Alien true bugs (Hemiptera: Heteroptera) in Canada: composition and adaptations[1]

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Abstract—The distribution, spread, and adaptations of the 81 alien heteropterous species recorded in Canada are summarized. Sixty-nine species had eastern introductions and 47 had western introductions; 35 were introduced separately on both coasts. Most of the alien species are mirids of European origin. Several of these alien mirids have adapted and become pests of fruit and other agricultural crops, and some have become useful predators. Only 3 have adapted and spread across the whole country.

Résumé—Nous résumons la répartition l'étendue et les adaptations des 81 punaises (Heteroptera) exotiques au Canada. Soixante-neuf espèces sont venues de l'Est et 47 de l'Ouest. Trente-cinq de l'ensemble sont passées par les deux régions côtières. La plupart sont des mirides d'origine européenne. Certains mirides se sont adaptés, ravagent les récoltes de fruits et d'autres cultures ou sont des prédateurs utiles. Seuls 3 mirides se sont dispersés dans l'ensemble du pays.

Introduction

Alien species are usually viewed quite negatively by biologists because they can have dramatic economic impacts (Pimentel *et al.* 2000; Pimentel 2002) and are often considered a cause of native species decline second only to habitat loss (Wilcove *et al.* 1998; Enserink 1999; Pimentel 2002; Scudder 2002). Whether alien species actually cause extinctions is still being debated (Gurevitch and Padilla 2004; Ricciardi 2004; Clavero and García-Berthon 2005), but they are often associated with ecological change (Didham *et al.* 2005).

In this paper, however, we wish to view alien species from the point of adaptation. We examine the introduction, distribution patterns, pathways of spread, and some of the ecological impacts of alien bugs in Canada. This research provides a foundation for ongoing studies of distribution, dispersal, and pest risk assessment now and with impending climate change.

Materials and methods

Provincial records of Heteroptera were taken mostly from the entries in Maw *et al.* (2000) under Hemiptera (suborder Prosorrhyncha). The tabulation in Maw *et al.* (2000) shows that no alien species of the infraorders Enicocephalomorpha, Dipsocoromorpha, Nepomorpha, Gerromorpha, and Leptopodomorpha occur in Canada, so these taxa were excluded from further study. Hence, this paper considers the terrestrial Heteroptera, *i.e.*, the taxa within the infraorders Cimicomorpha and Pentatomomorpha, both of which include alien species.

Distribution data were obtained from the published literature. The monograph by Wheeler and Henry (1992) provided a valuable guide in our study of the Miridae.

Most of the dates given in Tables 3–10 were obtained from the literature references cited therein. However, through the cooperation of various museum curators, we obtained collection

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dates earlier than those cited in the published papers. In such cases, we have cited the original specimen collection data and sources. Collection abbreviations are as follows:

CNC	Canadian National Collection of Insects, Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada
JBWM	J.B. Wallis Museum, Department of Entomology, University of Manitoba, Winnipeg, Manitoba, Canada
LEMQ	Lyman Entomological Museum, Macdonald College, McGill University, Sainte-Anne-de-Bellevue, Quebec, Canada
OSAC	Oregon State Arthropod Collection, Oregon State University, Corvallis, Oregon, United States of America
PFC	Pacific Forestry Centre, Victoria, British Columbia, Canada
UBCZ	Spencer Entomological Museum, Department of Zoology, University of British Columbia, Vancouver, British Columbia, Canada
USNM	National Museum of Natural History, Smithsonian Institution, Washington, D.C., United States of America

We have not attempted to assemble and cite the first published records for the various alien bugs in North America. However, most such citations can be found in Henry and Froeschner (1988), Wheeler and Henry (1992), and the references listed at the end of this paper.

We examined specimens of alien heteropterous species in most of the major collections across Canada and developed a georeferenced database of all material studied; a Microsoft Excel file is available from the authors. This enabled us to map the occurrence of species across the country. From this database, records of the earliest collection of species were obtained for the various provinces.

Data on ecological impact were also assessed from the published literature. Beirne (1972) and Kelton (1982*c*) provided information on the major pests.

Results and discussion

Mode of introduction

In the case of biological control agents released in Canada, we have precise documentation of the mode of introduction. Thus, we know that in 1963 *Anthocoris nemoralis* from Switzerland was released in Summerland, British Columbia, for the control of the pear psylla, *Cacopsylla pyricola* (Förster) (Hemiptera: Psyllidae), and that it has survived. Two other species from Switzerland, *Anthocoris nemorum* (L.) and *Anthocoris pilosus* (Jakovlev), were released the same year but did not survive (McMullen 1971), the numbers released being just 2 and 10, respectively. The native western North American species *Anthocoris tomentosus* Péricart (= *A. melanocerus* Reuter) was transported from British Columbia and released in Ontario for control of the same pest, but again without success (McMullen 1971).

Two species of *Tetraphleps* Fieber were also introduced into Canada in attempts at biological control of the balsam woolly adelgid, *Adelges piceae* (Ratzeburg) (Hemiptera: Adelgidae). *Tetraphleps abdulghani* Ghauri from Pakistan and India was released in 1962–1965 into New Brunswick, and in 1965 into Nova Scotia and British Columbia. *Tetraphleps raoi* Ghauri from India was released in 1965 into both New Brunswick and Nova Scotia. Neither of these species have become established (Schooley *et al.* 1984).

More recently, growers have brought the eastern North American species *Orius insidiosus* into greenhouses in British Columbia to control thrips (Thysanoptera), and although it has proven successful as a predator, and has occasionally escaped, so far it has evidently not become established in the wild in the Lower Fraser Valley (D. Gillespie, personal communication).

However, for the majority of the alien bugs, the mode of introduction is not well defined, although there is substantial circumstantial evidence for introductions by way of nursery stock, solid ballast, and other commodities. Miller (1991) and Gill *et al.* (1996, 1998) documented interceptions of alien Heteroptera in the years 1990–1996 in Alberta, British Columbia, Nova Scotia, Ontario, Quebec, and Saskatchewan. These heteropterans were in containers, dunnage, flowering plants, foodstuffs, fruit trees, nursery stock, personal effects, plant material, and vegetables from China, the Czech Republic, Fiji, Ghana, Hawai'i, India, Indonesia, Italy, Japan, the Netherlands, Nigeria, Portugal, and South Africa. One of the most frequently intercepted species was the southern green stink bug, *Nezara viridula* (L.), a major pest of soybean and other agricultural crops in

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the world (McPherson and McPherson 2000; Panizzi *et al.* 2000), although this species has not become established in Canada.

For the majority of the alien Heteroptera that have adapted and survived in Canada, available literature suggests that the major mode of introduction was via nursery stock (Wheeler and Henry 1992). This is especially evident for plant bugs (Miridae) and lace bugs (Tingidae), which seem to have been often transported in the egg stage in plant tissue.

There is some evidence that a number of ground-dwelling bugs, such as seed bugs (Lygaeidae), were introduced in solid ballast, which was used by the shipping industry up to the early 1900s on both the east and the west coast. Soil, sand, and other solid material used as ballast were unloaded in the port where cargo was to be picked up. This served as a means of transport for various soil- and ground-dwelling organisms and seeds of terrestrial plants. However, most European insects introduced to the Pacific Northwest via ballast have been late arrivals compared with those on the Atlantic coast, and this is related to the opening of the Panama Canal in 1914 (Lindroth 1957; Scudder 1958, 1960, 1961; Lattin 1966; Waloff 1966).

There is evidence for post-ballast introduction of some seed bugs on the west coast (Asquith and Lattin 1991). Also, even within a single species, the mode of introduction may differ between the east and west coasts. Thus, it has been suggested that *Megalonotus sabulicola* was introduced to western North America via ballast (Slater and Sweet 1958; Scudder 1961), but the late discovery of this species on the east coast suggests post-ballast introduction via plants (Slater and Sweet 1958). The same situation seems to prevail with *Stygnocoris rusticus*: ballast introduction was suggested by Sweet (1964), but on the east coast this species was detected well after the main solid ballast period, suggesting an introduction via soil, seed, packing material around nursery stock, or other products of commerce (Wheeler 1983). Ballast introduction was suggested for the nabid *Himacerus major* in western North America (Scudder 1961; Lattin 1966), but a post-ballast introduction is most likely in eastern North America (Wheeler 1976).

Although the majority of established alien bugs in Canada are of European origin, this could well change in the future with changes in trading patterns. Already there is evidence for an increase in aliens of Asian origin in some taxa (Humphreys *et al.* 1998).

With nursery stock being imported at an ever-increasing rate, this mode of introduction will undoubtedly persist, especially since it is difficult to detect eggs in plant tissue. Although solid ballast introductions have ceased, other modes of introduction could become dominant. Transport of aliens into Canada in fresh vegetables and fruit from California, Florida, and Central and South America is a likely candidate. Insects such as the seed bug, *Geocoris punctipes* (Say) (native in the more southern United States), have been collected alive on lettuce, apparently from California, in a British Columbia supermarket (G.G.E. Scudder, unpublished data). Plant bug stowaways in tropical fruit are continually recorded in the United States (US Congress, Office of Technical Assessment 1993).

Faunistic results

Eighty-one alien species of Heteroptera have become successfully established in Canada (Table 1). All are terrestrial species and constitute 6.8% of the fauna. All but one are of European origin: *Taylorilygus apicalis* is widespread in the southern United States and throughout the Neotropics and was likely introduced to Canada from these regions. No established alien aquatic or semiaquatic bugs have been reported, although they have been intercepted in nursery stock (Miller 1991; Gill *et al.* 1998).

We have not included the bed bug, *Cimex lectularius* (L.), in this analysis because it is confined to human habitations and is now cosmopolitan. The species is reported to have appeared in England in 1503, and by 1730 it was evidently abundant in all seaports in England (Southwood and Leston 1959). Ships leaving these ports for North America would have transported the bugs to the colonial seaports shortly thereafter (Sailer 1983). Morris (1983) noted that this species was probably introduced into Newfoundland by man when the island was first colonized.

No alien bugs have been reported so far from Labrador, Nunavut, or Yukon Territory. Nova Scotia has the highest number of alien species (55), followed by British Columbia (49) and Ontario (44) (Table 2). With 20% of the terrestrial true bug fauna of Prince Edward Island being introduced, this province has the highest percentage of aliens (Table 2). It is followed by

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Table 1. Tabular checklist of the alien Heteroptera in Canada.

	Province or territory												
	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	PE	NS	NL
Infraorder Cimicomorpha													
Family Anthocoridae													
Acompocoris pygmaeus (Fallén)								ON		NB	PE	NS	
Anthocoris confusus Reuter				BC				ON			PE	NS	
Anthocoris nemoralis (Fabr.)				BC				ON					
Brachysteles parvicornis (Costa)												NS	
Orius insidiosus (Say)[a]				BC									
Orius minutus (L.)				BC									
Temnostethus gracilis Horvath												NS	
Family Nabidae													
Himacerus apterus (Fabr.)												NS	
Himacerus major (Costa)				BC				ON[b]				NS[c]	
Nabicula limbata (Dahlbom)													NL
Family Microphysidae													
Loricula bipunctata (Perris)				BC									
Loricula pselaphiformis Curtis												NS	
Myrmedobia exilis (Fallén)													NL
Family Miridae													
Subfamily Bryocorinae													
Campyloneura virgula (Herrich-Schaeffer)				BC									
Dicyphus pallicornis (Fieber)				BC									
Subfamily Deraeocorinae													
Deraeocoris ruber (L.)[d]								ON			PE	NS	
Subfamily Mirinae													
Tribe Mirini													
Adelphocoris lineolatus (Goeze)				BC	AB	SK	MB	ON	QC	NB	PE	NS	NL
Camptozygum aequale (Villers)								ON	QC			NS	
Capsus ater (L.)[e]				BC				ON	QC	NB	PE	NS	NL
Closterotomus norwegicus (Gmelin)				BC					QC	NB	PE	NS	NL

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Table 1 (*continued*).

	Province or territory												
	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	PE	NS	NL
Dichrooscytus rufipennis (Fallén)								ON					
Lygocoris lucorum (Meyer-Dür)									QC				
Phytocoris dimidiatus Kirschbaum				BC								NS	
Phytocoris populi (L.)				BC			MB[f]	ON[f]				NS	
Phytocoris tiliae (Fabr.)				BC								NS	
Phytocoris ulmi (L.)												NS	
Pinalitus cervinus (Herrich-Schaeffer)												NS	
Pinalitus rubricatus (Fallén)												NS	
Stenotus binotatus (Fabr.)				BC			MB	ON	QC		PE	NS	NL
Taylorilygus apicalis (Fieber)[d]								ON		NB			
Tribe Stenodemini													
Leptopterna dolabrata (L.)				BC	AB[f]		MB	ON	QC	NB	PE	NS	NL
Megaloceroea recticornis (Geoffroy)				BC	AB[f]			ON	QC	NB	PE	NS	NL
Pithanus maerkelii (Herrich-Schaeffer)				BC	AB			ON	QC	NB	PE	NS	NL
Subfamily Orthotylinae													
Tribe Halticini													
Halticus apterus (L.)								ON	QC	NB	PE	NS	NL
Orthocephalus coriaceus (Fabr.)				BC				ON	QC	NB	PE	NS	NL
Orthocephalus saltator (Hahn)								ON	QC	NB	PE	NS	NL
Tribe Orthotylini													
Blepharidopterus angulatus (Fallén)				BC	AB					NB	PE	NS	NL
Heterotoma planicorne (Pallas)				BC								NS	
Malacocoris chlorizans (Panzer)				BC									
Melanotrichus concolor (Kirschbaum)[g,h]				BC								NS	
Melanotrichus flavosparsus (Sahlberg)[g]		NT		BC	AB	SK	MB	ON	QC	NB	PE	NS	
Melanotrichus virescens (Douglas and Scott)[g]				BC					QC			NS	
Orthotylus nassatus (Fabr.)								ON			PE	NS	
Orthotylus ochrotrichus Fieber				BC									
Orthotylus viridinervis (Kirschbaum)								ON				NS	

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Table 1 (*continued*).

	Province or territory												
	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	PE	NS	NL
Pseudoloxops coccineus (Meyer-Dür)								ON				NS[c]	
Subfamily Phylinae													
Tribe Phylini													
Amblytylus nasutus (Kirschbaum)				BC				ON					
Asciodema obsoletum (Fieber)				BC									
Atractotomus magnicorinis (Fallén)								ON	QC			NS	NL
Atractotomus mali (Meyer-Dür) (*incertae sedis*)				BC						NB	PE	NS	
Campylomma verbasci (Meyer-Dür)				BC				ON	QC	NB		NS	
Compsidolon salicellum (Herrich-Schaeffer)				BC				ON			PE	NS	
Lepidargyrus ancorifer (Fieber)				BC				ON					
Lopus decolor (Fallén)				BC				ON	QC	NB	PE	NS	NL
Megalocoleus molliculus (Fallén)								ON	QC	NB	PE	NS	NL
Phylus coryli (L.)				BC									
Plagiognathus arbustorum (Fabr.)				BC									NL
Plagiognathus chrysanthemi (Wolff)				BC	AB[f]	SK[f]	MB	ON	QC	NB	PE	NS	NL
Plagiognathus vitellinus (Scholtz)								ON	QC			NS[f]	
Psallus flavellus Stichel												NS	
Psallus haematodes (Gmelin)				BC									
Psallus lepidus Fieber											PE	NS	
Sthenarus rotermundi (Scholtz)								ON	QC[f]			NS[c]	
Tribe Pilophorini													
Pilophorus confusus Kirschbaum									QC			NS	
Pilophorus perplexus Douglas and Scott				BC				ON	QC		PE	NS	
Family Tingidae													
Dictyla echii (Schrank)								ON	QC			NS[c]	
Dictyonota fuliginosa Costa				BC									
Stephanitis rhododendri Horváth				BC				ON	QC	NB		NS	NL
Stephanitis takeyai Drake and Maa[i]				BC									
Family Reduviidae													
Empicoris culiciformis (DeGeer)				BC				ON					

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Table 1 (*concluded*).

	Province or territory												
	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	PE	NS	NL
Empicoris pilosus (Fieber)				BC				ON	QC			NS	
Empicoris vagabundus (L.)				BC				ON	QC		PE	NS	NL
Infraorder Pentatomomorpha													
Family Artheneidae													
Chilacis typhae (Perris)				BC				ON					
Family Berytidae													
Berytinus minor (Herrich-Schaeffer)								ON	QC	NB	PE	NS	NL
Family Rhyparochromidae													
Drymus brunneus (Sahlberg)[j]				BC[k]									
Lamprodema maurum (Fabr.)												NS	
Megalonotus sabulicola (Thomson)[l]				BC				ON	QC[k]				
Pachybrachius fracticollis (Schilling)									QC				
Pachybrachius luridus Hahn									QC				
Stygnocoris rusticus (Fallén)				BC	AB			ON	QC	NB[f]	PE	NS	NL
Stygnocoris sabulosus (Schilling)[m]				BC	AB		MB[k]	ON	QC	NB	PE	NS	NL
Family Pentatomidae													
Picromermus bidens (L.)								ON	QC	NB	PE	NS	

Note: The systematic order follows Maw *et al.* (2000). *Leptoglossus occidentalis* Heidemann was listed in Maw *et al.* (2000) as introduced into Ontario and New Brunswick, but this is incorrect, as this is a natural expansion from the west (Schaffner 1967; McPherson *et al.* 1990; Marshall 1991; Gall 1992). *Lasiomerus annulatus* (Reuter) also was not introduced into Ontario and Quebec. *Psallus variabilis* (Fallén) should be deleted from the Canadian list, as Henry and Wheeler (1988) incorrectly included Ontario in the distribution of this species (Wheeler and Henry 1992).

[a]Eastern species introduced into British Columbia for biological control in greenhouses, and escaped; excluded from most analyses.
[b]Record from Paiero *et al.* (2003), not in Maw *et al.* (2000).
[c]Records from Wheeler and Hoebeke (2004), not in Maw *et al.* (2000).
[d]Not listed in Maw *et al.* (2000); occurrence in Canada documented by Schwartz and Scudder (2001).
[e]The record of *Capsus ater* from Alberta (Knight 1925) is in error, as it is *C. cinctus* (Kolenati).
[f]Records from Barnes *et al.* (2000), not in Maw *et al.* (2000).
[g]For alternative nomenclature see Kerzhner and Josifov (1999).
[h]The record of *Melanotrichus concolor* from Quebec (Moore 1950) should be referred to as *M. virescens* (Henry 1991).
[i]New record for Canada (Scudder 2004).
[j]New records for North America (G.G.E. Scudder and L.M. Humble, unpublished data; see Table 3 or 5 for record data).
[k]New record.
[l]New record for Quebec: Herdman, 10.xi.1979 (Larochelle, Larivière) (LEMQ); earliest record.
[m]New record for Manitoba: Winnipeg, St. Charles Rifle Range, A. Spring, 20–26.viii.1998 (D.A. Pollock, J.K. Diehl, and R.E. Roughley) (JBWM); earliest record.

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Table 2. Summary of the distribution of alien Heteroptera in Canada and the proportions of terrestrial Heteroptera and Miridae they represent.

	Terrestrial Heteroptera			Miridae		
Region	Total no. of species	Total no. of aliens	% of terrestrial Heteroptera	Total no. of species	Total no. of aliens	% of Miridae
Yukon Territory	186	0	0	113	0	0
Northwest Territories	133	1	0.8	72	1	1.4
Nunavut	15	0	0	13	0	0
British Columbia	655	49	7.5	358	32	9.0
Alberta	462	9	2.0	276	7	2.5
Saskatchewan	388	3	0.8	235	3	1.3
Manitoba	418	7	1.7	248	6	2.4
Ontario	649	44	6.8	382	29	7.6
Quebec	553	34	6.2	325	23	7.1
New Brunswick	242	23	9.5	147	17	11.6
Prince Edward Island	143	28	19.6	90	21	23.3
Nova Scotia	311	55	17.7	197	39	19.8
Newfoundland[a]	146	23	15.8	81	16	19.8
Labrador	47	0	0	29	0	0
Canada[b]	1190	81	6.8	706	52	7.4

[a]Includes recent records from D.J. Larson not in Maw *et al.* (2000).
[b]Totals as of 12 June 2005.

Nova Scotia (17.7%) and Newfoundland (15.6%); the prairie provinces have some of the lowest levels of alien species.

The majority (almost 60%) of the terrestrial heteropterous fauna in Canada comprises plant bugs of the family Miridae (Maw *et al.* 2000). An analysis of this family shows that 7.4% of it is introduced, with the highest percentages in the Atlantic Maritime provinces (Table 2). However, the actual numbers of introduced species in British Columbia and Ontario are also high.

Points of introduction, distribution patterns, and spread

Based on current distributions and dates of first collection or occurrence reported in the literature, the general area of introduction of the alien bugs can be deduced. They show clear evidence of eastern and (or) western entries.

Sixty-nine of the alien species were introduced in the east and 47 were introduced in the west; 35 of the 81 evidently had both eastern and western introductions. The ranges of many of the latter show a distinct gap in the middle of Canada (Table 1). Only 3 species are now transcontinental.

The 12 western-introduced alien bugs in Canada that are confined to British Columbia (Table 3) appeared relatively recently and have not spread far from the coastal areas where most of them were introduced. Moreover, among the 47 species with western introductions, 39 (83%) have evidently not moved within western Canada beyond British Columbia, having been collected in western Canada only in this province. Only 6 bugs (*Blepharidopterus angulatus*, *Leptopterna dolabrata*, *Megaloceroea recticornis*, *Pithanus maerkelii*, *Stygnocoris rusticus*, and *S. sabulosus*) have adapted and extended their range into Alberta (Table 1), although the published record for *B. angulatus* in Alberta (Carvalho 1958) has not been confirmed (Wheeler and Henry 1992). All 6 seem to have spread east from British Columbia, judging by their dates of first recorded occurrence (Table 4).

Of the 47 western-introduced alien bugs, 12 (25.5%) (Table 5) are known in all of western North America only from British Columbia and thus appear to have been introduced into this province. The tingid *Stephanitis takeyai*, first recorded in Richmond, British Columbia, in 2001 on Japanese andromeda (*Pieris japonica* (Thunb.) D. Don *ex* G. Don) (Scudder 2004), is clearly a

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Table 3. Alien Heteroptera in Canada confined to British Columbia; sequence of species as in Table 1.

Species	Earliest record	Reference
Orius minutus	1950	Barnes *et al.* 2000
Loricula bipunctata	1990	Schwartz *et al.* 1991
Campyloneura virgula	1949	Downes 1957
Dicyphus pallicornis	1944	Downes 1957
Malacocoris chlorizans	1959	Schwartz and Scudder 1998
Orthotylus ochrotrichus	1959	Schwartz and Scudder 1998
Asciodema obsoletum	1959	Barnes *et al.* 2000
Phylus coryli	1959	Kelton 1982*d*
Psallus haematodes	1970	Kelton 1983*b*, as *Psallus roseus*
Dictyonota fuliginosa	1957	Barnes *et al.* 2000
Stephanitis takeyai	2001	Scudder 2004
Drymus brunneus	1996	Richmond, Nature Park, 23.vi.–13.viii.1996 (L. Humble, J. Seed) (PFC)

separate western introduction, having been first found in 1946 in Connecticut (Bailey 1950) and subsequently in several other eastern states (Wheeler 1977). *Stephanitis takeyai* probably came into British Columbia on nursery stock. Likewise, *Anthocoris confusus* appears to have been introduced separately into British Columbia and eastern North America (see Table 9) because it has not been reported between these well-separated areas. We believe these are separate, accidental introductions in the west and the east, but we cannot rule out the possibility of range expansions by human transport within Canada.

Of the 35 western-introduced alien species that also occur in the western United States, 21 have their earliest recorded occurrence in British Columbia (Table 6), so they may also have been introduced into this province first and then spread south. The other 14 western-introduced aliens appear to have spread north into British Columbia from the south, as the earliest recorded occurrences are in the western United States (Table 7). *Anthocoris nemoralis*, which was intentionally introduced for biological control in British Columbia in 1963 (McMullen 1971) and in Washington State in 1976 (Unruh *et al.* 1995), has now been reported from California (Hagen and Dreistadt 1990) and Oregon (Lewis *et al*. 2005). *Anthocoris nemoralis* has thus had multiple introductions, and it is quite possible that other western-introduced aliens may also have had multiple introductions (Schuh 2000).

Of the 69 eastern-introduced alien bugs, 20 (29.0%) (Table 8) occur only in Canada and have not spread far from where they were first recorded. Three bugs (*Nabicula limbata*, *Myrmedobia exilis*, and *Plagiognathus arbustorum*) appear to have been introduced into Newfoundland, since this is the only eastern province in which they occur, although *P. arbustorum* was also separately introduced into British Columbia.

Two species of seed bug, *Pachybrachius fracticollis* and *Pachybrachius luridus*, were evidently introduced into Quebec but have not spread and may not have survived, as there are no records beyond their first recorded occurrence in 1915 (Parshley 1923*b*). *Anthocoris nemoralis* was definitely introduced into Ontario for biological control (McMullen 1971). *Pseudoloxops coccineus* seems to be confined to Ontario (Kelton 1983*a*) and hence was probably originally introduced into this province.

Twelve of the eastern-introduced alien bugs confined to Canada were first recorded in Nova Scotia. However, *Orthotylus viridinervis* may have been separately introduced into Nova Scotia and Ontario, being recorded in the former province in 1976 and in the latter in 1977 (Kelton 1982*b*). The minute pirate bug *Acompocoris pygmaeus* is confined to eastern Canada, with the first recorded occurrence in New Brunswick in 1965 and in Nova Scotia in 1966 (Kelton 1977*a*).

Of the 49 eastern-introduced alien bugs that occur in both eastern Canada and the eastern half of the United States, 19 (38.8%) have their earliest recorded occurrence in Canada and thus appear to have been first introduced into the various provinces indicated in Table 9. The

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Table 4. Year of first recorded occurrence in British Columbia and Alberta of six alien heteropterous species confined to these provinces in western Canada; sequence of species as in Table 1.

	British Columbia		Alberta	
Species	Earliest record	Reference	Earliest record	Reference
Leptopterna dolabrata	1916	Parshley 1919	1994	Barnes *et al.* 2000
Megaloceroea recticornis	1921	Knight 1927	1994	Barnes *et al.* 2000
Pithanus maerkelii	1917	Parshley 1919	1952	Barnes *et al.* 2000
Blepharidopterus angulatus	1924	Knight 1927	"1958"	Carvalho 1958
Stygnocoris rusticus	1919	Downes 1924	1993	Barnes *et al.* 2000
Stygnocoris sabulosus	1924	Asquith and Lattin 1991	1998	Barnes *et al.* 2000

Note: Year in quotation marks is year of publication (actual date not available).

Table 5. Alien Heteroptera known in western North America only from British Columbia; sequence of species as in Table 1.

Species	Earliest record	Reference
Anthocoris confusus	1977	Scudder 1986
Loricula bipunctata	1990	Schwartz *et al.* 1991
Orthocephalus coriaceus	1976	Barnes *et al.* 2000
Orthotylus ochrotrichus	1959	Schwartz and Scudder 1998
Asciodema obsoletum	1959	Barnes *et al.* 2000
Atractotomus mali	1970	Barnes *et al.* 2000
Phylus coryli	1959	Kelton 1982*d*
Plagiognathus arbustorum	1954	Barnes *et al.* 2000
Dictyonota fuliginosa	1957	Barnes *et al.* 2000
Empicoris pilosus	1918	Downes 1927
Stephanitis takeyai	2001	Scudder 2004
Drymus brunneus	1996	Richmond, Nature Park, 23.vi.–13.viii.1996 (L. Humble, J. Seed) (PFC)

other 30 (61.2%) have their first recorded occurrence in the eastern United States (Table 10) and thus seem to have spread into Canada from the south. However, although the earliest records for *Brachysteles parvicornis*, *Heterotoma planicorne*, and *Phytocoris tiliae* are in the United States, the geographic gap between their occurrence in New York in the United States and Nova Scotia in Canada suggests separate introductions rather than simple spread north. Nevertheless, the recent captures of *Deraeocoris ruber* and *Taylorilygus apicalis* suggest that a northward spread is ongoing. Whether the spread is natural dispersal or movement through commerce is not clear.

Schuh (2000) has confirmed the suggestion of Wheeler and Henry (1992) that the introduced species *Lepidargyrus ancorifer* has disappeared from northeastern North America, although there is a 1965 record for Ontario. In contrast, the species persists in western North America.

Only three bugs — *Adelphocoris lineolatus* (Fig. 1), *Melanotrichus flavosparsus* (Fig. 2), and *Plagiognathus chrysanthemi* — have achieved a greater level of adaptation to the conditions in Canada and have now truly invaded the whole country, occurring more or less across all of the southern provinces.

Melanotrichus flavosparsus (Fig. 3) was first reported in North America from Quebec (Provancher 1872) and seems to have spread to the District of Columbia by 1886 (Table 9) and Ontario by 1903 (Barnes *et al.* 2000). By 1917 it was present in the District of Columbia, Kansas, Maine, New Jersey, Ohio, and Virginia (Van Duzee 1917). It reached Nova Scotia by 1920 (Parshley 1923*a*). The occurrence of

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Table 6. Alien Heteroptera in western Canada and the western United States recorded earlier in Canada; sequence of species as in Table 1.

	Western Canada		Western United States	
Species	Earliest record	Reference	Earliest record	Reference
Anthocoris nemoralis	BC, 1963	McMullen 1971	WA, 1976	Unruh *et al.* 1995
Capsus ater	BC, 1919	Downes 1924	WA, 1939	Seattle, 3.vii.1939 (OSAC)
Closterotomus norwegicus	BC, 1917	Barnes *et al.* 2000	CA, 1966	Lincoln, 21.iv.1966 (W.W. Wiard and J. Wilson) (USNM)
Phytocoris populi	BC, 1955	Stonedahl 1983	WA, 1981	Stonedahl 1983
Phytocoris tiliae	BC, 1921	Downes 1924	WA, 1932	Puyallup, 12.viii.1932 (W.V. Baker) (USNM)
Leptopterna dolabrata	BC, 1916	Parshley 1919	OR, 1931	Portland, 1931 (J.E. Davis) (OSAC)
Megaloceroea recticornis	BC, 1921	Knight 1927	ID, "1941"	Knight 1941
Pithanus maerkelii	BC, 1917	Parsley 1919	WA, 1926	Knight 1927
Blepharidopterus angulatus	BC, 1924	Knight 1927	WA, 1979	Watcom Co., Bellingham, 19.vii.1979 (G.M. Stonedahl) (OSAC)
Heterotoma planicorne	BC, 1923	Barnes *et al.* 2000	WA, 1930	Wheeler and Henry 1992
Malacocoris chlorizans	BC, 1959	Schwartz and Scudder 1998	WA, 1986	Schwartz and Scudder 1998
Melanotrichus concolor	BC, 1932	Anonymous 1932	OR, 1940	Portland, Borsch Nursery, 14.vi.1940 (Schuh and Gray) (CNC)
Melanotrichus virescens	BC, 1932	Downes 1957, as *Melanotrichus concolor*	CA, 1963	Waloff 1966
Amblytylus nasutus	BC, 1950	Barnes *et al.* 2000	OR, 1979	Jackson Co., 27.vi.1979 (John D. Lattin) (OSAC)
Campylomma verbasci	BC, 1917	Parshley 1919	OR, 1926	Knight 1927
Compsidolon salicellum	BC, 1952	Kelton 1982*a*	WA, 1979	Lattin and Messing 1984
Lopus decolor	BC, 1919	Duncan, 28.vii.1919 (W. Downes) (USNM)	OR, 1951	Clatakanie, 27.vii.1951 (B.G. Thompson) (OSAC)
Psallus haematodes	BC, 1970	Kelton 1983*b*, as *Psallus roseus*	WA, 1986	W. Seattle, Discovery Park (Ft. Lawton), 28.viii.1986 (M.D. Schwartz) (CNC)
Empicoris vagabundus	BC, 1918	Parshley 1919	WA, 1954	Wygodzinsky 1966
Stygnocoris rusticus	BC, 1919	Downes 1924	WA, 1939	Asquith and Lattin 1991
Stygnocoris sabulosus	BC, 1924	Asquith and Lattin 1991	WA, 1960	Asquith and Lattin 1991

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Table 7. Alien Heteroptera in western Canada and the western United States recorded earlier in the United States; sequence of species as in Table 1.

	Western Canada		Western United States	
Species	Earliest record	Reference	Earliest record	Reference
Orius minutus	BC, 1950	Barnes *et al.* 2000	WA, 1930	Lattin *et al.* 1989
Himacerus major	BC, 1944	Scudder 1961	OR, 1931	Barber 1932
Campyloneura virgula	BC, 1946	Vancouver, 15.vii.1946 (H.H. Ross) (USNM)	CA, 1944	Santa Rosa, on elm (white), 11.vii.1944 (Osborn and Byers) (USNM)
Dicyphus pallicornis	BC, 1944	Downes 1957	WA, 1939	Knight 1968
Phytocoris dimidiatus	BC, 1954	Downes 1957	OR, 1940	Stonedahl 1983
Stenotus binotatus	BC, 1917	Parshley 1919	MT, 1915	Wheeler and Henry 1992
Melanotrichus flavosparsus	BC, 1923	Barnes *et al.* 2000	WA, 1922	Yakima, 27.vii.1922 (W. Downes) (UBCZ)
Lepidargyrus ancorifer	BC, 1959	Barnes *et al.* 2000	CA, 1912	Van Duzee 1914
Plagiognathus chrysanthemi	BC, 1948	Barnes *et al.* 2000	WA, 1944	Schuh 2001
Pilophorus perplexus	BC, 1927	Barnes *et al.* 2000	OR, 1921	Mt. Hood, 6000 ft., 29.vii.1921 (W. Downes) (UBCZ)
Stephanitis rhododendri	BC, 1924	Downes 1927	OR, 1914	Portland, 15.vi.1914 (Oreg. Agric. Exp. Stn. Acc. 1144) (OSAC)
Empicoris culiciformis	BC, 1921	Scudder 2000	OR, 1900	Corvallis, 1.ix.1900 (OSAC)
Chilacis typhae	BC, 1999	Scudder 2000	WA, 1997	Wheeler and Stoops 1999
Megalonotus sabulicola	BC, 1926	Asquith and Lattin 1991	CA, 1921, as *Rhyparochromus chiragra* var. *californicus*	Van Duzee 1928

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Table 8. Alien Heteroptera that occur in eastern North America only in Canada; sequence of species as in Table 1.

Species	Earliest record	Reference
Acompocoris pygmaeus	NB, 1965	Kelton 1977*a*
Anthocoris nemoralis	ON, 1928	McMullen 1971
Temnostethus gracilis	NS, 1966	Kelton 1977*a*
Himacerus apterus	NS, 1943	Larivière 1992
Nabicula limbata	NL, 1949	Lindberg 1958
Loricula pselaphiformis	NS, 1976	Kelton 1980
Myrmedobia exilis	NL, 1980	Kelton 1981
Phytocoris dimidiatus	NS, 1917	Knight 1923
Phytocoris populi	ON, 1918	Barnes *et al.* 2000
Phytocoris ulmi	NS, 1914	Knight 1923
Pinalitus cervinus	NS, 1980	Schwartz and Scudder 2001
Orthotylus viridinervis	NS, 1976	Kelton 1982*b*
Pseudoloxops coccineus	ON, 1961	Kelton 1983*a*
Compsidolon salicellum	NS, 1959	Grand Pré, apple, 28.vii.1959 (H.T. Stultz) (CNC)
Plagiognathus arbustorum	NL, 1982	Barnes *et al.* 2000
Psallus flavellus	NS, 1966	Kelton 1983*b*
Pilophorus confusus	NS, 1976	Kelton 1982*b*
Lamprodema maura	NS, 1913	Ashlock 1977
Pachybrachius fracticollis	QC, 1915	Parshley 1923*b*
Pachybrachius luridus	QC, 1915	Parshley 1923*b*

M. flavosparsus in the prairies, where it was reported from Saskatchewan in 1929 and Manitoba in 1930 (Barnes *et al.* 2000), was evidently the result of dispersal from the states to the south. However, its appearance in British Columbia in 1923 (Barnes *et al.* 2000) seems to be the result of a separate dispersal from Washington State, where it was present in 1922 (Table 7). A similar pattern of introduction and dispersal evidently occurred with *P. chrysanthemi*.

It would seem that the populations of *M. flavosparsus* and *P. chrysanthemi* first established in the east have adapted and spread more readily than those established in the west. The more extensive spread of the eastern-introduced populations is supported by the spread of the third transcontinental species, *A. lineolatus*.

Plotting data from collection specimens suggests that *A. lineolatus* (Fig. 4) was introduced into Nova Scotia prior to 1917 (Knight 1922) and then spread out into adjacent areas of eastern Canada, reaching Prince Edward Island by 1929 (Barnes *et al.* 2000), New Brunswick and Ontario by 1942 (Hughes 1943; Barnes *et al.* 2000), and Newfoundland by 1949 (Lindberg 1958). The occurrence of this species in Manitoba by 1939 (Knight 1941) and its subsequent spread west in Canada (Craig 1971) were probably the result of dispersal from a separate introduction into Iowa around 1929 (Knight 1930*a*, 1930*b*), perhaps via Minnesota, where it was first recognized in 1933 (Knight 1941). Only relatively recently has it entered British Columbia from the east. Using BIOCLIM/BIOMAP methodology that has been applied elsewhere in Canada for other taxa (McKenney *et al.* 1996, 1998; Venier *et al.* 1999), we can predict that it will soon spread further into the north (D.W. McKenney *et al.*, unpublished data). Indeed, it now appears to have reached Beaverlodge and Fort Vermilion in the Peace River district (J. Otani, personal communication). With impending climate change, we can expect increased movement of alien and other species, with concomitant spread into areas where they currently do not occur (Dukes and Mooney 1999).

A number of other alien bugs have been recorded in the northeastern United States in recent years but so far have not been identified in Canada. These include the mirids *Dicyphus rhododendri* Dolling, *Stethoconus japonicus* Schumacher, *Trigonotylus tenuis* Reuter, *Brachynotocoris puncticornis* Reuter, *Phoenicocoris*

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Table 9. Alien Heteroptera in eastern Canada and the eastern United States recorded earlier in Canada; sequence of species as in Table 1.

	Eastern Canada		Eastern United States	
Species	Earliest record	Reference	Earliest record	Reference
Anthocoris confusus	ON, 1929	Anderson and Kelton 1963	NY, 1932	Tannersville, 10.ix.1932 (J.R. Torre-Bueno) (USNM)
Himacerus major	ON, 1956	Paiero *et al.* 2003	NY, 1957	Lattin 1966
Adelphocoris lineolatus	NS, 1917	Knight 1922	IA, 1929	Knight 1930*a*
Closterotomus norwegicus	QC, "1886"	Provancher 1886	NY, 1908	Maspeth, 13.vi.1908 (C.E. Olsen) (CNC)
Pinalitus rubricatus	NS, 1966	Kelton 1977*b*	PA, 1973	Henry and Wheeler 1974
Orthocephalus saltator	NS, 1947	Henry and Kelton 1986	NY, 1974	Henry and Kelton 1986
Blepharidopterus angulatus	NS, 1919	Knight 1922	CT, "1974"	Slater 1974
Melanotrichus concolor	NS, 1958	Barnes *et al.* 2000	WI, "1972"	Akingbohungbe *et al.* 1972
Melanotrichus flavosparsus	QC, "1872"	Provancher 1872	DC, 1886	D.C., 15.x.1886 (P.R. Uhler coll.) (USNM)
Orthotylus nassatus	ON, 1963	Barnes *et al.* 2000	PA, 1973	Henry 1977
Atractotomus mali	NS, 1923	Knight 1924	CT, 1963	Leonard 1965
Campylomma verbasci	QC, "1887"	Provancher 1887	NY, "1887"	Van Duzee 1887
Lopus decolor	QC, "1872"	Provancher 1872, as *Lygus unicolor*	DC, 1895	Washington, 3.vii.1895 (CNC)
Plagiognathus chrysanthemi	QC, "1887"	Provancher 1887	VT, 1898	Schuh 2001
Plagiognathus vitellinus	ON, 1961	Barnes *et al.* 2000	PA, 1972	Henry and Wheeler 1973
Psallus lepidus	NS, 1966	Kelton 1983*b*	MA, 1988	Wheeler and Hoebeke 1990
Berytinus minor	ON, 1929	Walley 1935	MI, 1933	Harris 1941
Stygnocoris rusticus	QC, 1907	Barnes *et al.* 2000	NY, 1908	Heidemann 1908*a*
Stygnocoris sabulosus	NS, 1913	Parshley 1923*a*, as *Stygnocoris pedestris*	NY, 1917	Barber 1918, as *Stygnocoris pedestris*

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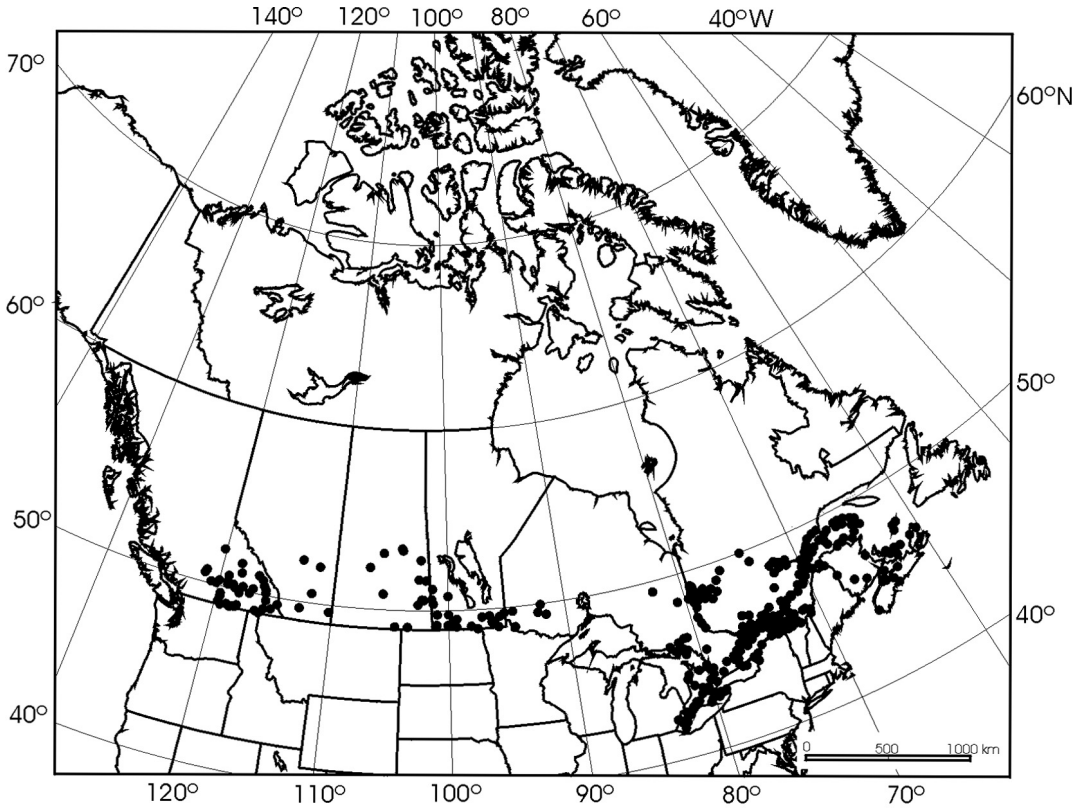
Table 10. Alien Heteroptera in eastern Canada and the eastern United States recorded earlier in the United States; sequence of species as in Table 1.

	Eastern Canada		Eastern United States	
Species	Earliest record	Reference	Earliest record	Reference
Brachysteles parvicornis	NS, 1992	Lattin 1993	NY, 1925	Asquith and Lattin 1990
Deraeocoris ruber	ON, 1929	Schwartz and Scudder 2001	NY, "1878"	Uhler 1878, as *Capsus capillaris*
Camptozygum aequale	NS, 1976	Kelton 1983*a*	PA, 1938	Wheeler and Henry 1973
Capsus ater	QC, "1872"	Provancher 1872	ME, 1826	Uhler 1878
Dichrooscytus rufipennis	ON, 1961	Kelton 1972*a*	NY, 1920	Ithaca, 22.vi.1920 (H.H. Knight) (CNC, USNM)
Lygocoris lucorum	QC, 1919	Johnston 1934	ME, 1885	Knight 1930*c*
Phytocoris tiliae	NS, 1966	Barnes *et al.* 2000	NY, 1965	Wheeler and Henry 1976
Stenotus binotatus	ON, 1911	Barnes *et al.* 2000	MA, "1878"	Uhler 1878
Taylorilygus apicalis	ON, 1961	Schwartz and Scudder 2001	TX, "1876"	Reuter 1876
Leptopterna dolabrata	QC, "1872"	Provancher 1872	MA, 1832	Uhler 1878
Megaloceroea recticornis	ON, 1919	Knight 1927	WI, 1909	Knight 1927
Pithanus maerkelii	NS, "1916"	Parshley 1916	NY, 1909	Olsen 1915
Halticus apterus	QC, "1914"	Gibson 1914	ME, 1903	Parshley 1917
Orthocephalus coriaceus	QC, 1936	Barnes *et al.* 2000	ME, 1913	Knight 1917, as *Orthocephalus mutabilis*
Heterotoma planicorne	NS, 1980	Barnes *et al.* 2000	NY, 1915	Knight 1917, as *Heterotoma meriopterum*
Melanotrichus virescens	QC, "1950"	Moore 1950, as *O. concolor*	MA, 1918	Knight 1922, as *Orthotylus concolor*
Amblytylus nasutus	ON, 1952	Barnes *et al.* 2000	IN, 1927	Blatchley 1928, as *A. vanduzeii*
Atractotomus magnicorinis	ON, 1955	Barnes *et al.* 2000	NY, 1919	Knight 1923
Lepidargyrus ancorifer	ON, 1924	Barnes *et al.* 2000	DC, 1879	Schuh 2000
Megalocoleus molliculus	NB, 1921	Barnes *et al.* 2000	MA, 1916	Knight 1922
Sthenarus rotermundi	ON, 1977	Henry and Wheeler 1979	PA, 1977	Henry and Wheeler 1979
Pilophorus perplexus	ON, 1915	Hamilton, 20.vi.1915 (H.C. Crawford) (USNM)	NY, 1914	Batavia, 5.vii.1914 (H.H. Knight) (USNM)
Dictyla echii	ON, 1983	Wheeler and Hoebeke 1985	PA, 1958	Devonshire Hts., 25.vii.1958 (E.U. Balsbaugh, Jr.) (USNM)
Stephanitis rhododendri	QC, 1933	Barnes *et al.* 2000	PA, 1877	Heidemann 1908*b*, as *Leptobyrsa explanata*
Empicoris culiciformis	ON, 1928	Scudder 2000	PA, "1847"	Haldeman 1847, as *Ploiaria maculata*
Empicoris pilosus	ON, 1915	Barnes *et al.* 2000	VT, 1908	Banks 1912, as *Ploiariodes hirtipes*
Empicoris vagabundus	ON, 1940	Barnes *et al.* 2000	DC, 1898	McAtee and Malloch 1925
Chilacis typhae	ON, 1991	Scudder 2000	DE, 1986	Wheeler and Fetter 1987
Megalonotus sabulicola	ON, 1965	Barnes *et al.* 2000	CT, 1957	Slater and Sweet 1958
Picromerus bidens	QC, 1968	Kelton 1972*b*	ME, 1932	Cooper 1967

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Fig. 1. Known distribution of *Adelphocoris lineolatus* in Canada.



dissimilis (Reuter), and *Psallus variabilis* (Fallén) (Wheeler and Henry 1992) and the microphysid *Myrmedobia coleoptrata* (Fallén) (Schwartz 1989), as well as the rhopalid *Rhopalus tigrinus* (Schilling) (Hoebeke and Wheeler 1982) and the cydnid *Aethus nigritus* (Fabr.) (Hoebeke and Wheeler 1983). Over time, these could well spread into eastern Canada, as others have in the past.

The mirid *Phytocoris varipes* Boheman (Stonedahl 1983), the leptopodid *Patapius spinosus* (Rossi) (Lattin 2002), and six alien seed bugs that occur on the Pacific Coast farther south, namely *Metopoplax ditomoides* (Costa) (Lattin and Wetherill 2002), *Plinthisus brevipennis* (Latr.) (Asquith and Lattin 1991), *Raglius alboacuminatus* (Goeze), *Rhyparochromus vulgaris* (Schilling) (Henry 2004), *Xanthochilus saturnius* (Rossi) (Henry and Adamski 1998; Henry 2004), and *Holcocranum saturejae* (Kolenati) (Wheeler and Stoops 1999), could well spread into British Columbia, the latter especially because the cattail host *Typha latifolia* L. (Typhaceae) is well established with another alien species (*Chilacis typhae*) (Scudder 2000). *Holcocranum saturejae* is also established in the eastern United States (Hoffman and Slater 1995) and could spread to eastern Canada. *Anthocoris nemorum*, which was introduced into Washington State in 1983 for biological control of pear psylla, is now established (Unruh *et al.* 1995) and could well spread north into British Columbia.

There is also the possibility of species being introduced into western North America from the eastern areas of the continent. This has been documented by Lattin and LaBonte (2002), who recorded the eastern North American anthocorid *Cardiastethus luridellus* Fieber being introduced into Oregon in solid-wood packing material. The occurrence of eastern *O. insidiosus* in greenhouses in British Columbia has been mentioned above.

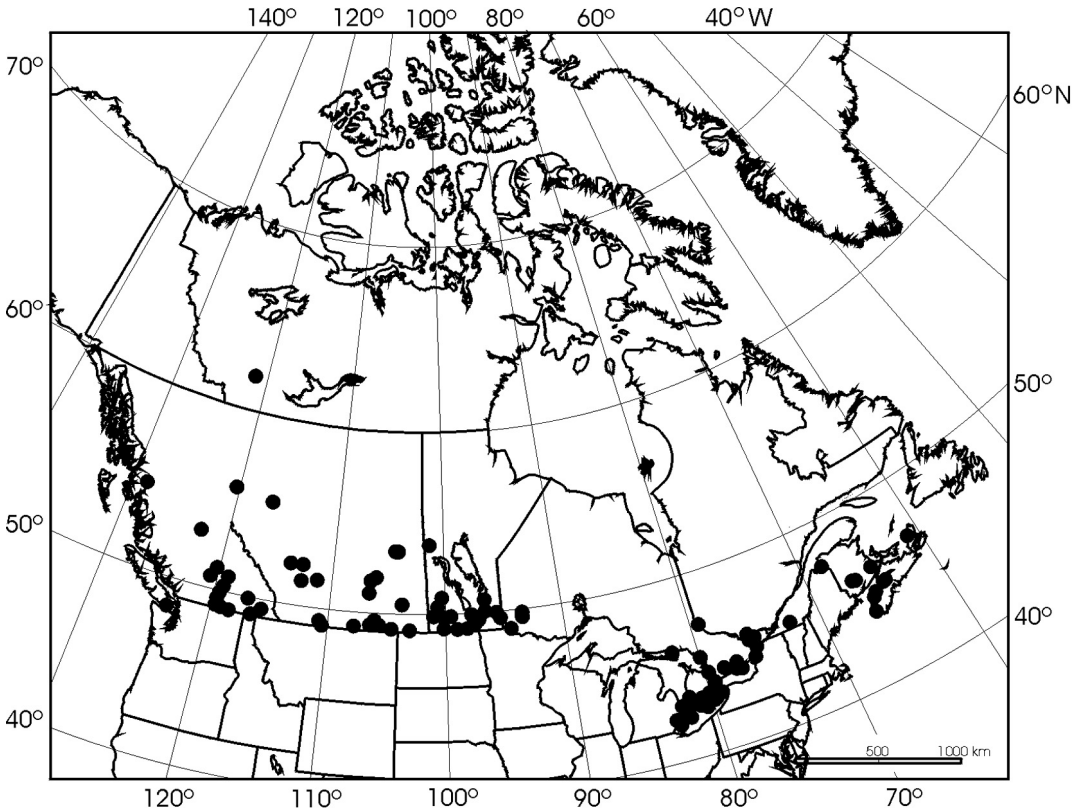
Adaptation and economic importance

Although not all alien bugs are of economic importance (Hoebeke and Wheeler 1983), several alien species have adapted to the monocultures created by agriculture and have become major pests in Canada (Beirne 1972;

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Fig. 2. Known distribution of *Melanotrichus flavosparsus* in Canada.



Kelton 1982*c*) and the United States (Wilson and Graham 1983), and much effort is put into their control (Hedlund and Graham 1987). *Adelphocoris lineolatus* has caused serious damage to alfalfa (genus *Medicago* L.; Fabaceae) in both Canada (Craig 1963, 1971; Beirne 1972) and the United States (Drake 1948; Radcliffe and Barnes 1970; Wheeler 1974). It is primarily an economic pest of alfalfa grown for seed (Craig 1971) but is also a pest of the forage crop birdsfoot trefoil (*Lotus corniculatus* L.; Fabaceae) in New York (Neunzig and Gyrisco 1955).

Closterotomus norwegicus occurs on fruit crops (Kelton 1982*c*) and has caused damage to strawberries (genus *Fragaria* L.; Rosaceae) in Nova Scotia (Pickett *et al.* 1944) and potato (*Solanum tuberosum* L.; Solanaceae) in Newfoundland (Beirne 1972). *Leptopterna dolabrata* has damaged cereal crops and has been shown to reduce yield and seed quality of grain grown for seed (Beirne 1972). It is a well-known pest of grasses in the United States (Osborn 1918; Watson 1928; Jewett and Townsend 1947). *Amblytylus nasutus* has also been reported as being destructive to Kentucky bluegrass (*Poa pratensis* L.; Poaceae) (Jewett and Townsend 1947).

Stenotus binotatus has not been reported as a major pest in Canada, but it is a definite pest of timothy (*Phleum pratense* L.) and orchard grass (*Dactylis glomerata* L.) (Poaceae) in the United States (Watson 1928; Knight 1941) and Japan (Hori *et al.* 1985), and in New Zealand it has been recorded as damaging wheat (*Triticum aestivum* L.; Poaceae) (Meredith 1970; Eyles 1999). *Plagiognathus chrysanthemi* has been recorded as a significant pest of forage legumes in Canada (Beirne 1972) and has been recorded as injuring buds of birdsfoot trefoil in Ontario (Guppy 1963); it may also be a pest on fruit crops (Kelton 1982*c*).

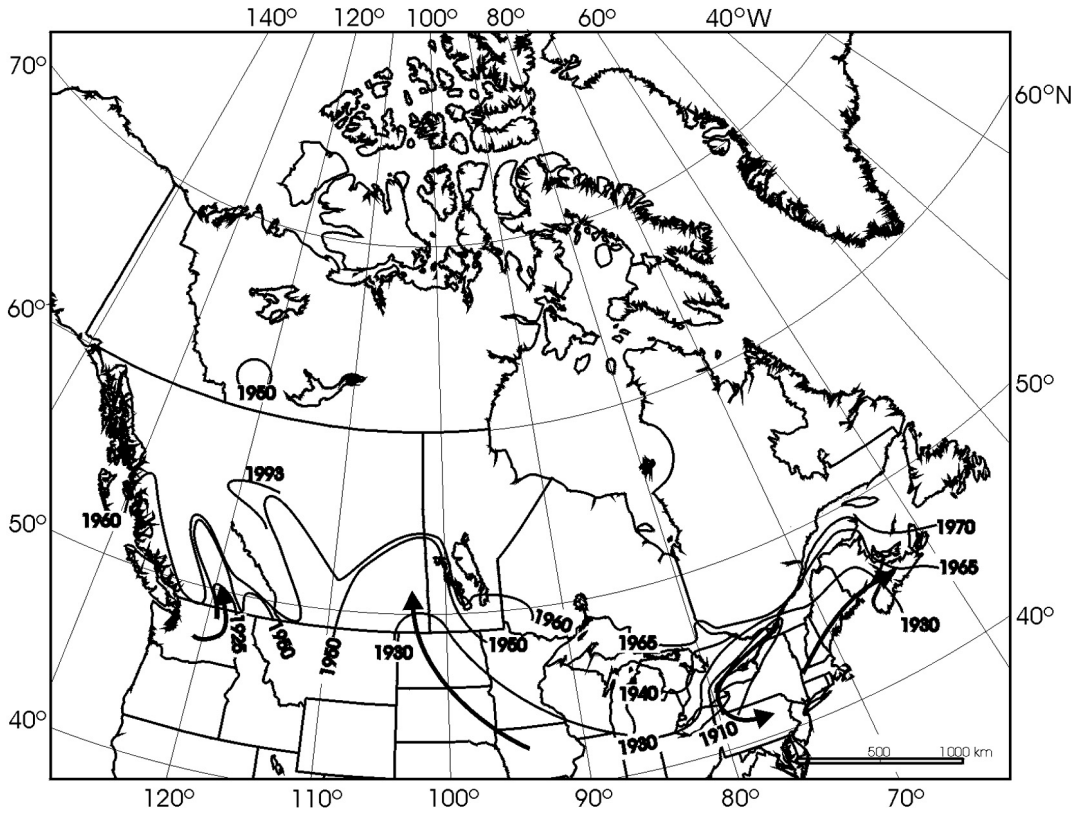
Listed as pests, these alien bugs have in fact just adapted well to the new environment they encounter in the New World, an adaptation often made easier by the probable lack of their specific parasites and predators.

Another group of alien bugs, all predators, have utilized these monocultures in another way, namely by adaptively moving to feed on

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Fig. 3. Apparent route of spread of *Melanotrichus flavosparsus* in Canada.



the pest species in these habitats in Canada. *Blepharidopterus angulatus* will feed on the European red mite, *Panonychus ulmi* (Koch) (Acarina: Tetranychidae) (Lord 1971), and in Nova Scotia is an important natural enemy of the white apple leafhopper, *Typhlocyba pomaria* McAtee (Hemiptera: Cicadellidae) (MacPhee 1979).

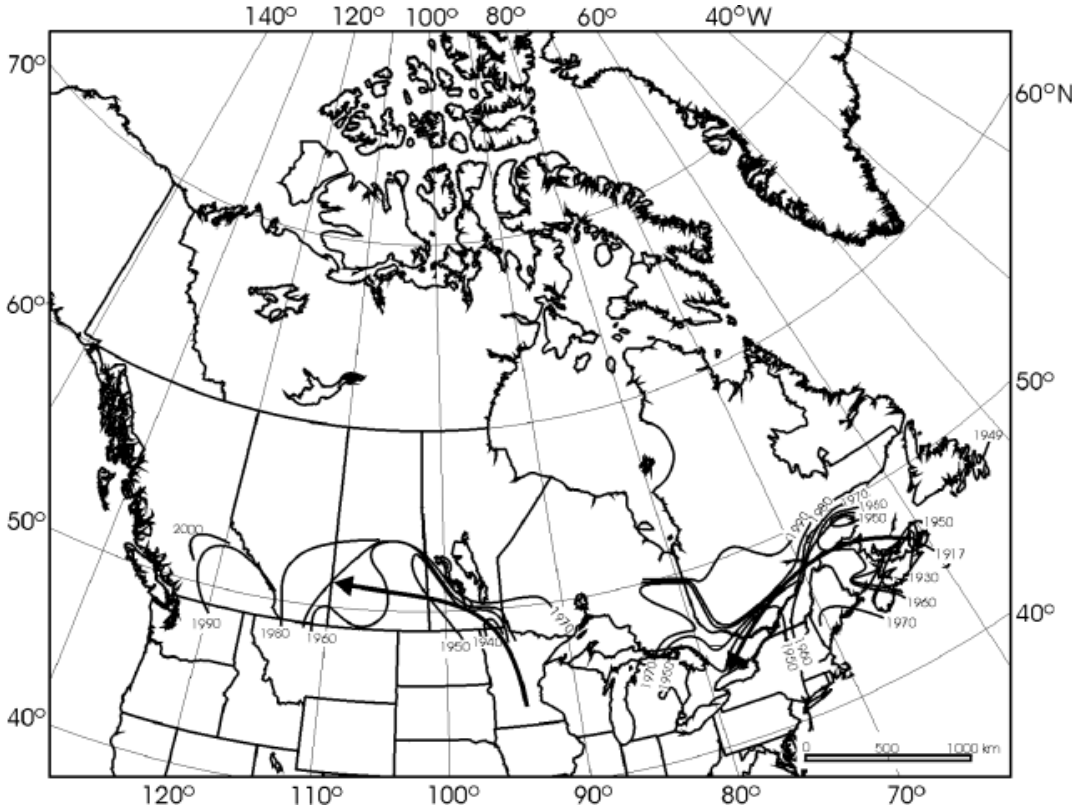
Pilophorus perplexus can be an important predator of aphids on apple (genus *Malus* P. Mill.; Rosaceae) (Fulton 1918; Knight 1924), and the following alien mirids, many of which have been recorded on fruit crops, are all predaceous and so may be beneficial in some contexts (Kelton 1982*c*): *Campyloneura virgula*, *D. ruber*, *Phytocoris dimidiatus*, *Orthotylus nassatus*, *O. viridinervis*, and *Compsidolon salicellum*. The pentatomid *Picromerus bidens* could be considered a useful predator against certain leaf-feeding insects (Larivière and Larochelle 1989), as it has been reported to feed on larvae of the sawfly *Diprion frutetorum* (Fabr.) (Hymenoptera: Diprionidae) in pine (genus *Pinus* L.; Pinaceae) forests in Quebec (Oliveira and Juillet 1971). However, as noted by Larivière and Larochelle (1989), it is not a great traveler, does not disperse well, and has a wide range of prey items. Thus, it may not be very effective.

Hendrickson (2002) reported two other aliens, *O. viridinervis* and *Pilophorus confusus*, as feeding on woody plants in Canada, but both are predators. Predatory Heteroptera can also be phytophagous (Alomar and Wiedenmann 1996). Thus, the alien *Campylomma verbasci* is both phytophagous and predaceous (Leonard 1965; Coll and Ruberson 1998; Thistlewood and Smith 2000), so it has been a serious pest of apple crops in eastern Canada since 1919 (Ross and Caesar 1920; Pickett 1938) and a sporadic pest in western Canada (Madsen *et al.* 1975; Thistlewood *et al.* 1989) and Washington State (Horton *et al.* 1997; Reding and Beers 2000). However, it is also beneficial in biological control of the European red mite (Gilliatt 1935; Lord 1949) and other apple pests (Knight 1924; Thistlewood and Smith 2000). It also disseminates the causative organism of fire blight, *Erwinia amylovora* (Burrill) Winslow (Stewart and Leonard 1915). *Atractotomus mali* is also

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Fig. 4. Apparent route of spread of *Adelphocoris lineolatus* in Canada. A 1964 record from British Columbia that lacked a locality was omitted.



an important predator of the European red mite on apples in both Canada and the United States (Sanford 1964*a*; Horsburgh and Asquith 1968; Lord 1971; MacPhee 1976), but it can be a pest on apples (Sanford 1964*b*).

Other ecological considerations

To date, there is no evidence that accidentally introduced alien bugs in Canada have caused extinction, decline, or disruption of indigenous species. There is no conclusive evidence of direct competitive displacement of native predatory *Anthocoris* species by the alien *A. nemoralis* (Horton *et al*. 2004). However, Fields and Beirne (1973) stated that *A. nemoralis* could have some indirect influence by causing the native *A. tomentosus* to leave pear orchards late in July. By contributing to the lowering of the population of the pear psylla in such pear orchards, *A. nemoralis* may induce the native species to move to more abundant prey on other plants.

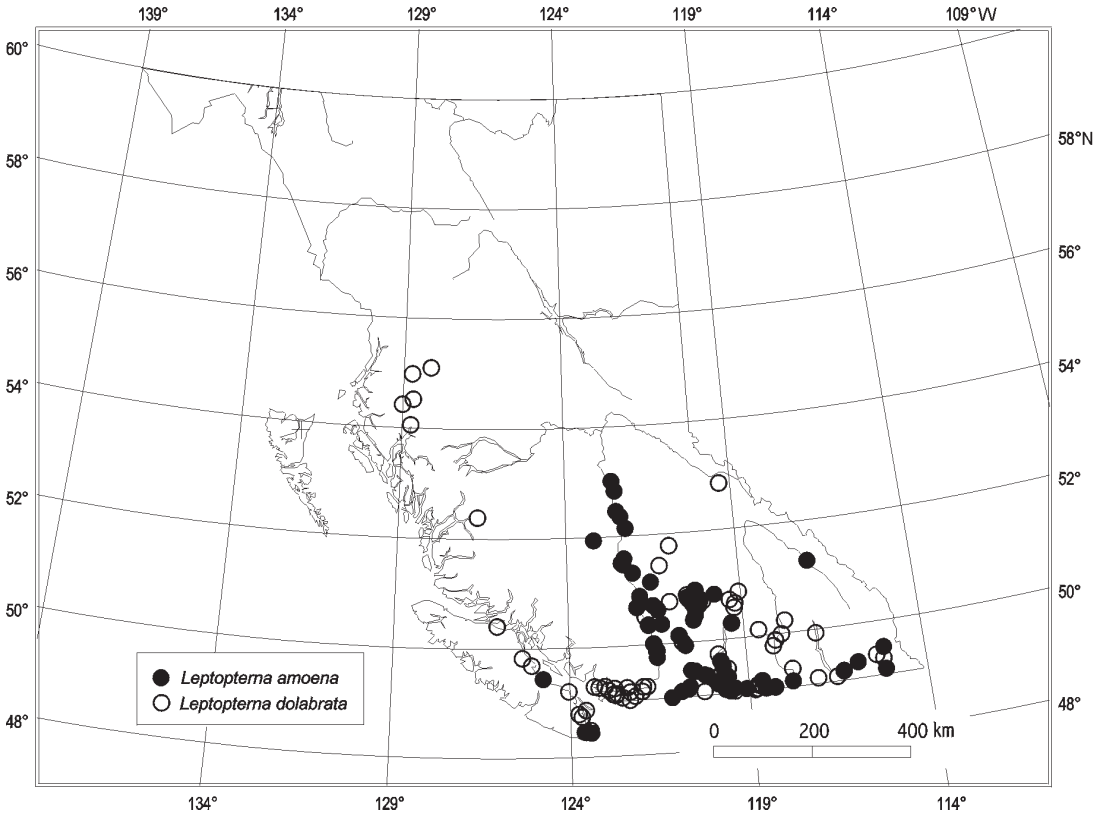
Lattin and Oman (1983) reported that *L. dolabrata* replaces *L. amoena* Uhler (recorded as *L. ferrugata* (Fallén)) in disturbed habitats in the Willamette Valley of western Oregon. Such ecological displacement in Canada is not obvious. In British Columbia, *L. dolabrata* occurs in disturbed habitats in the wetter coastal areas and in moist areas in the southern interior, whereas *L. amoena* is found mostly in drier, undisturbed, native grassland habitats (Fig. 5). In 2003, both species were found in habitats of the latter type at both Barnhartvale near Kamloops and the Churn Creek Protected Area, less than 50 m apart (G.G.E. Scudder, unpublished data). No clear case for competitive exclusion was evident.

Asquith and Lattin (1991) noted that the seed bug *S. rusticus* is far more restricted in its distribution in the Pacific Northwest than in the eastern United States. They stated that this may be because forested mountains, high moisture gradients, and patterns of agricultural development in the west present potential dispersal problems for less vagile species. *Stygnocoris rusticus*, like many introduced species, is probably synanthropic and may be restricted to

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Fig. 5. Distribution of *Leptopterna amoena* (solid circles) and *L. dolabrata* (open circles) in British Columbia.



relatively disturbed areas. However, the seed bug *M. sabulicola* in British Columbia is now also found with other ground-dwelling bugs in relatively undisturbed bunchgrass ecosystems, especially the endangered Antelope brush (*Purshia glandulosa* Curran; Rosaceae) community and protected areas in the South Okanagan (G.G.E. Scudder, unpublished data).

The entry of *M. sabulicola* into natural communities in grasslands of the South Okanagan could well have been facilitated by the invasion of alien diffuse and spotted knapweed (*Centaurea* L. spp.; Asteraceae), now a major problem in the area (Strang *et al.* 1979). Slater and Sweet (1958) reported a close association of *M. sabulicola* with cornflower or bachelor's button (*Centaurea cyanus* L.) in New England, and Sweet (1964) observed feeding on seeds. Wheeler (1989) reported *M. sabulicola* feeding mainly on fallen seeds of spotted knapweed (*Centaurea biebersteinii* DC.) in the mid-Atlantic region of the eastern United States and noted that this species could therefore be considered a beneficial immigrant. However, its effects on plant density are apparently negligible, and *M. sabulicola* appears to compete poorly with native rhyparochromine bugs (Sweet 1964; Wheeler 1989).

In discussing the relative abundance of alien bugs on introduced Scotch broom (*Cytisus scoparius* (L.) Link; Fabaceae) in British Columbia, and comparing this with population densities in both California and the British Isles, Waloff (1966) noted that the broom fauna in British Columbia is richer than that in California, but found that in both regions it is characterized by the total absence of seed and pod insects, although an alien bruchid, *Bruchidius villosus* Fabr. (Coleoptera: Chrysomelidae), has now been reported (Hooper 2003). Waloff (1966) noted that while *Melanotrichus concolor* predominates in California, *Melanotrichus virescens* dominates in British Columbia. The enormous populations of these species in the two localities were reminiscent of the "ecological explosions" described by Elton (1958).

Waloff (1966) suggested that part of the reason for these abundances may lie in the absence of the partially predatory mirids *Heterocordylus tibialis* (Hahn) and *Melanotrichus adenocarpi*

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(Perris). She also noted that the complexes of insect populations on broom were undergoing not only quantitative but also qualitative changes in composition. She noted that two predatory mirids abounded on broom in British Columbia, namely the introduced *H. planicorne* (reported as *H. merioptera* (Scop.)) and the North American *Deraeocoris brevis* (Uhler). The tingid *Dictyonota fuliginosa* on the mainland of British Columbia and the membracid *Gargara genistae* Fabr. on Vancouver Island were undergoing expansion, and the numbers of *Heterotoma* species on broom far exceeded any previously encountered. This may have been associated with the absence of part of the faunal complex usually found on broom in the British Isles.

Conclusion

Alien species are highly adaptive. Although 81 alien true bugs have now been reported in Canada, only the anthocorid *A. nemoralis* might have had some ecological impact. Only 6 of these aliens, the mirids *A. lineolatus*, *C. norwegicus*, *L. dolabrata*, *S. binotatus*, *P. chrysanthemi*, and *C. verbasci*, have had some economic impact. These 6 species collectively represent just 7.4% of the 81 alien true bugs: the other 92.6% have no recorded impact. This percentage is consistent with observations elsewhere, which indicate that 80%–90% of established nonindigenous species may actually have minimal detectable effects (Williamson 1996) and that few have a significant impact on native biota (Barlow and Goldson 2002).

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