

Research Article

First Record of the European Rusted Flea Beetle, *Neocrepidodera ferruginea* (Scopoli, 1763), in North America (Coleoptera: Chrysomelidae: Galerucinae: Alticini)

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The European rusted flea beetle *Neocrepidodera ferruginea* (Scopoli, 1763) is reported for the first time from Québec and Ontario, Canada. It was likely introduced into southern Ontario at an international port on the Great Lakes in early 1970s, or possibly earlier in the 1960s. However, the exact location and date of introduction could not be precisely determined. The flea beetle has since dispersed northeastwards and reached Aylmer, north of Ottawa River, in Québec, by 2003. This is about 375 km from Niagara Falls, where the oldest known specimens were collected in 1977. In 2009, various wild habitats and cultivated areas of Aylmer were surveyed. The host plants of the larvae could not be determined, but adults were swept from many plant species including various weeds and cultivated grasses: *Alopecurus pratense* (meadow foxtail), *Dactylis glomerata* (orchard-grass), *Festuca rubra* (red fescue-grass), and *Poa pratensis* (Kentucky blue-grass). Adults were also collected from flowers of several weeds: *Aster* sp. (undetermined species), *Aster novae-angliae* (New England aster), *Ambrosia artemisiifolia* (small ragweed), *Echium vulgare* (viper's bugloss), *Nasturtium officinale* (water cress), *Melilotus alba* (white sweet-clover), *Hypericum perforatum* (common St. John's-wort), *Lythrum salicaria* (purple loosestrife), *Ranunculus acris* (buttercup), and *Solidago* spp. (goldenrods). Since larvae are known to develop inside the roots and central stems of cereals, this new alien species represents a threat to Canadian agriculture, particularly if it reaches the Prairies in western Canada, where cereals represent a considerable part of their economy. *European rusted flea beetle* and *Altise ferrugineuse européenne* are suggested for the English and French common names of this flea beetle, respectively.

1. Introduction

Spectacular and large (20–35 mm) alien insects such as the *Asian longhorn beetle*, *Anoplophora glabripennis* (Motschulsky, 1853), cannot establish themselves unnoticed due to their large size, showy appearance, and the considerable damage they cause to trees. Although much smaller (7–14 mm), the *Emerald ash borer*, *Agrilus planipennis* Fairmaire, 1888, was quickly identified by its bright metallic green color and evident damage to ornamental ash (*Fraxinus* spp.) trees. In contrast, decades may pass before small species are detected, and it may take even longer if they are not associated with economically important plants of horticultural, agricultural, or forestry value. The European flea beetle, *Neocrepidodera ferruginea* [1], is such a species. Its small size (3–4 mm) and

rusty color contributed to hide it within the vegetation. In addition, the lack of regular insect monitoring in agricultural lands of eastern Canada or of surveys in natural habitats also explain in part why it has been thriving unnoticed for over 30 years. Consequently, the present communication provides information on its identification, habitats, biology, host plants, economic importance, and history of introduction into North America.

2. Material and Methods

The specimens collected by the authors were obtained using the technique of LeSage [2].

The habitus photograph was taken using a digital Leica DFC-420 camera mounted on a Leica MZ-16 dissecting

microscope. The male aedeagus was photographed with an image processing system composed of a Nikon SMZ-1500 stereoscopic microscope coupled to a Nikon Digital camera DXM-1200F. The final image treatment was made with Photoshop Elements 7.0 software. The female genitalic features were dissected in 75% ethanol, preserved in terpineol, positioned on a microscope slide, and photographed with a Nikon Coolpix 950 digital camera attached to a Nikon Eclipse E-800 compound microscope.

3. Nomenclature

Originally described as *Chrysomela ferruginea* by Scopoli [1], this species was transferred to the flea beetle genus *Altica* by Geoffroy [3], but in the eighteenth century, the “genus” concept was so broad that it included all contemporary flea beetles. In the second edition of the catalogue of the beetles preserved in the collection of count Dejean, Chevrolat [4] split the large genus *Altica* into several new genera including *Crepidodera* under which he listed *C. ferruginea*, but did not designate a type species for the genus. The generic description itself appeared seven years later in the universal dictionary of d’Orbigny [5] mainly based on a transverse furrow on the pronotum and elytral punctures arranged in rows. Foudras [6] fragmented the original *Crepidodera* into six genera using new taxonomic characters and designated *Chrysomela nitidula* Linnaeus, 1758 as the type species of *Chalcoides*, one of his new genera. According to Biondi [7], Maulik [8] was not aware of this designation and designated the same species (*nitidula*) as the type species of *Chalcoides* Foudras with the result that species previously placed in *Crepidodera sensu* Foudras had to be transferred to *Asiorestia* created by Jakobson [9]. For the following sixty years, the species *ferruginea* was cited by authors in this genus. Exhaustive lists of references can be found in Biondi [10] and Gruev and Döberl [11, 12], and a detailed history of *Asiorestia* in Biondi [7]. The last nomenclatorial change happened when Konstantinov and Vandenberg [13] established the synonymy of *Asiorestia* Jakobson, 1926 with the genus *Neocrepidodera* created by Heikertinger [14] to include in a new generic unit, a Siberian flea beetle, *Ochrosia sibirica*, described by Pic [15], and the Japanese *Crepidodera recticollis* described by Jacoby [16]. Consequently, the official current name of the species treated here is *Neocrepidodera ferruginea* [1].

The early French entomologist Geoffroy [3] and Fourcroy [17] referred to *Neocrepidodera ferruginea* as the “*Altise fauve à stries*” on the basis of its elytral punctures arranged in rows, whereas Olivier [18] and du Chatenet [19] named it “*Altise ferrugineuse*” based on the typical reddish brown color of this flea beetle. In England, Shaw [20] and Jones and Jones [21] reported it as the “*Wheat flea beetle*.” Davies [22] used a more specific name: the “*Wheat stem flea beetle*.”

Adults are polyphagous and larvae attack several cultivated cereals [10, 19, 23–25]. Consequently, it might be confusing, even erroneous, to assign a popular name on the basis of a single host plant. On the other hand, the body color is typical and unusual, at least among the North American flea beetle fauna, although such rusted color is also found in



FIGURE 1: *Neocrepidodera ferruginea*, dorsal habitus. Body length, 3.5 mm, excluding antennae.

other species of the Old World. For these reasons, we follow Olivier [18] and suggest “*European rusted flea beetle*” and “*Altise ferrugineuse européenne*,” respectively for the English and French common names of *N. ferruginea*. We have added a reference to the origin of the beetle to indicate that it is an alien species for North America.

4. Identification

Several recent publications are available for the identification of *Neocrepidodera* at generic level. In North America, Riley et al. [26] provided the most recent synthesis of the North American leaf beetles including a key to *Neocrepidodera* and all other flea beetle genera of this continent. In the Old World, the handbook of Konstantinov and Vandenberg [13], and the keys of Warchalowski [27], are excellent tools for the identification of the Palearctic fauna. The European and Mediterranean fauna were treated by Warchalowski [28], the fauna of Britain and Ireland by Cox [24], and the flea beetles of France by Doguet [29]. Species in the *N. ferruginea* group were recently revisited by Baselga and Novoa [30] including the illustration of their spermatheca and styli (vaginal palpi) for all treated species.

The characters most often used in generic keys are antennae 11-segmented, antennal calli raised and oval, pronotum transverse, narrowly explanate laterally, pronotal antebasal transverse impression present as well as a pair of lateral longitudinal furrows, elytral punctures generally arranged in regular rows, no hairs on elytra, procoxal cavities closed behind, and metatarsal claws not strongly inflated.

At the specific level, the diagnostic characters of *Neocrepidodera ferruginea* are as follows. Length of adult, 2.6–3.7 mm. Color uniformly yellowish brown to rusty brown (Figure 1). Frontal carina broad and low, frontal tubercles triangular, and not delineated posteriorly by a groove. Ocular groove behind eyes present. Frons and vertex smooth. Pronotum transverse, laterally margined; anterior angles large, protruding, bearing large seta; microsculpture finer on disk, coarser at basal groove; basal transverse groove



FIGURE 2: *Neocrepidodera ferruginea*, male aedeagus: (a) lateral view; (b) ventral view.

moderately deep, lateral longitudinal furrows deep. Elytra tapering at apex; elytral punctures large, deep, in regular rows, sometimes partially duplicated or disordered near suture; humeral callus well developed. Species fully winged. In the male, first tarsal segment of front and median legs markedly broadened (Figure 1). Sides of male aedeagus subparallel in dorsal view with apex triangular, slightly nipple-shaped in middle (Figure 2(b)); tip slightly upright in lateral view (Figure 2(a)); ventral median membranous portion almost reaching base. Female spermatheca elongate, slightly ovoid at base, spermathecal pump cylindrical and bent at 90°, spermathecal duct not coiled, bent at 45° to the median axis of the spermathecal pump (Figure 3(a)). Styli moderately short and thick, fused at base, tapered and pointed at apex (Figure 3(b)).

The body color of the native North American *Neocrepidodera robusta* (Leconte, 1874) is deep red, whereas *N. ferruginea* is brownish yellow (Figure 1). The antennomeres of the former are shorter and thicker than those of the latter. The elytra of the former are not tapered at the apex as they are in the latter. *Neocrepidodera robusta* has been reported from Québec to British Columbia and in Newfoundland [32, 33], but specimens are rare in collections examined. Those from Québec and Ontario, preserved in the CNC, were all collected in northern localities of these provinces and not in southern localities as is the case for *N. ferruginea*.

The larva of *Neocrepidodera ferruginea* was described in detail by Blunck [23] and included in keys by Oglobin and Medvedev [34], Medvedev and Zaitsev [35], and Steinhäuser [36, 37]. These keys are largely based on the number, position, and chaetotaxy of the tergites. According to these authors, the larva of *Neocrepidodera ferruginea* is yellowish-white with dark-brown head, legs, and thoracic and abdominal tergites. The epicranial suture is Y-shaped, the coronal stem short, only one-third the length of the head. There are 6 setae on the frons and 10 on the vertex. One ocellum is present near the base of each antenna, but only

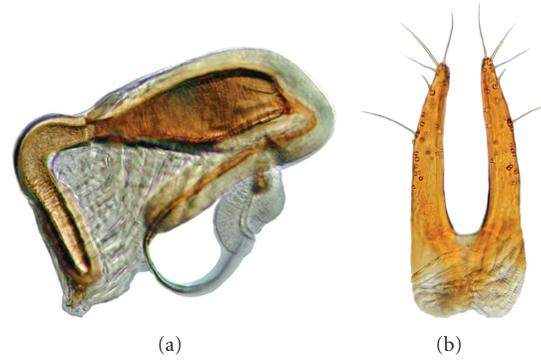


FIGURE 3: *Neocrepidodera ferruginea*, female genitalia: (a) spermatheca; (b) styli (vaginal palpi).

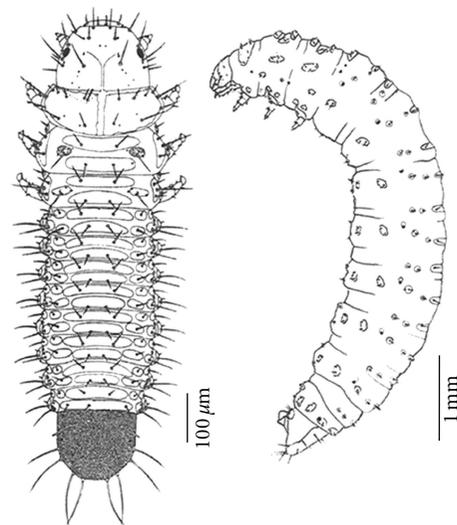


FIGURE 4: *Neocrepidodera ferruginea*, habitus of larva: (a) dorsal view; (b) lateral view. Modified from Blunck [23].

in the first instar larvae. The antennae are 2-segmented. The maxillary palpi are 3-segmented and the labial palpi are 2-segmented. The pronotum bears 10 setae on its anterior margin, 6 on the posterior margin. The last (9th) abdominal tergite forms a plate bearing 8 marginal and 4 discal setae; the whole surface is covered with an alveolar microsculpturing (Figures 4(a) and 4(b)). The pupa is still undescribed. The egg was sketched by Blunck [23], and its rough hexagonal microsculpture was illustrated, but its distinctive fine microsculpture was not shown (Figure 5).

5. Introduction into North America

During the winter of 2008, a small yellowish flea beetle was found in a pitfall trap from an alvar (limestone plain) of Aylmer (Québec). It was an unusual flea beetle for the local fauna. Comparisons with European specimens of similar appearance exchanged with the late French entomologist Michel Bergeal [25] convinced us that this specimen was identical to the Palearctic *N. ferruginea*. During the summer

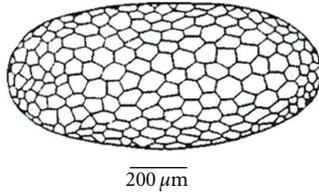


FIGURE 5: *Neocrepidodera ferruginea*, egg (after Blunck [23]).

of 2009, several natural and agricultural open habitats of Aylmer were surveyed in order to collect more specimens. The unsorted and unidentified holdings of the Canadian National Collection (CNC) were also examined, and eleven specimens were found: two were mixed with the miscellaneous Newfoundland flea beetles donated by Dave Larson (formerly at Memorial University, St. John's), nine were found in the unsorted beetles of the Carr's collection recently bequeathed to the CNC. Additional specimens received in the 1990s from S.A. Marshall (Guelph University), are also included in the present communication.

The date and place of these insect specimens are the most important clues to determining the history of introduction of this alien species. As concerning *Neocrepidodera ferruginea*, the oldest voucher specimens available were collected in 1977, but this species must have been thriving many years before this date. For instance, the lily leaf beetle, *Lilioceris lili* [1] (Criocerinae), a bright red-bodied beetle with black head and appendages, was first detected in Montréal in 1943, but persisted at low levels for 30 years before expanding on the island of Montréal and making a noticeable jump to Ottawa by 1981 [38, 39]. It reached Nova Scotia in 1992, Toronto (Ontario) in 1993, and Portage la Prairie (Manitoba) in 2003 [40, 41]. Another pest, the cereal leaf beetle, *Oulema melanopus* (Linnaeus, 1758) (Criocerinae), is suspected to have been introduced into North America between 1947 and 1949, but was detected and positively identified only in 1962 from Berrien Co., in Michigan [42–44]. These case studies lead us to believe that *N. crepidodera* may have gone through a similar introduction and distribution pattern, survived at low numbers for many years, and only commenced long-range dispersal when high population levels were reached. The two 1977 specimens collected at Niagara Falls represent the beginning of the population expansion phase. This locality is probably not the original site of introduction which is more likely an international port located on one or the other Great Lakes.

6. Distribution

According to the *Catalogue of Palaearctic Coleoptera* of Löbl and Smetana [31], the distribution of *Neocrepidodera ferruginea* includes the Azores, all of Europe, except Iceland, the European parts of Russia, Asia Minor, Iran, and Turkey (Figure 6). It could also be present in Armenia, but no published records are available, and this needs to be confirmed. However, according to Gruev and Döberl [11, 12], Corsica, Egypt, Morocco, Siberia, and West Turkestan are doubtful records.

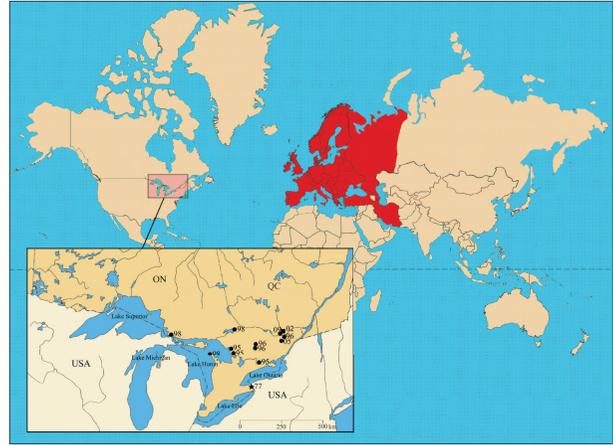


FIGURE 6: Old World distribution of *Neocrepidodera ferruginea* according to the countries listed in the catalogue of Löbl and Smetana [31]. Insert: distribution of *Neocrepidodera ferruginea* in North America. Star: Niagara Falls (Ontario), where the first specimens were collected. Solid circles: collection localities with collection years of 77 (1977) 95 (1995), 96 (1996), 98 (1998), 02 (2002), and 05 (=2005). Solid square: all collections in Aylmer (Québec) grouped together.

In North America, *N. ferruginea* is currently known from southern Ontario, and southwestern Québec on the north shore of the Ottawa River (inserted in Figure 6). The collection data of these new locations are as follows.

Material Examined. Canada: Québec: Gatineau/Aylmer (45°24' N, 75°50' W): Baillie street (north), 28.VII.2009, L. LeSage, border of Breckenridge stream on *Solidago* spp., grasses, and so forth, general sweeping [CBUM] 2; [CFIM] 2; [CNC] 3; Boucher Forest (north-east), north path, east-west, 16.VIII.2009, L. LeSage, on *Rhus radicans*, and so forth, general sweeping [CBUM] 1; [CNC] 1; Boucher Forest (west), 11.VIII.2009, L. LeSage, under Hydro-Québec electric line, on flowers of *Ambrosia* sp., *Solidago* spp., *Daucus* sp., *Melilotus* sp., general sweeping [CBUM] 3; [CFIM] 1; [CNC] 2; Boucher road (north), 8.VIII.2009, L. LeSage, in waste land on flowers of *Solidago* spp., *Melilotus* sp., *Daucus* sp., *Aster* spp, *Ambrosia* sp., and so forth, general sweeping, [CBUM] 1; [CNC]1; Boucher/Klock roads (north-east), close to transmission tower, 21.VII.2009, L. LeSage, waste land, on *Daucus* sp., *Solidago* spp., *Lythrum* sp., *Salix* sp., *Scirpus* sp., *Melilotus* sp., and so forth, general sweeping [CNC] 1; (north-west), 14.VIII.2009, L. LeSage, waste land, grasses, *Scirpus* sp., *Daucus* sp., *Solidago* spp., *Melilotus* sp., and so forth, general sweeping [CBUM] 1; [CNC] 1; Chagnon street (east), 18.VII.2010, V. Théberge, close to Hydro-Québec electricity line, on grass [CNC] 1; Cook road (north), 2.VII.2009, L. LeSage, ditch between two pastures on *Lythrum* sp., *Nasturtium* sp., *Ranunculus* sp., *Scirpus* sp., *Echium* sp., *Daucus* sp., and so forth general sweeping [CBUM] 1; [CFIM] 1; [CNC] 1; 16.VII.2009, L. LeSage, ditch between two fields on *Nasturtium*, and so forth, general sweeping [CNC] 1; 5.VIII.2009, L. LeSage, ditch between two fields on *Nasturtium officinale*, *Scirpus* sp., general sweeping

[CBUM] 2; [CFIM] 2; [CNC] 2; 5.VIII.2009, L. LeSage, pasture, *Echium vulgare* flowers, *Daucus carota*, grasses, and so forth, general sweeping [CBUM] 1; [CFIM] 1; [CNC] 1; west of Cook dump, 17.VII.2009, L. LeSage, *Daucus* sp., flowers, *Melilotus* sp., *Hypericum* sp., and so forth, general sweeping [CFIM] 1; [CNC] 1; Cook road (south), 21.VII.2009, L. LeSage, close to pound with *Equisetum* sp., *Daucus carota* flowers, *Solidago* spp., grasses, and so forth, general sweeping [CBUM] 2; [CNC] 1; 25.VII.2009, L. LeSage, fallow field on limestone, *Asclepias syriaca*, *Solidago* spp., *Hypericum* sp., grasses, and so forth, general sweeping [CBUM] 3; [CFIM] 1; [CNC] 2.; 25.VII.2009, L. LeSage, fallow field on limestone, *Asclepias* sp., *Apocynum* sp., *Solidago* spp., grasses, and so forth, general sweeping [CBUM] 1; [CFIM] 1; [CNC] 1; Pink road (south), near Museum of Nature, path north-south, 26.VII.2009, L. LeSage, abandoned field, *Lythrum salicaria*, grasses, and so forth, general sweeping [CBUM] 1; [CFIM] 1; [CNC] 1; Pink/Scholle roads, 25.VII-1.VIII.2006, L. LeSage, alvar, burned cedar forest of origin, on limestone, yellow pan trap [CNC] 1; 31.VII.2009, L. LeSage, alvar, *Daucus carota* flowers, *Solidago* spp., *Hypericum* sp., *Melilotus* sp., grasses, and so forth, general sweeping [CBUM] 2; [CFIM] 1; [CNC] 1; Principale street (north), around Golf La Croisée, 30.VII.2009, L. LeSage, *Daucus* sp. flowers, *Arctium* sp., *Solidago* spp., grasses, and so forth, general sweeping [CBUM] 4; [CFIM] 2; [CNC] 2; 30.VII.2009, L. LeSage, around a containment basin, *Daucus* sp., *Arctium* sp., *Solidago* spp., grasses, and so forth, general sweeping [CBUM] 8; [CFIM] 2; [CNC] 3; Simmons street (south), 7.VII.2007, L. LeSage, cleared space for future street, small stand of *Plantago major*, general sweeping [CNC] 1; 27.VIII.2009, L. LeSage, clearing in mixed forest, on limestone, grasses, *Solidago* spp., sweeping, LL03-39 [CBUM] 2; [CFIM] 1; [CNC]; Vanier/Pink roads (north), north Mountain View church, 29.VII.2009, L. LeSage, abandoned field, grasses, *Solidago* spp. flowers, *Asclepias* sp., and so forth, general sweeping [CBUM] 4; [CFIM] 1; [CNC] 6; Vernon street (north), tributary of Lac des Fées, 1.VIII.2003, L. LeSage, border of creek, *Lythrum salicaria*, sweeping, LL03-85 [CNC] 1. Gatineau Park (45°34' N, 75°57' W): 1 km south of Ramsay Lake, 19.VIII.2009, L. LeSage, forest path, toward [Eardley] Escarpment, general sweeping [CNC] 1. Ontario: Algoma District (48°00' N, 84°00' W): Sault Sainte-Marie, 29.VI.1998, R. Atkinson [CNC] 4; Bruce Co. (44°18' N, 81°25' W): Dunks Bay, 45.14 N; 81.38 W, 30.VII.1998, S.A., Marshall [CNC] 1; 20.VII.-1.IX.1999, S.A., Marshall, on shoreline, Malaise [CNC] 2; [SAMC] 3; 15.XI.1999-15.III.2000, S.A., Marshall, Lake edge, Malaise [SAMC] 1; 23-27.VII.2000, S.A., Marshall [CNC] 1; Dorcas Bay, VII.1998, S.A., Marshall, alvar [SAMC] 1; 16.VII-2.VIII.1999, S.A., Marshall, in pound behind dune, Malaise [SAMC] 1; Cameron Lake Road South, 20-29.VII.1999, S.A., Marshall, spring fen, pan trap [SAMC] 1; Georgian Bay, Fathom Five National Park, 25.VI-28.VII.1995, T. Woodcock & S. Marshall, Land Base Cedar Duff, pan trap [CNC] 1; [SMAC] 1; Hastings Co. (44°45' N, 77°40' W): Baptiste Lake, 10.VII.1995, B.F. & J.L. Carr [CNC] 3; Maynooth, 17.VII.1996, B.F. & J.L. Carr [CNC] 1; Cardiff, 22.VII.1996, B.F. & J.L. Carr [CNC] 1; Highway 69, 2 km north of Nobel,

23.VI.1996, B.F. & J.L. Carr [CNC] 1; Welland Co. (43°05' N, 79°04' W): Niagara Falls, 23.VII.1977, D. Larson [CNC] 2; Carleton Co. (45°15' N, 75°45' W): Stittsville, 5.VII.2005, Envirocontrol, Topsoil (large number) [CNC] 4. Nepean, 2.VII.1996, B.F. & J.L. Carr [CNC] 1; Nepean, 4.VII.1996, B.F. & J.L. Carr [CNC] 1; Parry Sound District (45°45' N, 79°50' W): Parry Sound, 12.VII.1995, B.F. & J.L. Carr [CNC] 1.

7. Habitats

Neocrepidodera ferruginea has been reported from a large variety of habitats or sites. Medvedev and Zaitsev [35] stated that it was found on wet meadows, bogs, and cereal fields in Siberia and the Russian Far East. In France, Doguet [29] mentioned fallow fields, roadsides, cultivated areas, natural prairies, and so forth. In his guide of the leaf beetles of Europe, du Chatenet [19] reported it from fields, prairies, and fallows. In Britain and Ireland, Cox [24] listed woodland, downland, heathland, moorland, commons, arable land, set-aside, gardens, roadside verges, pits, quarries, sea walls, and dunes. In Québec (Aylmer), specimens were collected in alvars, abandoned fields, pastures, vacant lots, ditches, edges of creek, limestone outcrops, and forest trails. According to the Watford Coleoptera Group [45], meadows and wet meadows are the biotopes of this flea beetle in Britain.

8. Biology

Little is known on the biology of *Neocrepidodera ferruginea* in North America except for the habitats, where it was collected. In Europe, there has been few additional publications published since the pioneering work of Blunck [23]. According to this author, adults emerge in June in Germany, but earlier in warmer climates. They mate and lay eggs in summer and fall. Females deposit their eggs in the ground beside the seeds of potential host plants. The young larvae enter seedlings at the host's base and later excavate tunnels throughout their roots and central stems [46]. Larval development extends into the winter, but as temperature decreases, larvae leave their host plants, move deeper into the ground, and overwinter in the soil. They become active again the next spring as the top soil thaws after which they search for new host plants to complete their development. Pupation occurs underground in earthen cells and lasts 2-3 weeks. They become fully developed by the end of May or the beginning of June. There is only one generation per year (univoltine) in Germany.

9. Host Plants

Although dozens of "hosts" were reported for the adults of *Neocrepidodera ferruginea*, quite a few are probably no more than incidental presences of the beetle on such plants since larval development has been observed only in a few species of Poaceae. Blunck [23] tested over 40 potential hosts and estimated that half of them were markedly used or preferred by the adults in some 20 plant families (Table 1). Thistles (*Carduus* spp. and *Cirsium* spp.) are the most frequently cited hosts for adults: Bedel [47], Balachowsky and Mesnil [48],

TABLE 1: Most important lists of recorded host plants for *Neocrepidodera ferruginea*. The list of Blunck [23] includes only the first two categories.

| Family | Latin names | Popular names | Blunck 1932 [23] | Biondi 1982 [51] | Doguet 1989 | du Chatenet 2002 [19] | Cox 2007 [24] | LeSage/Savard 2011 |
|---------------|--------------------------------------|---------------------------|------------------------|------------------------|----------------|-----------------------------|---------------------|-----------------------|
| Anacardiaceae | <i>Rhus radicans</i> L. | Poison ivy | | | | | | X |
| Apiaceae | <i>Daucus carota</i> L. | Wild carrot | | | | | | Flowers |
| Apocynaceae | <i>Apocynum androsaemifolium</i> L. | Spreading dogbane | | | | | | X |
| Asclepiaceae | <i>Asclepias syriaca</i> L. | Milkweed | | | | | | X |
| Asteraceae | (species not specified) | Composite family | | | | X | | X |
| Asteraceae | <i>Aster</i> spp. | Aster | | | | | | Flowers |
| Asteraceae | <i>Aster novae-angliae</i> L. | New England aster | | | | | | Flowers |
| Asteraceae | <i>Ambrosia artemisiifolia</i> L. | Small ragweed | | | | | | Flowers |
| Asteraceae | <i>Artemisia vulgaris</i> L. | Mugwort | XX | | X | | | |
| Asteraceae | <i>Carduus</i> sp. | Thistle | | | X | | | |
| Asteraceae | <i>Carduus acanthoides</i> L. | Plumeless nodding thistle | | X | | | | |
| Asteraceae | <i>Carduus nutans</i> L. | Musk thistle | | X | | | | |
| Asteraceae | <i>Centaurea acaulis</i> Willd. | Dwarf thistle | XX | | | | | |
| Asteraceae | <i>Centaurea cyanus</i> L. | Corn flower | XX | | X | | | |
| Asteraceae | <i>Centaurea scabiosa</i> L. | Greater knapweed | XX | X | X | | | |
| Asteraceae | <i>Chrysanthemum leucanthemum</i> L. | Daisy | Xx | | | | X | |
| Asteraceae | <i>Cirsium arvense</i> Scop. | Canada thistle | | X | | | | |
| Asteraceae | <i>Cirsium canum</i> Moench. | Queen Anne’s thistle | | X | | | | |
| Asteraceae | <i>Cirsium lanceolatum</i> Hill.* | Spear thistle | | X | | | | |
| Asteraceae | <i>Cirsium oleraceum</i> L. | Cabbage thistle | XX | | X | | | |
| Asteraceae | <i>Silybum marianum</i> Gaertn. | Milk thistle | XX | | X | | | |
| Asteraceae | <i>Solidago</i> spp. | Goldenrod | | | | | | Flowers |
| Asteraceae | <i>Taraxacum officinale</i> Weber | Dandelion | XX | | X | | | |
| Boraginaceae | (species not specified) | Borage family | | | | X | | |
| Boraginaceae | <i>Borago officinalis</i> L. | Borage | XX | | | | X | |
| Boraginaceae | <i>Echium vulgare</i> L. | Viper’s bugloss | | | | | | Flowers |
| Boraginaceae | <i>Symphytum officinale</i> L. | Comfrey | | X | | | | |
| Boraginaceae | <i>Symphytum</i> sp. | Comfrey | XX | | | | X | |
| Brassicaceae | <i>Brassica napus</i> L. | Rape | X | | | | | |
| Brassicaceae | <i>Brassica oleracea</i> L. | Cabbage | Xx | | | | X | |
| Brassicaceae | <i>Brassica rapa</i> L. | Wild turnip | Xx | | | | | |
| Brassicaceae | <i>Nasturtium officinale</i> R. Br. | Water cress | | | | | | Flowers |
| Cannabaceae | <i>Cannabis sativa</i> L. | Hemp | | | X | X | | |
| Compositae | <i>Achillea millefolium</i> L. | Common yarrow | Xx | | | | flowers | |
| Cyperaceae | <i>Scirpus</i> sp. | Bulrush | | | | | | X |
| Equisetaceae | <i>Equisetum</i> sp. | Horsetail | | | | | | X |
| Fabaceae | (species not specified) | Pulse family | | | | X | | |
| Fabaceae | <i>Melilotus alba</i> Medik. | White sweet-clover | | | | | | Flowers |
| Fabaceae | <i>Onobrychis</i> sp. | Sanfoins (“sainfoins”) | | | X | | | |
| Fabaceae | <i>Pisum sativum</i> L. | Peas | | | | | X | |
| Fabaceae | <i>Trifolium</i> sp. | Clover | | | X | | | |
| Fabaceae | <i>Vicia</i> sp. | Vetch | | | X | | | |
| Hypericaceae | <i>Hypericum perforatum</i> L. | Common St. John’s-wort | | | | | | Flowers |

TABLE 1: Continued.

| Family | Latin names | Popular names | Blunck 1932 [23] | Biondi 1982 [51] | Doguet 1989 | du Chatenet 2002 [19] | Cox 2007 [24] | LeSage/Savard 2011 |
|---------------|---------------------------------|--------------------|------------------------|------------------------|----------------|-----------------------------|---------------------|-----------------------|
| Lamiaceae | <i>Lamium</i> sp. | Dead-nettle | | | | | X | |
| Lythraceae | <i>Lythrum salicaria</i> L. | Purple loosestrife | | | | | | Flowers |
| Poaceae | (species not specified) | Cultivated cereals | XX | X | X | X | X | |
| Poaceae | (species not specified) | Wild grasses | XX | | | X | X | X |
| Poaceae | <i>Avena sativa</i> L. | Oats | XX | | | | | |
| Poaceae | <i>Bromus</i> sp. | Brome grass | | | X | | | |
| Poaceae | <i>Cynosurus</i> sp. | Dog's tail | | | X | | | |
| Poaceae | <i>Dactylis</i> sp. | Orchard grass | | | X | | | |
| Poaceae | <i>Festuca</i> sp. | Fescue grass | | | X | | | |
| Poaceae | <i>Hordeum vulgare</i> L. | Barley | XX | | (X) | | | |
| Poaceae | <i>Lolium</i> sp. | Ryegrass | | | X | | | |
| Poaceae | <i>Phalaris</i> sp. | Canary grass | | | | | | |
| Poaceae | <i>Phleum pratense</i> L. | Timothy | | | | | | X |
| Poaceae | <i>Poa</i> sp. | Bluegrass | | | X | | | |
| Poaceae | <i>Secale cereale</i> L. | Rye | XX | | | | | |
| Poaceae | <i>Triticum vulgare</i> Vill.** | Wheat | XX | | | | | |
| Polygonaceae | (species not specified) | Buckwheat family | | | X | X | | |
| Polygonaceae | <i>Polygonum</i> sp. | Knotweed | XX | | | | X | |
| Ranunculaceae | <i>Ranunculus acris</i> L. | Buttercup | | | | | | Flowers |
| Salicaceae | <i>Salix</i> sp. | Willow | | | | | | X |
| Urticaceae | <i>Urtica dioica</i> L. | Stinging nettle | XX | X | | | | |
| Urticaceae | <i>Urtica</i> sp. | Nettle | | | X | X | X | |

X: used

XX: strongly used

Xx: more or less used

(X): plant species doubtful

* *Cirsium lanceolatum* currently considered synonym of *Cirsium vulgare* (Savi) Ten. [58].

** *Triticum vulgare* currently considered synonym of *Triticum aestivum* L. [59].

and Doguet [29] in France; Lameere [49] in Belgium; Blunck [23] in Germany; Joy [50] in England; Ogloblin and Medvedev [34] in the European part of Ru

ssia of the past USSR, Medvedev and Zaitsev [35] in Siberia and the Russian Far East; Biondi [51], in Italy; Gruev and Tomov [52] in Bulgaria; Warchalowski [28] in Europe and Asia; Gök and Çilbıroğlu [53] in Turkey; Bukejs [54] in Latvia. Nettles (*Urtica* spp.), or more precisely the stinging nettle (*Urtica dioica* L.), are the next most frequently given hosts: Kutschera [55] for Europe; Allard [56] for Austria, Favre [57] for France; Joy [50] for England; Ogloblin and Medvedev [34] European part of USSR, Medvedev and Zaitsev [35] for Siberia and the Far East; Biondi [51] for Italy; Doguet [29] for France; du Chatenet [19] for Europe; Cox [24] for Britain and Ireland.

In addition to thistles and nettles, grasses are economically important hosts reported by many authors. According to Blunck [23], barley, rye, and wheat were frequently used. Doguet [29] listed blue-grass (*Poa* sp.), brome-grass (*Bromus* sp.), dog's tail (*Cynosurus* sp.), fescue-grass (*Festuca* sp.), orchard-grass (*Dactylis* sp.), and rye-grass (*Lolium* sp.), but did not specify a preference. du Chatenet [19] and Cox [24]

referred to cultivated and wild grasses in general without mentioning a peculiar variety. During our 2009 survey four species appeared most common: Kentucky blue-grass (*Poa pratensis*), meadow foxtail (*Alopecurus pratensis*), orchard-grass (*Dactylis glomerata*), and red fescue-grass (*Festuca rubra*). Voucher specimens of these grasses are deposited in DAO herbarium in Ottawa.

Flowering weeds were also surveyed because they could easily be identified in pastures and fields while sweeping. The viper's bugloss, or blueweed, (*Echium vulgare*) cannot be missed with its numerous bright blue flowers forming a large ear-like cluster. These flowers seemed very attractive to adult *Neocrepidodera ferruginea*, and such attraction was reported by the early authors Fabricius [60] and Olivier [18]. Adults were also collected on the flowers of other plants: buttercup (*Ranunculus acris*), common St. John's-wort (*Hypericum perforatum*), purple loosestrife (*Lythrum salicaria*), small ragweed (*Ambrosia artemisiifolia*), various unspecified asters (*Aster* spp.), New England asters (*Aster novae-angliae*), various goldenrods (*Solidago* spp.), water cress (*Nasturtium officinale*), white sweet-clover (*Melilotus alba*), and wild carrot (*Daucus carota*) (Table 1). These plants are probably not

actual hosts, but alternative food sources for maturation feeding by adults. Such alternative feeding preference is noticeable and well known in corn leaf beetles (*Diabrotica* spp.). For instance, adults of the northern corn leaf beetle (*Diabrotica barberi*, Smith and Lawrence, 1967) migrate outside corn fields to feed on the pollen of various plants, preferably goldenrods (*Solidago* spp.), even though the larvae prefer corn. Such migration was observed in many corn fields located on both sides of Highway 20, between Montréal and Québec city in Québec [61]. According to Naranjo [62], adults stay in corn fields as long as the quality and the quantity of corn pollen is good and acceptable, but move outside when pollen is rare or of poor quality. Apparently, the adults of *N. ferruginea* behave in a similar manner, but more information is needed to confirm these preliminary observations.

10. Parasites

Unknown.

11. Predators

Unknown.

12. Economic Importance

Ahlberg [63] stated that following a dry spring, injury by flea beetles was unusually severe in Sweden in 1941. Barley and spring wheat, and to a lesser extent winter wheat and rye, were damaged by overwintering adults of *Phyllotreta vittula* (Redtenbacher, 1849). However, the larvae that occur low down in straw in late summer were not those of *P. vittula* as previously thought, but those of *Neocrepidodera ferruginea*, which was considered a serious pest in Sweden. Johansson [64] observed that the leaves of wheat which turned yellow and ceased to grow, contained larvae of *Chaetocnema aridula* Gyllenhal, 1827 and *C. hortensis* (Geoffroy 1785) and also *N. ferruginea*. However, he considered the latter of little importance, even though it may infest cereals and wild grasses.

In England, Gough [65] found *Neocrepidodera ferruginea* larvae in only nine fields during a survey of 136 fields of winter wheat, in Yorkshire, two-thirds of which were on light soils. Attacked wheat plants exhibited yellow central shoots, while the leaves remained green. Such symptoms were observed, in March, in only 3% of the fields. According to Jones and Jones [21], the normal host plants are thistles and related plants, but larvae may enter wheat plants by accident while searching for suitable hosts through the soil. Davies [22] reported extensive damage to spring oats, variety *Forward* in the Ruthin district of Denbighshire. Very few wireworms, or fruit fly larvae (*Oscinella* spp.; Diptera, Chloropidae) were found in oat stems, but larvae of *N. ferruginea* were numerous within the yellowed central shoots examined in the laboratory. In the field, damage appeared as large patches where plants had been considerably thinned.

In north-east Scotland, Shaw [20] reported damage to the winter wheat variety *Cappelle* and oats, in April. Areas with extensive thinning necessitated resowing. Where damage was

significant, almost every damaged stem revealed a larva, but it was extremely difficult to find larvae inside oat stems, although some were found in the soil after much searching. The following year, Shaw and Osborne [66] reported extensive damage in a 20-acre field of the winter wheat variety *Cappelle* at Dirleton, east Lothian.

13. Discussion

Due to its small size, inconspicuous color, and still undetermined economic impact, *Neocrepidodera ferruginea* has remained unnoticed until now. On the basis of the available specimens, we believe that it was introduced in early 1970s, or even earlier in the 1960s, at an undetermined international port located on the Great Lakes [67]. The ports on Erie, ON or Huron Lake appear to be the most probable introduction sites since they are the closest to Niagara Falls, Ontario, Canada, where the first specimens were found. On the other hand, those on Lake Michigan or Lake Superior cannot be excluded if we suppose that *N. ferruginea* followed an introduction pattern similar to that of the cereal leaf beetle, which was probably introduced at an international port on Lake Michigan between 1947 and 1949, and positively identified only 15 years later, and has since been expanding eastward and westward [44].

In about 35 years, *Neocrepidodera ferruginea* moved eastward and reached the Ottawa Valley most likely by natural dispersal, a distance of about 375 km from Niagara Falls, where the first specimens were collected. Aylmer, on the north shore of the Ottawa River, is presently the northernmost known location of this flea beetle; however, we suspect that it has already established further north from this locality. In Ontario, it would be crucial to determine if it is moving westward towards the Canadian Prairies.

The attraction of *Neocrepidodera ferruginea* adults to the flowers of various plants is similar to that of the adults of the northern corn leaf beetle, which migrate outside corn fields to feed on the pollen of goldenrods and other weeds [68]. However, *N. ferruginea* do not have to migrate far outside fields since most weeds are ubiquitous and grow within fields in the company of cultivated grasses. Consequently, adults can easily move from one plant species to another and adjust their food preferences to the flowering sequence of weeds which varies with habitats and localities.

Abbreviations

CBUM: Centre sur la biodiversité de l'Université de Montréal, Montréal, QC, Canada H1X 2B2. S. LeTirant

CFIA: Canadian Food Inspection Agency

CFIM: Collections en Fiducie de l'Insectarium de Montréal, Insectarium de Montréal, Montréal, QC, Canada H1X 2B2. S. LeTirant

CNC: Canadian National Collection, Agriculture Canada, Ottawa, ON, Canada K1A 0C6. L. LeSage

DAO: Department of Agriculture Ottawa.
Official acronym of the Herbarium of the
Department, Central Experimental Farm,
Ottawa. Amanda Ward

ECORC: Eastern Cereal and Oilseed Research
Centre, Agriculture, Ottawa, ON, Canada
K1A 0C6

SAMC: S.A. Marshall Private Collection,
Department of Environmental Biology,
University of Guelph, Guelph, ON,
Canada N1G 2W1. S.A. Marshall.

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