. polygoni* vigorously attacked wild buckwheat (*Fagopyrum* sp.) in Saskatchewan (MacNay 1955a, 1957; SEL 1957). Handford & Arrand (1958) reported that the beetle attacked wild buckwheat in grain fields throughout central and west-central Saskatchewan, in some instances causing severe defoliation. MacNay (1957) and Handford & Arrand (1958) added that the beetle also occurred in Moose Jaw on *P. aviculare*.

Biocontrol

MacNay (1955a) reported that Saskatchewan farmers regarded *G. polygoni* as beneficial because the defoliation of *F. convolvulus* caused by this species assisted in harvesting operations. Some growers have even collected specimens for release in fields infested by wild buckwheat (MacNay 1956a). Complete defoliation was observed in several localities, especially those in the west-central portion of this province (MacNay 1955a, 1955b, 1956b). McDonald (1956) and McDonald *et al.* (1956) reported that *G. polygoni* effectively controlled wild buckwheat in west-central Saskatchewan and observed that *G. polygoni* completely eliminated the weed in plots being used in herbicide tests. These preliminary observations on *G. polygoni* were not tested further in Canada, except once at the research station in Sainte-Foy (Québec). An absence of competition between wheat, oats, and wild buckwheat at the research station was attributed to the presence of *G. polygoni* in experimental fields, but the original data were never published (Bourget 1976).

In Italy, Marocchi (1994) suggested that the reduced use of insecticides in alfalfa fields might obviate the need for herbicides to control *P. aviculare*. He came to this conclusion after observing total destruction of the weed in ditches on the borders of a beet field and in alfalfa fields by *G. polygoni* on a farm near Bologna. In Turkey, the beetle was identified as a potential candidate for the control of *F. convolvulus* (Kismali & Madanlar 1990). In Poland, Piesik (2000) studied the dynamics of *G. viridula* and *G. polygoni* on mossy sorrel (*Rumex confertus* Willd.). The effect of *G. polygoni* was much less than that of *G. viridula* because only two generations were observed in this species (three in *G. viridula*) and it was thirty times less abundant than *G. viridula*.

Hatcher *et al.* (1994a, b, c, 1995) studied the effects of *G. viridula* alone or combined with the rust fungus *Uromyces rumicis* (Schum.) for the control of curled (*R. crispus*) and broad-leaved dock (*R. obtusifolius* L.). Such results could also apply to *G. polygoni*.

Economic importance

In Canada, *G. polygoni* has only been reported once attacking the foliage of rhubarb (*Rheum rhaponticum* L.) in New Brunswick (Gorham 1928). In Europe, occasional damage has also been reported on rhubarb (Balachowsky & Mesnil 1936).

During trials to rear adults of *G. polygoni* on cultivated common buckwheat (*F. esculentum*), Chevin (1964) observed that adults first made large holes in the foliage, but then died after two to five days. Lühmann (1938) noticed that second and third instar larvae and adults fed on buckwheat, but that damage was primarily associated with the presence of *Polygonum (sensu lato)* weeds in the same fields. Young larvae first fed on these weeds before later instars migrated to buckwheat.

In trials conducted in Minnesota, Marcovitch (1916) observed that adults ate leaves and deposited eggs on buckwheat but concluded that *G. polygoni* would probably never become a serious pest.

Distribution in the Maritime Provinces

Gastrophysa polygoni is generally distributed throughout the Maritime Provinces (Fig. 3). Records (46 specimens) from the Maritime Provinces examined in the present study include:

NEW BRUNSWICK: Kent Co.: Buctouche, 4.VI.1990, M. Cassie (1, UMNB); Kouchibouguac National Park, 11.VII.1978, H. Goulet, (1, CNC). **Northumberland Co**.: Tabisintac, 12.VI.1939, W.J. Brown (1, CNC). **Saint John Co**.: Saint John, 19.V.2000, D.F. McAlpine (2, NBM); Saint John, 17.VI.1902, W. McIntosh (1, NBM); Saint John, 20.V.1901, W. McIntosh (1, NBM). **York Co**.: Fredericton, 2.VI.1927, R.P. Gorham (3, CNC).

NOVA SCOTIA: [locality not specified] Kirby (1837, 216, as *Phaedon polygoni*). **Annapolis Co**.: Annapolis Royal, 20.VI.1920, J.P. Spitall (1, CNC); Granville Ferry, [no date specified], H.G. Payne (1, NSAC). **Antigonish Co**.: Antigonish, 24.IX.1996, S. Gillis (1, STFX). **Cape Breton Co**.: Alder Point, 12.VI.1994, V. Jessome (1, CBU); George's River, 29.VI.1997, D.B. McCorquodale (1, CBU). **Colchester Co**.: Debert, 30.VII.1994, E. Georgeson (1, JOC); Debert, 31.VII.1998, J. Ogden (1, NSNR); Old Barns, 26.VIII.1949, F.A. Walsh (1, NSAC); Tatamagouche, 8.VIII.1971 (3, NSAC); Tatamagouche, 9.VIII.1971, L. Blackburn (1, NSAC); Tatamagouche, 9.VIII.1971, L. Blackburn (4, NSAC); Truro, 31.VIII–2.IX.1917, W.E. Whitehead, on *Polygonum* (*Fallopia*) *convolvulus* (Whitehead 1918). **Cumberland Co**.: Nappan, 4.IX.1974, H.B. Specht (4, ACNS). **Halifax Co**.: Halifax, 10.VIII.1945, D.C. Ferguson (1, NCMC); Halifax, 27.VIII.1945, D.C. Ferguson (1, NCMC). **Hants Co**.: Noel Shore, 2.VII.2002, A.J. Hebda, garden (1, NSMC); [no locality specified], "June", K.A. Neil (1 pupa, NSMC). **Kings Co**.: Kentville, 18.VI.1924, [collector unknown] (2, CNC); Kentville, 18.V.1951, C.J.S. Fox (1, ACNS); [no locality specified,], 27.VI.1921, [collector unknown] (2, NSAC).

PRINCE EDWARD ISLAND: Kings Co.: Basin Head, 13.VII.1988, Y. Bousquet (1, CNC); Greenwich, 8.VII.1981, sweeping (2, UPEI); Upton, 6.VIII.1953, F.M. Cannon (1, ACPE). **Prince Co**.: 21.X.1983. M.E.M. Smith, rutabaga field (1, ACPE); O'Leary, 7.VII.1988, M.E.M. Smith, potato field (1, ACPE); Summerside, 17.VI.1992, M.E.M. Smith, potato field (1, ACPE). **Queens Co**.: Borden, 15.VI.1964. G.G.E. Scudder (2, CNC); Charlottetown, 10.VIII.1948, R. H. Wigmore (1, CNC); Charlottetown, 24.VIII.1977, L.S. Thompson (1, ACPE); Harrington, 9.VI.1987, J.G. Stewart, potato field (2, ACPE); Mount Herbert, 10.VI.1921, J.R. Mutch (1, UPEI); Mount Herbert, 29.VII.1921, J.R. Mutch (1, UPEI); Springvale, 31.V.1989, M.E.M. Smith (1, ACPE).

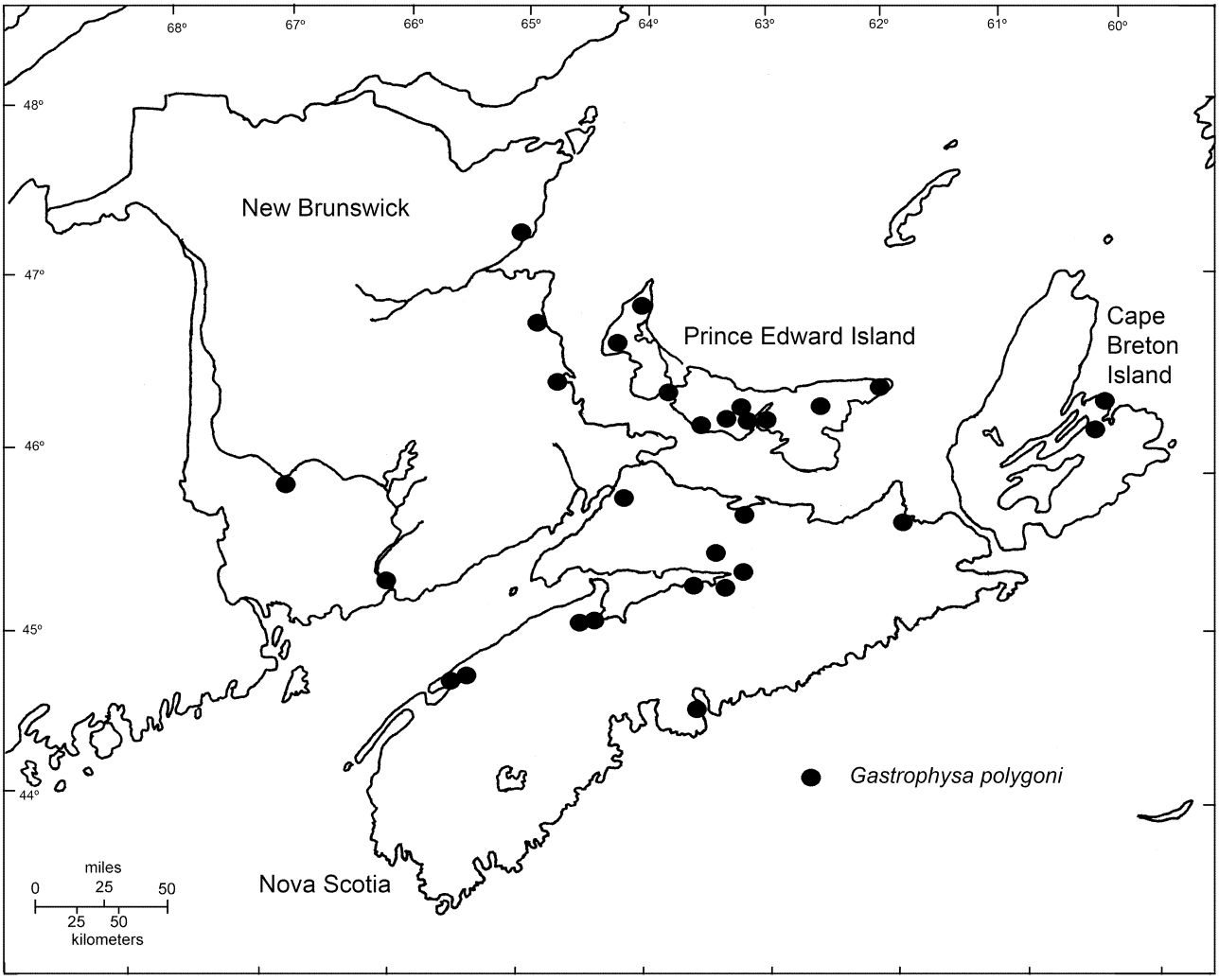

FIGURE 3. Distribution of *Gastrophysa polygoni* in the Maritime Provinces of Canada.

Conclusions

In his survey of introduced weeds of Québec, Rousseau (1968) identified the following major pathways of introduction: contaminated seeds, transported feed for cattle, ornamentals plants, ships' ballast, and manufacturing equipment, in addition to forest clearing, which favoured the establishment of weeds. Because *G. polygoni* feeds mainly on knotweeds and wild buckwheat, and these two weeds are common in cereals, it is probable that the beetle was introduced with weed-contaminated seed. The beetle's establishment of weeds in North America might have been assisted by European farmers, explorers, or soldiers who carried with them hay and cereals contaminated with various weeds for their cattle and horses. This factor may have been conducive for the spread of a species whose natural dispersal capacity is limited (Potts & Vickerman 1974).

It is clear that *G. polygoni* must have been established early in the settlement of North America because reports from the first half of the 19th century already indicated that the species was widely established and common in many locations across New England, west to Indiana, and north to Québec and Nova Scotia. Whether multiple points of introduction were involved cannot be determined because populations across southern Canada and the northern United States have largely merged. The beetle has had a minimal impact as a pest of crops such as buckwheat (*Fagopyrum* spp.) but might have some potential as a biocontrol agent against weeds such as *Polygonum aviculare* and *Fallopia convolvulus*.

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