Erroneous records of *Aleochara bipustulata* from North America: an assessment of the evidence

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Abstract—*Aleochara bipustulata* (L., 1761) (Coleoptera: Staphylinidae) is a Palearctic species and a natural enemy of the cabbage root maggot, *Delia radicum* (L., 1758) (Diptera: Anthomyiidae). It has been identified as a candidate for introduction to Canada for classical biological control of *D. radicum*. Recent taxonomic studies assert that *A. bipustulata* is absent from the Nearctic; however, there are numerous publications reporting the presence of the species in North America. We examined voucher material relating to these publications and additional museum specimens labeled as *A. bipustulata*. In addition, we reared *Aleochara* spp. from *D. radicum* puparia collected in the Canadian prairie provinces. Specimens that, based on external anatomy, could be *A. bipustulata* were definitively identified using characters of the genitalia. All of the 141 museum specimens labeled *A. bipustulata* were found to be *Aleochara verna* Say, 1836. A total of 811 individuals of *Aleochara* spp. were reared from *D. radicum* puparia; of these, 690 were *Aleochara bilineata* Gyllenhal, 1810, 121 were *A. verna*, and none were *A. bipustulata*. We have found no evidence that *A. bipustulata* occurs in North America.

Résumé—*Aleochara bipustulata* (L., 1761) (Coleoptera : Staphylinidae) est une espèce paléarctique qui est l'ennemi naturel de la mouche du chou, *Delia radicum* (L., 1758) (Diptera : Anthomyiidae). Il a été retenu comme un agent potentiel à introduire au Canada pour la lutte biologique classique contre *D. radicum.* Des études taxonomiques récentes affirment qu'*A. bipustulata* n'est pas présent dans la région néarctique, bien que de nombreuses publications en signalent l'existence en Amérique du Nord. Nous avons examiné des spécimens de référence associés à ces publications, de même que des spécimens additionnels de musée identifiés comme *A. bipustulata*. Nous avons aussi mis en élevage des *Aleochara* spp. provenant de pupariums de *D. radicum* récoltés dans les provinces canadiennes des prairies. Les spécimens, qui d'après leur morphologie externe auraient pu être *A. bipustulata*, ont été identifiés de façon certaine d'après les caractères de leurs génitalias. Tous les 141 spécimens de collection étiquetés *A. bipustulata* se sont avérés être *A. verna* Say, 1836. Des 811 individus obtenus par élevage des pupariums de *D. radicum*, 690 étaient *A. bilineata* Gyllenhal, 1810, 121 *A. verna* et aucun *A. bipustulata.* Nous n'avons trouvé aucune indication qu'*A. bipustala* existe en Amérique du Nord.

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Introduction

Aleochara species (Coleoptera: Staphylinidae) have been the subject of research related to biological control of the cabbage root maggot, *Delia radicum* (L., 1758) (Diptera: Anthomyiidae) over the last 60 years (McLeod

1962; Soroka *et al.* 2002). *Aleochara bilineata* Gyllenhal, 1810, *Aleochara bipustulata* (L., 1761), and *Aleochara verna* Say, 1836 have been investigated because the adult beetles prey upon eggs and larvae of *D. radicum*, and first-instar *Aleochara* spp. larvae parasitize *D. radicum* pupae (Fuldner 1960; Klimaszewski 1984; Jonasson 1995; Maus *et al.* 1998; Fournet *et al.* 2000). In an attempt to achieve classical biological control of *D. radicum* in Canada, scientists of the Belleville laboratory of the Canada Department of Agriculture introduced *A. bilineata* and a species identified as *A. bipustulata* in the 1950s (McLeod 1962; Soroka *et al.* 2002). However, *A. bilineata* was in Canada before the introductions (Soroka *et al.* 2002) and had been identified as *Baryodma ontarionis* Casey, 1916 (Coleoptera: Staphylinidae) (Casey 1916; Colhoun 1953). *Aleochara bilineata* is widespread in brassica vegetable habitats in Canada (Wishart 1957; Nair and McEwen 1975; Turnock *et al.* 1995).

Lohse (1986) established the status of *A. verna* and *A. bipustulata* as two distinct species, and the records of *A. bipustulata* and *A. verna* before this publication are confusing. In the European literature, "*A. bipustulata*" could refer to *A. bipustulata* or *A. verna*, and "*A. verna*" could refer to *A. verna* or *Aleochara binotata* Kraatz, 1856 (Maus *et al.* 1998). *Aleochara bipustulata* and *A. verna* are difficult to separate using external anatomical characteristics (Maus *et al.* 1998), and positive identification of the two species depends on characteristics of the spermatheca or the median lobe of the aedeagus (Klimaszewski 1984; Maus 1996, 1998). In a revision of the genus *Aleochara* in America north of Mexico, *A. bipustulata* was considered absent from North America (Klimaszewski 1984), an opinion unaltered by Lohse's (1986) revision and shared by the European *Aleochara* taxonomist Maus (1996, 1998). *Aleochara bipustulata* is not listed in the *Checklist of Beetles of Canada and Alaska* (Bousquet 1991). Despite this consensus among taxonomists, numerous publications report the occurrence of the species in North America. *Aleochara bipustulata* has been proposed as a candidate species for classical biological control of *D. radicum* in canola on the Canadian prairies (Hemachandra 2004). Therefore, it is essential to verify that this species does not already occur in North America before proceeding further in evaluating its value as a classical biological control agent. This paper assesses the evidence for the occurrence of *A. bipustulata* in North America through examination of voucher and other museum specimens and through field surveys in three Canadian provinces.

Materials and methods

Museum specimens of *Aleochara* species from North America that had been identified as *A. bipustulata* were studied. Curators of insect collections were contacted and specimens that carried *A. bipustulata* labels were borrowed. In particular, we sought voucher specimens related to publications referring to collection of *A. bipustulata* in North America. The following institutions were contacted (number of specimens labelled *A. bipustulata* that were received for examination is given in parentheses): Agriculture and Agri-Food Canada, Saint-Jean-sur-Richelieu, Quebec (0); Agriculture and Agri-Food Canada, London, Ontario (7); Canadian National Collection, Ottawa, Ontario (13); Cornell University Insect Collection, Ithaca, New York (13); Enns Entomology Museum, University of Missouri, Columbia (41); Entomology Research Museum, University of California, Riverside (41); Field Museum of Natural History, Chicago, Illinois (12); J.B. Wallis Museum of Entomology, University of Manitoba, Winnipeg (0); Lyman Entomological Museum, McGill University, Sainte-Anne-de-Bellevue, Quebec (9); Mississippi Entomological Museum, Mississippi State University, Mississippi State (0); Spencer Entomological Museum, University of British Columbia, Vancouver (0); Strickland Museum, University of Alberta, Edmonton (0); and University of Guelph, Guelph, Ontario (5).

In addition, in summer and autumn 2000, a field survey was carried out in root-maggot-infested canola fields at Carman (49°30′N, 98°00′W) and Altamont (49°24′N, 98°30′W), Manitoba; Shellbrook, Saskatchewan (53°13′N, 106°24′W); and two fields at Vegreville, Alberta (53°30′N, 112°03′W). *Delia radicum* puparia were collected in these fields, and puparia were maintained in the laboratory until adult emergence (Hemachandra 2004).

Museum and field-collected *Aleochara* specimens were initially keyed based on external anatomy following Klimaszewski (1984). Specimens that were thought to be *A. bipustulata* or *A. verna* were dissected, and genitalia were embedded in Canada balsam and mounted on

Table 1. Specimens of *Aleochara verna* from North America that were previously identified as *Aleochara bipustulata*.

Location of collection	No. of specimens	Date of collection	Collector	Location where specimens are held
Ames, Iowa	3	17 June 1969		University of California, Riverside
Baja, California	1	28 May 1950	I. Moore	University of California, Riverside
Berkeley, California	2	Aug.–Sept. 1919	H. Dietrich	Cornell University Insect Collection, Ithaca, New York
Big Pine, California	1	June 1971	D. Giuliani	University of California, Riverside
Bloomington Lake, Wasatch Mountains, Idaho*	1	7 July 1952	B. Malkin	Field Museum of Natural History, Chicago, Illinois
Brown's Valley	3	Oct. 1972	R.W. Merritt	University of California, Riverside
California	2	May–Aug. 1968	—	University of California, Riverside
Chiquito Creek, California	1	7 June 1920	H. Dietrich	Cornell University Insect Collection, Ithaca, New York
Columbia, Missouri	1	1 June 1972	C. Wingo	University of California, Riverside
Columbia, Missouri	41	May–June 1971	C. Wingo	Enns Entomology Museum, University of Missouri, Columbia
Coupeville, Washington	1	27 June 1944	M.H. Hatch	Field Museum of Natural History, Chicago, Illinois
Dalton Creek, California	1	15 May 1920	H. Dietrich	Cornell University Insect Collection, Ithaca, New York
Dulzura, California	1	24 Apr. 1973	McErery	University of California, Riverside
Green Canyon, Hot Spgs., Idaho*	1	2 July 1952	B. Malkin	Field Museum of Natural History, Chicago, Illinois
Guelph, Ontario	3	Aug. 1951	—	Canadian National Collection, Ottawa, Ontario
Ithaca, New York	2	20 July 1917	H. Dietrich	Cornell University Insect Collection, Ithaca, New York
Kane Spgs, California	1	23 Feb. 1941	G.P. Mackenzie	University of California, Riverside
L. Arrowhead, California	1	24 Sept. 1939	G.P. Mackenzie	University of California, Riverside
Lake Hemet, California	1	30 June 1965	R.E. Orth	University of California, Riverside
Linton Meadow, Oregon*	2	31 Aug. 1941	Deschufeb	Field Museum of Natural History, Chicago, Illinois
Mount Falls Valley	3	25 May 1935	Timberlake	University of California, Riverside
Mount Wilson, California	1	19 May 1950	G.P. Mackenzie	University of California, Riverside
Northfolk, California	6	May–June 1920	H. Dietrich	Cornell University Insect Collection, Ithaca, New York
Pac. Grove, California	1	—	A. Fenyes	Field Museum of Natural History, Chicago, Illinois
Pawnee Grassland, Colorado*	6	7 July 1971	—	University of California, Riverside
Peachland, British Columbia	3	July–Aug. 1912	J.B. Wallis	Canadian National Collection, Ottawa, Ontario
Peachland, British Columbia	1	1918	J.B. Wallis	Canadian National Collection, Ottawa, Ontario
Peachland, British Columbia	3	July 1919	J.B. Wallis / Fenyes	Canadian National Collection, Ottawa, Ontario

Table 1 (*concluded*).

Location of collection	No. of specimens	Date of collection	Collector	Location where specimens are held
Phoenix, Arizona	2	1 Apr. 1934	R.H. Grandall	University of California, Riverside
Pistol River, Oregon*	1	7 July 1951	B. Malkin	Field Museum of Natural History, Chicago, Illinois
Preston, Ontario	5	July 1973	K.S.S. Nair	University of Guelph, Guelph, Ontario
Rock Creek R.S., Magic Mountain, Idaho*	2	19 July 1952	B. Malkin / W.F. Barr	Field Museum of Natural History, Chicago, Illinois
Saguva Beach, California	1	26 Dec. 1925	—	University of California, Riverside
San Francisco, California	1	29 Nov. 1919	H. Dietrich	Cornell University Insect Collection, Ithaca, New York
St. Augustin, Quebec	4	29 Aug. 1956	J.-C. Aubé	Lyman Entomological Museum, Sainte-Anne-de-Bellevue, Quebec
Ste. Catherine, Quebec	3	8 Sept. 1962	J.-C. Aubé	Lyman Entomological Museum, Sainte-Anne-de-Bellevue, Quebec
Ste. Catherine, Quebec	1	2 Sept. 1956	J.-C. Aubé	Lyman Entomological Museum, Sainte-Anne-de-Bellevue, Quebec
Ste. Catherine, Quebec	1	20 June 1958	J.-C. Aubé	Lyman Entomological Museum, Sainte-Anne-de-Bellevue, Quebec
Sant Jacinto, California	1	1 May 1958	E.I. Schlinger	University of California, Riverside
Santa Lucia Mountain, California	1	8 Sept. 1962	R. Vd Bosch	University of California, Riverside
Sebastopol, California	1	12 July 1962	E.F. Legner	University of California, Riverside
Southwestern Ontario	7	1980–1981	A.D. Tomlin	Agriculture and Agri-Food Canada, London, Ontario
St. Ana. River, California	1	3 Sept. 1953	A. Lander	University of California, Riverside
St. Jancinto Mountain, California	1	19 May 1950	G.P. Mackenzie	University of California, Riverside
Steens Mountain, Oregon*	2	22–26 June 1951	B. Malkin	Field Museum of Natural History, Chicago, Illinois
Sunnymead, California	1	7 May 1974	R.E. Orth	University of California, Riverside
Teel's Marsh, Nevada*	1	1 Aug. 1973	D. Giuliani	University of California, Riverside
Union, Ontario	1	1948	—	Canadian National Collection, Ottawa, Ontario
Union, Ontario	2	23 May 1949	—	Canadian National Collection, Ottawa, Ontario
White Mount Park, California	1	31 Aug. 1975	D. Giuliani	University of California, Riverside
White Mount Park, California	5	3 May 1974	D. Giuliani	University of California, Riverside
Yosemite Valley, California	1	26–28 Sept. 1944	B. Malkin	Field Museum of Natural History, Chicago, Illinois
Total	141	—	—	

*State or province has been added, based on gazeteer information where this is unequivocal. Otherwise information is exactly quoted from specimen labels.

microslides together with the terminal abdominal segments separated from the body. The median lobe of the aedeagus and the spermatheca were examined under the microscope (40×) and compared with reference materials and drawings of Klimaszewski (1984) and Maus (1996, 1998).

Results and discussion

We examined a total of 141 museum specimens, collected by at least 24 different collectors from at least 47 different North American locations between 1912 and 1981 (Table 1). None of those specimens were *A. bipustulata*. All were positively identified as *A. verna*.

Voucher material was sought for Schoene (1916), Wishart (1957), McLeod (1962), Moore and Legner (1971), Thomas and Morgan (1972), Nair and McEwen (1975), Watts and Combs (1975), and Tomlin *et al.* (1985), all publications reporting the presence of *A. bipustulata* in North America. Voucher specimens for Nair and McEwen (1975) and Tomlin *et al.* (1985) were among the material borrowed from the University of Guelph and Agriculture and Agri-Food Canada, London, respectively. Voucher material for Schoene (1916) was not found. Specimens related to Wishart (1957) and referred to in McLeod (1962) could not be traced; this material was originally housed at the Canada Department of Agriculture Research Institute at Belleville, but on the closure of that station apparently was not transferred to the Canadian National Collection. Voucher specimens for Moore and Legner (1971) were not found, but two of the specimens loaned by the University of California, Riverside, were collected by these authors on another occasion. No voucher material for Thomas and Morgan (1972) was found, but C. Wingo collaborated with Thomas and Morgan; we were able to examine 41 specimens loaned by the Enns Entomology Museum, University of Missouri, that were collected by C. Wingo. No voucher material was found for Watts and Combs (1975); these authors acknowledged I. Moore, University of California, Riverside, for identifications. Moore collected or identified as *A. bipustulata* two of the specimens borrowed from the University of California, Riverside, and the nine specimens from the Lyman Entomological Museum. These, like all other specimens examined, proved to be *A. verna* and not *A. bipustulata*.

During the field survey of canola in the three Canadian prairie provinces, 4134 *D. radicum* puparia were reared to adulthood and 811 *Aleochara* spp. beetles emerged. Of these beetles, 121 were *A. verna* and 690 were *A. bilineata*. Both these species were present at all sites, but no specimens of *A. bipustulata* were found.

From these results, we conclude that previous records of occurrence of *A. bipustulata* in North America are erroneous. Our data support the opinions of Klimaszewski (1984) and Maus (1996, 1998) that *A. bipustulata* is absent from North America.

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