Abundance and Seasonal Activity of Weevils (Coleoptera: Curculionidae) in a Raspberry Plantation and Adjacent Sites in Southern Quebec (Canada).

Claire Levesque

Gilles-Yvon Levesque

ABUNDANCE AND SEASONAL ACTIVITY OF WEEVILS (COLEOPTERA: CURCULIONIDAE) IN A RASPBERRY PLANTATION AND ADJACENT SITES IN SOUTHERN QUEBEC (CANADA)

Claire Levesque and Gilles-Yvon Levesque[1]

ABSTRACT

In a raspberry plantation and adjacent sites in southern Québec, we collected weevils with unbaited pitfall traps and flight interception traps from early May through late October in 1987–1989. We captured a total of 1592 weevils representing 65 species, including at least 21 Holarctic or introduced species in North America. In and around the raspberry plantation, the commonest species collected by the two methods were the short-nosed weevils of subfamilies Otiorhynchinae and Thylacitinae, mainly generalist species with root-feeding larvae. Ceutorhynchinae and Tychiinae species were also abundant in flight traps near the raspberry plantation, whereas *Hylobius congener* was the most abundant weevil active at the ground surface in an adjacent pine woods. *Sciaphilus asperatus* and *Otiorhynchus ovatus*, two introduced wingless weevils, were the most abundant species caught with pitfall traps in raspberry rows; the increase of their abundance in the young plantation was probably associated with the increase of raspberry root mass and canopy during the three study years. The weevil fauna at a woods-field boundary was quite variable in the relative abundance of species active in open sites or in wooded sites. We studied the seasonal activity of *H. congener, O. ovatus, S. asperatus, Sitona lepidus, Trachyphloeus bifoveolatus*, and nine other minor weevil species.

The development of an integrated pest management (IPM) program in red raspberry, *Rubus idaeus*, requires the knowledge of the most abundant insect species, mainly the injurious insects and their natural enemies, and knowledge of their seasonal fluctuations in the crop and adjacent sites. The aim of the present work was to evaluate variation of the epigean beetle community in a red raspberry plantation in southern Québec (Canada).

Nearly 60,000 adult beetles were caught during the study. We have already presented results for the Nitidulidae and Elateroidea (Levesque and Levesque 1992, 1993). We now present results on the weevils. The Curculionidae comprise many species that occasionally cause damage to most crops grown in temperate regions. Also, several weevil species are pests of red raspberry in Canada and other countries.

Hill (1952) recorded 137 species of insects on cultivated raspberry in Scotland, including 17 weevil species. Among the weevils, *Otiorhynchus singularis* (L.) was a major pest, and *Phyllobius pyri* (L.) a minor pest. Now, the wingless

---

[1]291 rue des Diamants, Fleurimont, Québec, Canada J1G 4A1.

weevils *O. singularis* and *O. sulcatus* (Fab.) are regarded as minor pests in the United Kingdom, but may be locally important (Gordon et al. 1990).

In the 1984–1985 growing season, 42 arthropod species were associated with raspberry in Chile, and the weevil *Naupactus xanthographus* (Germar) was a major pest (Guilleminot and Apablaza 1986).

Among species of root weevils found on *Rubus* spp., *Otiorhynchus sulcatus, O. ovatus* (L.) and *Sciopithes obscurus* Horn are most often encountered in North America (Shanks 1991). In the states of Washington and Oregon, *O. ovatus* was one of the commonest beetles contaminating mechanically harvested raspberries (Kieffer et al. 1983). In Canada, Campbell et al. (1989) reported 11 weevil species known to attack wild and cultivated red raspberry. In Ontario and the eastern provinces of Canada, *Anthonomus signatus* Say, a native eastern North America weevil, may cause serious injury to raspberry buds; whereas the larvae of *O. ovatus, O. singularis* and *O. sulcatus* attack the roots, and the adults of these three European introduced species in North America feed on the foliage of raspberry and many other host plants (Campbell et al. 1989).

Over a three-year period (1987–1989), we determined: (1) the composition and abundance of the epigean adult beetle fauna of young and old raspberry plants, in a boundary of the plantation and in an adjacent wooded site; (2) the seasonal activity of the most abundant species; and (3) the flight period and dispersal activity of the beetles between the raspberry plantation and adjacent sites.

MATERIALS AND METHODS

The beetles were collected from early May through late October in a commercial monocultural raspberry farm at Johnville (45°26'N, 71°41'W, about 240 m a.s.l.), near Sherbrooke, in southern Québec. In this conventionally cultivated plantation (about 7 ha, on sandy soil), we sampled in the Boyne cultivar.

The ground surface-active beetles were caught with pitfall traps in the following sites: (1) a raspberry row planted in 1978 (old plants), (2) a raspberry row planted in 1985 (young plants), (3) a woods-field boundary (boundary), and (4) an adjacent wooded site dominated by eastern white pine, *Pinus strobus* (pine woods). Pitfall traps consisted of glass jam jars (450 ml, 6.5 cm diameter at the top) partially filled with 100 ml of 4% formalin. In each site, a row of 20 traps (5 m apart) was set and traps were emptied weekly.

In addition, we studied beetles flying close to the ground with interception traps in four sites: (1) an open site near the center of the plantation (A), about 20 m from old plants; (2) an open site near a pond (B), about 5 m from young raspberry plants; (3) a woods-field boundary (C); and (4) a pine woods (D). These traps were not located between rows of raspberry plants because of grower's activities and public access during harvest. We installed one flight trap in each site; in the pine woods (D), the trap was operated in 1988 and 1989 only. Flight traps were modified from the large-area "window" trap design promoted by Peck and Davies (1980). Samples were collected twice a week and were pooled on a weekly basis.

The boundary vegetation included wild raspberry (*Rubus idaeus*). In the pine woods, the grower selectively cut some of the large pine trees and in 1988 and 1989, we observed the presence of wild raspberry around a few pitfall traps, but not around flight trap D. The white clover, *Trifolium repens*, was very abundant in and around the raspberry plantation, whereas the red clover, *Trifolium pratense*, was present chiefly in uncultivated open sites.

A weevil species was dominant when it represented 5% or more of total catches in a site during one year. Comparisons between years and sites were based on percent of similarity (*PS*) and Spearman's coefficient of rank correlation (r_{sc}). Levesque and Levesque (1992) presented detailed informations about study sites (including a sketch-map of the raspberry farm), sampling methods, climatic data and statistical analysis.

RESULTS AND DISCUSSION

Abundance of weevil catches. We captured a total of 1592 weevils including 65 species. Pitfall trapping caught 760 beetles of 30 species (Table 1). Total catches of weevils in flight traps comprised 832 individuals representing 64 species (Table 2). Among the 65 weevil species monitored, only two species, *Sciaphilus asperatus* (Bonsd.) and *Otiorhynchus ovatus*, were collected by both methods in all the sites and every year of the study; these introduced weevils represented 58.8% of total catches in pitfall traps and 17.7% of all individuals caught by flight traps.

In raspberry rows (old and young plants), the most abundant species were *S. asperatus, O. ovatus, Sitona lepidus* Gyll. (= *S. flavescens* [Marsh.]) and *Sitona hispidulus* (Fab.) (Table 1). On the basis of the absolute catch number (1987–1989), the major difference between old and young raspberry plants was associated with *S. asperatus* (Table 1). The three most abundant species caught by pitfall traps at the boundary were *S. asperatus, O. ovatus* and *Hylobius congener* D.T., Shen. & Mars., whereas *H. congener* was the most abundant weevil active at the ground surface in the pine woods (Table 1).

Species belonging to Otiorhynchinae (4 spp.) and Thylacitinae (including Brachyderinae and Sitoninae) (6 spp.) constituted about a third of species caught in pitfall traps, but represented more than 90% of individuals in raspberry rows, 74% at the boundary and 17% in the pine woods. The two species of Hylobiinae (*Hylobius* spp.) represented 74% of catches in the pine woods. Among the 30 weevil species collected in pitfall traps at Johnville, we observed the presence of at least 13 Holarctic or introduced species in North America according to McNamara (1991) (Table 1); these species represented more than 90% of the captures in raspberry rows, 74% at the boundary and 16% in the pine woods.

Species of Otiorhynchinae (4 spp.) and Thylacitinae (8 spp.) represented nearly 20% of species and 51% of catches in flight traps. Among these species, *O. ovatus, Phyllobius oblongus* (L.), *S. asperatus, S. hispidulus, Sitona scissifrons* Say and *Trachyphloeus bifoveolatus* (Beck) were the most abundant species captured in three flight traps (A, B and C) near the raspberry plants (Table 2). Ten Ceutorhynchinae species, particularly *Rhinoncus castor* (Fab.) and *R. pyrrhopus* Boh., comprised 15% of catches in flight traps, but they were not observed in the pine woods (Table 2). The two Tychiinae species, chiefly *Tychius picirostris* (Fab.), represented 10% of catches in flight traps, with only three adults captured in the pine woods (Table 2). At least 21 Holarctic or introduced species in North America were caught in our study, with all these species being present in flight traps, representing 67% of catches (Table 2).

Otiorhynchus ovatus, Phyllobius oblongus, Sciaphilus asperatus, Sitona hispidulus, S. lepidus, S. scissifrons and *Trachyphloeus bifoveolatus* are polyphagous short-nosed weevils with root-feeding larvae, and are sometimes of economic importance (Campbell et al. 1989, Witter and Fields 1977). The three former species are eurytopic whereas the four other species are generally collected in open sites (Campbell et al. 1989, Luff and Eyre 1988, Witter and

Table 1. Total captures of weevil species in pitfall traps at four sites at Johnville, Québec (1987 – 1989).

Species	Sub-fam.[a]	Old plants N	Old plants %	Young plants N	Young plants %	Boundary N	Boundary %	Pine woods N	Pine woods %	Total N	Biogeography[b]
Anthonomus signatus Say	Ant	1	0.3	1	0.5	0		0		2	
Barypeithes pellucidus (Boh.)	Thy	3	1.0	0		1	0.7	0		4	I
Carphonotus testaceus Casey	Cos	0		0		0		1	0.8	1	
Ceutorhynchus punctiger Gyll.	Ceu	1	0.3	4	2.2	0		0		5	I
Conotrachelus nenuphar (Herbst)	Cry	0		0		3	2.1	0		3	
Dryophthorus americanus Bedel	Cos	0		0		2	1.4	0		2	
Grypus equiseti (Fab.)	Eri	0		2	1.1	0		0		2	H
Gymnetron pascuorum (Gyll.)	Gym	0		0		2	1.4	0		2	I
Hormorus undulatus (Uhler)	Oti	0		1	0.5	0		2	1.6	3	
Hylobius congener D.T., Shen. & Mars.	Hyl	0		0		28	19.4	89	73.0	117	
Hylobius pales (Herbst)	Hyl	0		0		1	0.7	1	0.8	2	
Listroderes sp.	Cyl	1	0.3	1	0.5	0		0		2	
Otiorhynchus ovatus (L.)	Oti	50	16.2	64	34.6	44	30.6	3	2.5	161	I
Phyllobius oblongus (L.)	Oti	0		1	0.5	2	1.4	0		3	I
Phyxelis rigidus (Say)	Lep	0		1	0.5	0		0		1	
Pissodes sp. 1	Pis	0		0		0		1	0.8	1	
Pissodes sp. 3	Pis	0		0		0		1	0.8	1	
Polydrusus sericeus (Schaller)	Thy	0		0		2	1.4	0		2	I
Rhinoncus castor (Fab.)	Ceu	0		5	2.7	0		0		5	I
Rhinoncus prob. *longulus* LeC.	Ceu	4	1.3	3	1.6	0		0		7	
Rhinoncus pyrrhopus Boh.	Ceu	0		1	0.5	0		0		1	
Sciaphilus asperatus (Bonsd.)	Thy	183	59.2	36	19.5	52	36.1	15	12.3	286	I
Sitona hispidulus (Fab.)	Thy	22	7.1	22	11.9	2	1.4	1	0.8	47	I
Sitona lepidus Gyll.	Thy	31	10.0	37	20.0	0		0		68	I
Sitona scissifrons Say	Thy	5	1.6	4	2.2	3	2.1	0		12	
Sphenophorus zeae Walsh	Rhp	0		1	0.5	0		0		1	
Stenoscelis brevis (Boh.)	Cos	0		0		0		8	6.6	8	
Trachyphloeus bifoveolatus (Beck)	Oti	2	0.6	0		0		0		2	I
Tychius picirostris (Fab.)	Tyc	5	1.6	1	0.5	2	1.4	0		8	I
Tyloderma prob. *aereum* (Say)	Cry	1	0.3	0		0		0		1	
Total		309	99.8	185	99.8	144	100.1	122	100.0	760	
Number of species		13		17		13		10		30	

[a] Subfamilies: Ant = Anthonominae, Api = Apioninae, Bar = Baridinae, Ceu = Ceutorhynchinae, Cim = Cimberinae, Cos = Cossoninae, Cry = Cryptorhynchinae, Cyl = Cylindrorhininae, Eri = Erirhininae, Gym = Gymnetrinae, Hyl = Hylobiinae, Hyp = Hyperinae, Lep = Leptopiinae, Mag = Magdalinae, Oti = Otiorhynchinae, Pis = Pissodinae, Pri = Prionomerinae, Rhp = Rhynchophorinae, Rhy = Rhynchaeninae, Thy = Thylacitinae, Tyc = Tychiinae, Zyg = Zygopinae
[b] H = Holarctic species; I = Introduced species in North America

Fields 1977). Larvae of *Hylobius congener* feed on the inner bark of various pine logs or stumps. This species attacks red pine (*Pinus resinosa*), eastern white pine (*P. strobus*) and Scots pine (*P. sylvestris*) (Martin 1964). Adults caused 44% of mortality in a white pine seedling plantation in Maine (Welty and Houseweart 1985). Nearctic species of *Rhinoncus* feed primarily on the foliage of various Polygonaceae (*Polygonum* spp.), whereas *R. castor* has been taken from *Rumex acetosella, Medicago sativa* (alfalfa) and *Oenanthe* spp. (Hoebeke and Whitehead 1980). Larvae of *Tychius picirostris* damage the clover seed (Campbell et al. 1989).

Among the 72 weevil species collected by pitfall traps from 74 grassland sites in England, the commonest species were short-nosed weevils of the subfamilies Otiorhynchinae and Thylacitinae, being mainly generalist feeding species and many of which have root-feeding larvae (Luff and Eyre 1988). Thirteen of the 21 Holarctic or European introduced species caught in the present study were also captured by Luff and Eyre (1988) in grasslands of England.

Among the 11 most abundant weevils at Johnville, only *O. ovatus* and *S. asperatus* are known to damage raspberry in Europe (Campbell et al. 1989, Witter and Fields 1977). In North America, *O. ovatus* is also regarded as a raspberry pest (Shanks 1991), while it is apparently not the case for *S. asperatus*. We believe that raspberry growers do not detect adults of *S. asperatus* which are 5–6 mm long and light brown or ashy gray in color, because the adults are very difficult to observe on sandy soil, particularly when the ground surface is dry. Perennial weeds within or along the edges of raspberry or strawberry fields, and wooded or bushy areas may serve as sources of *O. ovatus* weevils to infest berry fields (Shanks 1991, Zalom et al. 1990). In the present study, in addition to perennial weeds between raspberry rows, the open sites (A and B), the woods-field boundary and perhaps also the pine woods were potential wild reservoirs for *O. ovatus*.

Flight traps constituted a method more effective than pitfall traps to assess weevil diversity since they collected 64 of 65 species monitored at Johnville. However, the deep pans of flight traps may be associated with sampling artifacts because climbing apterous adults of *O. ovatus, S. asperatus* and *T. bifoveolatus* cannot fly (Barstow and Getzin 1985, Warner and Negley 1976). According to Loan (1963), *Sitona scissifrons* is a predominantly brachypterous weevil in the Belleville area (Ontario) and macropterous adults cannot fly as flight muscles are always vestigial. Unfortunately, we did not investigate wing length and flight muscle condition of *S. scissifrons* at Johnville. Otherwise, in Connecticut ornamental nurseries, Hanula (1990) studied some sampling techniques for detecting a climbing wingless weevil, *Otiorhynchus sulcatus*: 4.5 cm deep-pan traps, constructed from dog food dishes (10.5 cm diameter, placed on the ground), were as effective as pitfall traps for monitoring adult emergence and seasonal abundance of this species, although pitfall traps captured more adults than deep-pan traps. Nevertheless, the simple design and easy installation of deep-pan traps may make them more useful for detecting *O. sulcatus* infestations (Hanula 1990).

Annual variations of weevil assemblages. In 1987, the epigean weevils in the pine woods were very different from those of the two raspberry rows (PS = 8.4% only), while the weevil fauna crawling at the boundary was intermediate between those of the raspberry plantation and of the pine woods (Table 3). We obtained a similarity of 24.8% for the boundary and young plants, and about 43% for the boundary and old plants or pine woods; the Spearman's coefficient was never significant for all these comparisons (Table 3). The species composition in old raspberry plants was rather similar from year to year (*PS* = 51.0 to 82.1%; r_{sc} = 0.449 to 0.827) (Table 3). However, the species composition in young raspberry plants was quite variable during the three

Table 2. Total captures of weevil species in flight traps at four sites at Johnville, Québec (1987–1989).

Species	Sub-fam.[a]	Open site near center		Open site near pond		Boundary		Pine woods[b]		Total	Biogeography[c]
		N	%	N	%	N	%	N	%	N	
Anthonomus prob. *decipiens* LeC.	Ant	0		2	0.5	0		0		2	
Anthonomus signatus Say	Ant	0		5	1.3	3	1.7	1	2.6	9	
Apion sp. 1	Api	0		1	0.3	0		0		1	
Apion sp. 2	Api	0		1	0.3	0		0		1	
Auleutes nebulosus (LeC.)	Ceu	1	0.4	2	0.5	0		0		3	
Bagous americanus LeC.	Eri	2	0.9	1	0.3	0		0		3	
Barypeithes pellucidus (Boh.)	Thy	0		1	0.3	0		0		1	I
Carphonotus testaceus Casey	Cos	0		0		0		3	7.7	3	
Ceutorhynchus erysimi (Fab.)	Ceu	1	0.4	3	0.8	0		0		4	I
Ceutorhynchus punctiger Gyll.	Ceu	5	2.1	6	1.6	0		0		11	I
Ceutorhynchus sp. 1	Ceu	2	0.9	1	0.3	1	0.6	0		4	
Ceutorhynchus sp. 2	Ceu	1	0.4	0		1	0.6	0		2	
Ceutorhynchus sp. 3	Ceu	1	0.4	0		0		0		1	
Cimberis elongata (LeC.)	Cim	0		0		7	4.0	1	2.6	8	
Conotrachelus nenuphar (Herbst)	Cry	0		0		4	2.3	0		4	
Cryptorhynchus lapathi (L.)	Cry	0		2	0.5	0		0		2	H
Dorytomus sp.	Eri	0		2	0.5	0		0		2	
Dryophthorus americanus Bedel	Cos	2	0.9	9	2.4	2	1.1	0		13	
Grypus equiseti (Fab.)	Eri	0		4	1.0	0		0		4	H
Gymnetron pascuorum (Gyll.)	Gym	5	2.1	1	0.3	2	1.1	1	2.6	9	I
Gymnetron teter (Fab.)	Gym	0		1	0.3	0		0		1	
Hylobius congener D.T., Shen. & Mars.	Hyl	0		0		4	2.3	7	17.9	11	
Hylobius pales (Herbst)	Hyl	0		0		1	0.6	0		1	
Hypera castor (LeC.)	Hyp	2	0.9	4	1.0	0		0		6	
Hypera nigrirostris (Fab.)	Hyp	3	1.3	10	2.6	3	1.7	0		16	I
Hypera punctata (Fab.)	Hyp	2	0.9	0		0		0		2	I
Isochnus rufipes (LeC.)	Rhy	8	3.4	15	3.9	3	1.7	0		26	
Lechriops oculata (Say)	Zyg	2	0.9	3	0.8	0		0		5	
Listroderes sp.	Cyl	7	3.0	16	4.2	0		0		23	
Magdalis sp.	Mag	0		0		1	0.6	1	2.6	2	
Notaris puncticollis (LeC.)	Eri	0		9	2.4	0		0		9	
Otiorhynchus ovatus (L.)	Oti	5	2.1	32	8.4	19	10.8	9	23.1	65	I
Otiorhynchus singularis (L.)	Oti	0		1	0.3	0		0		1	I

Pelenomus sp.	Ceu	2	0.9	0		0		0		2	
Phyllobius oblongus (L.)	Oti	21	8.9	7	1.8	5	2.8	0		33	I
Phyxelis rigidus (Say)	Lep	3	1.3	5	1.3	0		0		8	
Piazorhinus scutellaris (Say)	Pri	0		0		1	0.6	0		1	
Pissodes prob. *strobi* (Peck)	Pis	0		0		2	1.1	1	2.6	3	
Pissodes sp. 1	Pis	0		0		0		1	2.6	1	
Pissodes sp. 2	Pis	0		1	0.3	0		0		1	
Pissodes sp. 3	Pis	0		0		0		1	2.6	1	
Pissodes sp. 4	Pis	0		0		0		2	5.1	2	
Polydrusus cervinus (L.)	Thy	1	0.4	0		0		0		1	I
Polydrusus sericeus (Schaller)	Thy	4	1.7	1	0.3	8	4.5	0		13	I
Rhinoncus castor (Fab.)	Ceu	24	10.2	19	5.0	15	8.5	0		58	I
Rhinoncus prob. *longulus* LeC.	Ceu	2	0.9	1	0.3	0		0		3	
Rhinoncus pyrrhopus Boh.	Ceu	17	7.2	11	2.9	11	6.2	0		39	
Rhynchaenus sp.	Rhy	0		1	0.3	2	1.1	0		3	
Sciaphilus asperatus (Bonsd.)	Thy	17	7.2	35	9.2	24	13.6	6	15.4	82	I
Sibariops sp.	Bar	1	0.4	0		0		0		1	
Sitona cylindricollis (Fahraeus)	Thy	4	1.7	3	0.8	0		0		7	I
Sitona hispidulus (Fab.)	Thy	25	10.6	30	7.9	10	5.7	0		65	I
Sitona lepidus Gyll.	Thy	3	1.3	0		1	0.6	0		4	I
Sitona scissifrons Say	Thy	5	2.1	28	7.3	19	10.8	0		52	
Sphenophorus zeae Walsh	Rhp	1	0.4	4	1.0	0		0		5	
Stenoscelis brevis (Boh.)	Cos	0		0		0		2	5.1	2	
Stethobaris ovata (LeC.)	Bar	1	0.4	1	0.3	0		0		2	
Tachyerges niger (Horn)	Rhy	1	0.4	0		0		0		1	
Tachypterellus quadrigibbus (Say)	Ant	0		1	0.3	0		0		1	
Tanysphyrus lemnae (Fab.)	Eri	1	0.4	1	0.3	0		0		2	I
Trachyphloeus bifoveolatus (Beck)	Oti	24	10.2	73	19.1	1	0.6	0		98	I
Tychius picirostris (Fab.)	Tyc	28	11.9	27	7.1	25	14.2	3	7.7	83	I
Tychius sp.	Tyc	1	0.4	0		1	0.6	0		2	
Tyloderma prob. *aereum* (Say)	Cry	0		1	0.3	0		0		1	
Total		235	99.9	382	100.6	176	100.0	39	100.2	832	
Number of species		37		43		27		14		64	

[a] Subfamilies: Ant = Anthonominae, Api = Apioninae, Bar = Baridinae, Ceu = Ceutorhynchinae, Cim = Cimberinae, Cos = Cossoninae, Cry = Cryptorhynchinae, Cyl = Cylindrorhininae, Eri = Erirhininae, Gym = Gymnetrinae, Hyl = Hylobiinae, Hyp = Hyperinae, Lep = Leptopiinae, Mag = Magdalinae, Oti = Otiorhynchinae, Pis = Pissodinae, Pri = Prionomerinae, Rhp = Rhynchophorinae, Rhy = Rhynchaeninae, Thy = Thylacitinae, Tyc = Tychiinae, Zyg = Zygopinae

[b] not sampled in 1987.

[c] H = Holarctic species; I = Introduced species in North America

Table 3. Percent of similarity (*PS*, upper part of the oblique line) and Spearman's coefficient of rank correlation (r_{sc}, lower part) for Curculionidae captured with pitfall traps at Johnville, Québec.

		Old plants (OP)			Young plants (YP)			Boundary (BO)	Pine woods (PW)
Site	Year	1987	1988	1989	1987	1988	1989	1987	1987
OP	1987		51.0	82.1	33.7			43.1	8.4
	1988	0.528*		60.6		72.1			
	1989	0.449	0.827**				50.1		
YP	1987	0.535*				43.1	23.5	24.8	8.4
	1988		0.632*		0.424		54.4		
	1989			0.055	-0.226	0.081			
BO	1987	-0.108			-0.275				42.5
PW	1987	-0.212			-0.277			0.123	

* $0.01 \le P < 0.05$
** $0.001 \le P < 0.01$

study years; we obtained a similarity of 43.1% between 1987 and 1988 and only 23.5% between 1987 and 1989; the Spearman's coefficient varied from 0.424 for 1987–1988 to -0.226 for 1987–1989 (Table 3). These variations in young plants were associated with fluctuations in the annual number of caught species (from 11 in 1987 to 6 in 1989) and in the annual number of dominant species (from 7 in 1987 to 2 in 1989); the proportion of *O. ovatus* and *S. asperatus* increased from 22% in 1987 to 92% in 1989. The instability of the weevil fauna in young plants was also reflected by the similarity with the weevil fauna in old plants (r_{sc} = 0.535 in 1987 and only 0.055 in 1989) (Table 3). In old plants, the annual maximal development of the raspberry root mass and canopy was relatively constant during the study; however, in young plants, the increase of the raspberry root mass and canopy was observed between 1987 and 1989.

Weevils collected by flight traps in open sites (A and B) were quite similar over the years in a site (A or B) or between these two sites for one year (Table 4). We obtained a similarity of 58.1 to 64.0% for site A, 46.7 to 60.3% for site B, and 57.1 to 62.0% between sites A and B; the Spearman's coefficient was almost always significant ($P < 0.05$) for all comparisons. The species composition at the boundary was rather variable during the three study years (r_{sc} = -0.081 for 1987–1988 to 0.371 for 1988–1989 in site C) (Table 4). It seems that these variations were not only associated with fluctuations in the proportion of wingless weevils (*O. ovatus, S. asperatus* and *T. bifoveolatus*), but also with variations in the relative abundance of species active in open sites or in wooded sites.

Seasonal activity of most abundant species. Adults of *Sciaphilus asperatus* were captured in pitfall and flight traps from May through October in the three years (Fig. 1). The activity of overwintered beetles began to rise in May when at least 100 degree-days above 5°C were accumulated (starting date: 1 April). The first peak of captures occurred in May-June, probably during the oviposition period. From late August to early October in 1988 and 1989, we observed a second peak period of activity, characterized by the emergence of new generation adults. The autumnal activity was reduced when the weekly mean minimal temperature was lower than the freezing point. In North American deciduous forests, adults were captured from late April until late September (Levesque and Levesque 1986, Witter and Fields 1977). In southern Qué-

Table 4. Percent of similarity (*PS*, upper part of the oblique line) and Spearman's coefficient of rank correlation (r_{sc}, lower part) for Curculionidae captured with flight traps at Johnville, Québec.

		Open site near center (A)			Open site near pond (B)			Boundary (C)		
Site	Year	1987	1988	1989	1987	1988	1989	1987	1988	1989
A	1987		64.0	58.1	62.0			38.5		
	1988	0.398*		59.6		61.5			51.4	
	1989	0.391*	0.334*				57.1			46.6
B	1987	0.285				59.5	46.7	37.6		
	1988		0.388**		0.503**		60.3		52.6	
	1989			0.386*	0.202	0.431**				54.6
C	1987	-0.143			-0.072				46.1	41.5
	1988		0.114			0.224		0.228		59.4
	1989			0.338*			0.325*	-0.081	0.371*	

* $0.01 \leq P < 0.05$
** $0.001 \leq P < 0.01$

bec, Levesque and Levesque (1986) observed two peaks of activity, the first in May and the second at the end of June. According to Stein (1970) in Germany, adults overwintered in some meadows where they were not observed during the summer, suggesting a migration of this species towards an overwintering site. The complete life cycle of *S. asperatus* has not been investigated in North America; this species is probably parthenogenetic throughout its range (Witter and Fields 1977). According to Hesjedal (1981), *S. asperatus* needs a mean temperature of at least 12°C for egg laying which occurs in Norway from mid-May to late August, mainly in June. We suspect that some of the larvae cannot complete their development before overwintering, particularly in sites such as forests where the soil does not accumulate enough heat during the summer to permit rapid growth of root-feeding larvae. If true, the life cycle of *S. asperatus* may be longer in forests than in raspberry plantations or other open sites; soil type and soil humidity may also influence larval growth. In a previous study (Levesque and Levesque 1986), the second peak of activity in late June could be associated with emergence of new adults from overwintered larvae.

Adults of *Otiorhynchus ovatus* were active from early May until late October, mainly in summer and early autumn (Fig. 2). Tenerals were observed between 19 June and 21 August 1988, and between 2 July and 10 September 1989. Apparently, the two methods (pitfall and flight traps) were effective for monitoring adult emergence and seasonal activity of this species. Our results agreed generally with previous observations in North American raspberry and strawberry plantations and in a deciduous forest of southern Québec (Campbell et al. 1989, Levesque and Levesque 1986, Shanks 1991, Zalom et al. 1990). Adults were present only from late May until late July in peppermint in western Oregon (Emenegger and Berry 1978). According to Campbell et al. (1989), this parthenogenetic weevil overwinters in both larval and adult stages; adults from overwintered larvae emerge later in summer and start laying eggs shortly thereafter. This univoltine species requires a mean temperature of at least 15°C for egg laying (Hesjedal 1981). For populations in strawberry plantations, adult migrations occur in early summer in search of oviposition sites, and in autumn in search of hibernation quarters. A third

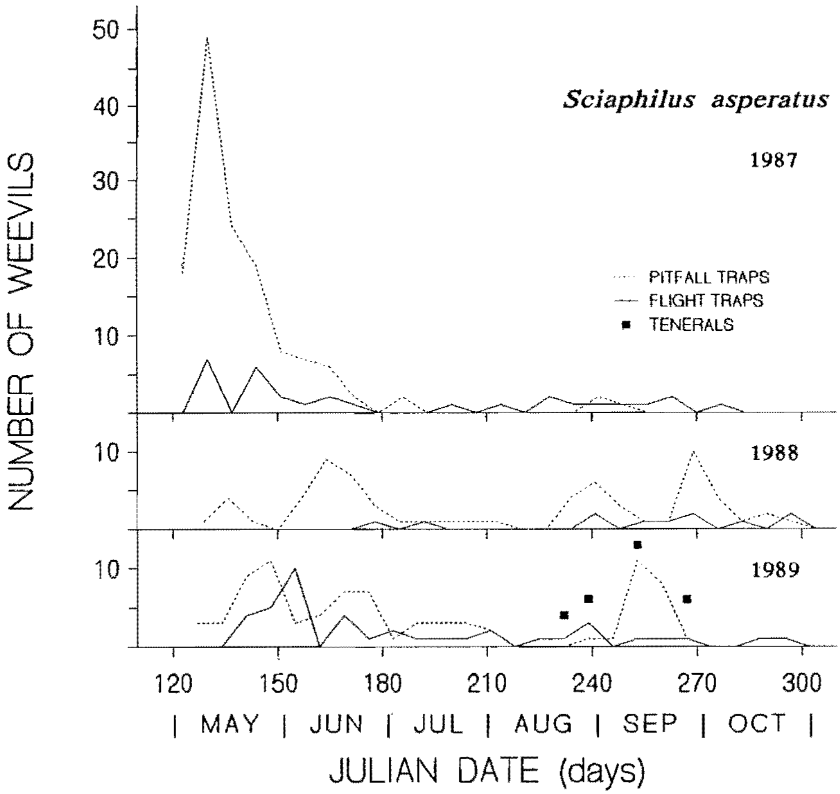

Figure 1. Seasonal abundance of *Sciaphilus asperatus* in pitfall traps and flight traps at Johnville, Québec (1987–1989).

migration in summer, before oviposition of new adults, may also exist (Campbell et al. 1989).

Adults of *Trachyphloeus bifoveolatus* were caught by flight traps from May through October during the three-year study. In 1989, overwintered adults were active from mid-May until mid-July, mainly between mid-May and mid-June (Fig. 2). We observed a second period of activity from mid-August until early October. The biology of this univoltine and parthenogenetic weevil was studied by Barstow and Getzin (1985) in western Washington. According to these authors, new generation adults appear in late July and within a month most begin leaving the fields to seek overwintering sites.

Adults of *Hylobius congener* were caught by pitfall traps from May until early August during the three study years, mainly in late May and June in 1987 (Fig. 3), and chiefly in June in 1989 (16 of 19 adults). In addition, we collected only 11 adults flying intermittently in May-September (1987–1989). We collected more females than males in pitfall traps (79 ♀♀: 38 ♂♂) and in flight traps (7 ♀♀: 4 ♂♂); formalin had possibly an attractant effect on females. In conifer plantations in Maine, the early season peak of catches at the split-

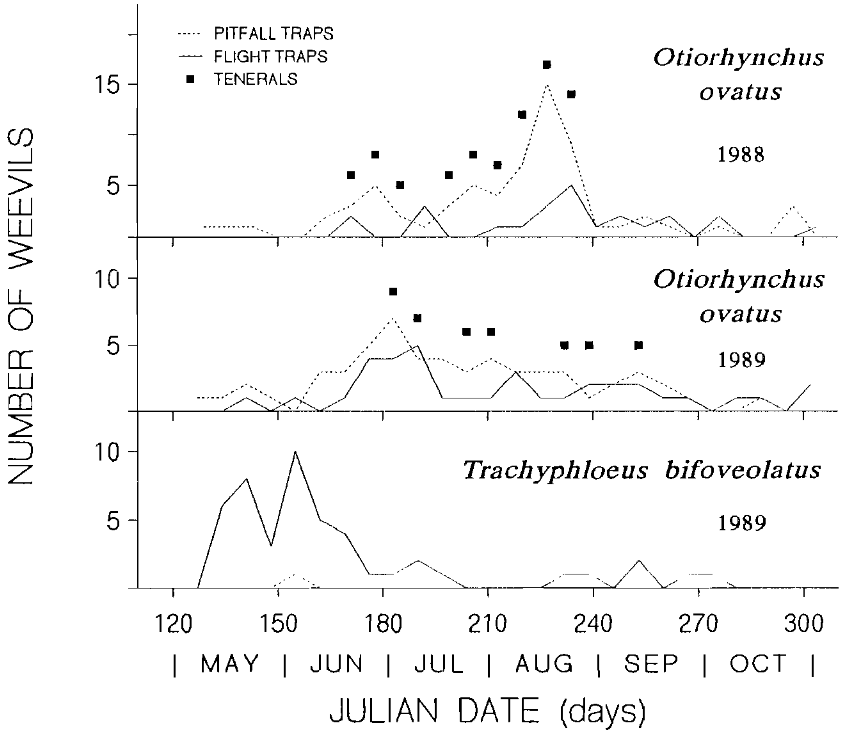

Figure 2. Seasonal abundance of *Otiorhynchus ovatus* (1988 and 1989) and *Trachyphloeus bifoveolatus* (1989) in pitfall traps and flight traps at Johnville, Québec.

bolt traps represented overwintered adults which laid eggs in late May and June, larvae overwintered, and the late-season peak (late July and August) represented captures of newly emerged adults from overwintered larvae (Welty and Houseweart 1985). In red pine plantations of central Ontario, Martin (1964) observed that a flight period of one or two weeks occurred just before the breeding period in May. In *Hylobius pales* (Herbst), *H. radicis* Buchanan and *Pachylobius picivorus* (Germar), the large proportion of female weevils caught in pitfall traps baited with ethanol plus turpentine suggests that these compounds are used as an ovipositional cue by females (Hunt and Raffa 1989, 1991); in *H. pales* and *P. picivorus*, these volatiles may also act as feeding or mating stimulants, or both (Rieske and Raffa 1990).

Adults of *Sitona lepidus* were active in raspberry rows from May through October during the three-year study. We observed two periods of activity, the first in June-July coinciding with the emergence of tenerals, the second in late September and October probably during the breeding period (Fig. 3). The new adults became inactive in summer when continuous hot weather occurred. We captured only four adults in flight traps (Table 2). It seems that adults overwintered in the raspberry plantation without migration towards the adjacent sites. In addition, this species possibly overwintered in egg and/or larval

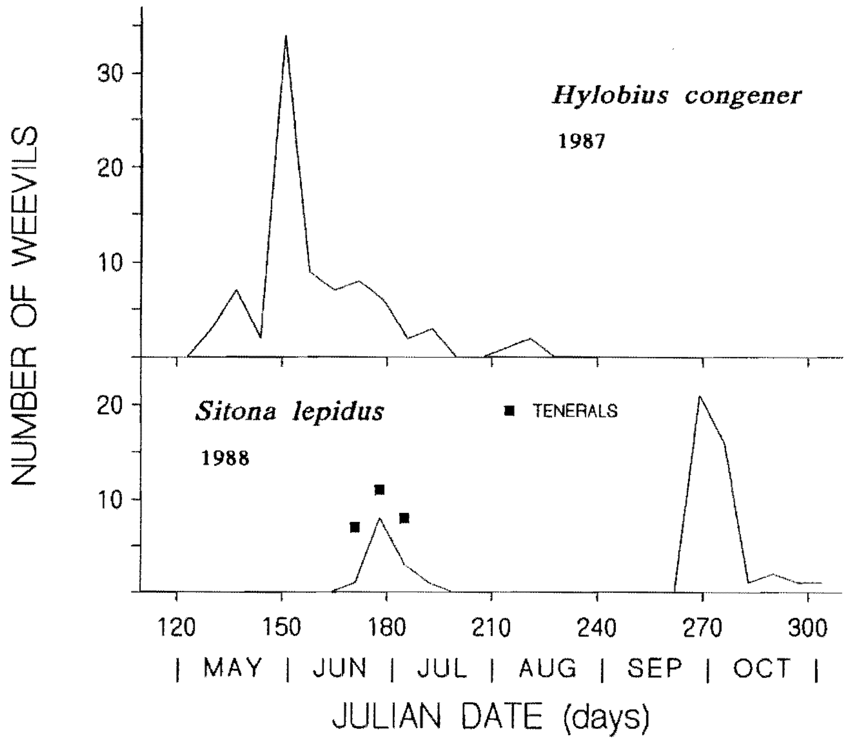

Figure 3. Seasonal abundance of *Hylobius congener* (1987) and *Sitona lepidus* (1988) in pitfall traps at Johnville, Québec.

stages at Johnville. According to Markkula and Köppä (1960), in Finland, a slight peak of overwintered adults occurs in spring and early summer, but the true peak of abundance occurs in late summer and autumn and is due to the emergence of new generation adults; larvae or pupae developing from later laid eggs hibernate. In Germany, adults of this species are present during the summer in meadows and in red-clover fields where they overwinter thereafter (Stein 1970). Our observations on the crawling activity of *S. lepidus* agreed generally with previous North American studies (Campbell et al. 1989), except for the spring activity of overwintered adults.

Seasonal abundance of some other species. We observed the flight of the lesser clover leaf weevil, *Hypera nigrirostris* (Fab.), only in May (Table 5). According to Campbell et al. (1989), adults overwinter in sheltered places in nearby woodlands, bushy hedges and to some extent around the crowns of clover plants, and in spring, these adults fly to clover plants as the plant begins to grow.

During the summer, the flight of the willow flea weevil, *Isochnus rufipes* (LeC.), was frequent in June-July (Table 5). In Maine, adults overwinter and begin to emerge around the middle of May, the mating period begins in early June and the new adults emerge in August and feed until hibernation (Ander-

Table 5. Seasonal abundance of some weevil species at Johnville, Québec (1987–1989).

Species	Trap type	Weevils caught					
		MAY	JUN	JUL	AUG	SEP	OCT
Hypera nigrirostris	Flight	16					
Isochnus rufipes	Flight		10	15	1		
Listroderes sp.	Flight	7	6	3	2	4	1
Phyllobius oblongus	Flight	3	27	3			
Rhinoncus castor	Flight	41	10	5	2		
Rhinoncus pyrrhopus	Flight	13	22	4			
Sitona hispidulus	Pitfall	33	3	2	1	5	3
Sitona hispidulus	Flight	19	4		11	18	13
Sitona scissifrons	Pitfall	3	5	3	1		
Sitona scissifrons	Flight	27	17		5	2	1
Tychius picirostris	Flight	5	48	14	12	4	

son 1989). At Johnville, we observed probably the flight of both overwintered and newly emerged adults during their search for food or oviposition sites.

Adults of *Listroderes* sp. flew from May through October, without a defined peak of activity (Table 5).

Adults of *Phyllobius oblongus* flew chiefly in June (Table 5). In North American deciduous forests, adults were captured from late May to about the third week of July, mainly in June (Levesque and Levesque 1986, Witter and Fields 1977). During this period, adults were observed copulating immediately after their emergence until they disappeared in late July; this insect overwintered as a mature larva (Witter and Fields 1977).

Adults of *Rhinoncus castor* flew from May until August, mainly in May and adults of *R. pyrrhopus* flew chiefly in May-June (Table 5); these two species overwintered probably as adults.

Adults of *Sitona hispidulus* were caught by pitfall trapping from May through October, mainly in May (Table 5); one teneral was captured in August. We also observed two periods of flight: the first in May-June and the second in late summer and autumn (Table 5). According to Campbell et al. (1989), *S. hispidulus* is similar to *S. lepidus* in habits and life cycle. In Kentucky, Oregon and Pennsylvania, overwintered adults do not fly, but the dispersion flight of *S. hispidulus* to new fields of alfalfa and red clover is accomplished by the new generation weevils from late August until late October (Leibee et al. 1981, Prescott and Newton 1963). We believe that the dispersion flight of *S. hispidulus* in its northern range may be partially accomplished in a spring flight period.

A few adults of *Sitona scissifrons* were caught in pitfall traps from May until August, whereas many adults were captured by flight traps in May-June and also a few adults in August-October (Table 5). In the Belleville area (Ontario), overwintered adults were active during their spring breeding period and the new adults emerged from early July to early September (Loan 1963).

We observed the flight of *Tychius picirostris* from May through September, but mainly in June (Table 5). Peak captures coincided probably with the migration of overwintered adults towards the raspberry plantation, before the breeding period (Campbell et al. 1989). The clover seed weevil injures alsike (*Trifolium hybridum*) and white clovers, but not the red clover (Yunus and Johansen 1967). In southwestern Ontario, adults were observed feeding on blossoms of wild strawberry and dandelion before the alsike clover bloomed (Moreland 1953). At Johnville in 1989, the flowering periods were, respectively, 21 May to 7 June for dandelion, 11 June to 2 July for raspberry, and 25

June to 27 August for clovers. Overwintered adults fed possibly on raspberry pollen in June.

ACKNOWLEDGMENTS

We are grateful to Dr. Guy Boivin (Research Station, Agriculture Canada, Saint-Jean-sur-Richelieu, Québec) and an anonymous reviewer for their comments on an earlier version of this manuscript. We appreciated the help of Dr. Donald E. Bright, Jr. (Centre for Land and Biological Resources Research, Agriculture Canada, Ottawa, Ontario) for identifications and confirmations of species collected in this study. We thank Mr. Michel Couture and Mrs. Lucie Labrecque, owners of "La Framboisière de l'Estrie, Enr." at Johnville (Québec). This study was partially supported by the Fonds F.C.A.R. (Québec).

LITERATURE CITED

Anderson, R. S. 1989. Revision of the subfamily Rhynchaeninae in North America (Coleoptera: Curculionidae). Trans. Am. Entomol. Soc. 115:207–312.

Barstow, D. A., and L. W. Getzin. 1985. The seasonal activity of *Trachyphloeus bifoveolatus* (Coleoptera: Curculionidae) in western Washington. J. Entomol. Soc. British Columbia 82:47–51.

Campbell, J. M., M. J. Sarazin, and D. B. Lyons. 1989. Canadian beetles (Coleoptera) injurious to crops, ornamentals, stored products, and buildings. Research Branch, Agriculture Canada, Publication 1826, Ottawa.

Emenegger, D. B., and R. E. Berry. 1978. Biology of strawberry root weevil on peppermint in western Oregon. Environ. Entomol. 7:495–498.

Gordon, S. C., J. A. T. Woodford, and I. A. Barrie. 1990. Monitoring pests of red raspberry in the United Kingdom and the possible implementation of an integrated pest management system. pp. 1–26. *In:* N. J. Bostanian, L. T. Wilson and T. J. Dennehy (eds.), Monitoring and integrated management of arthropod pests of small fruit crops. Intercept, Andover, England.

Guilleminot, R. A., and J. U. Apablaza. 1986. Insects and arachnids associated with raspberry (*Rubus idaeus*) in the metropolitan region, Chile. Cienc. Invest. Agrar. 13:251–256. (in Spanish)

Hanula, J. L. 1990. Monitoring adult emergence, ovary maturation, and control of the black vine weevil (Coleoptera: Curculionidae). J. Entomol. Sci. 25:134–142.

Hesjedal, K. 1981. The influence of temperature on root weevil populations in strawberry fields. Forskning og Forsøk i Landbruket 32:7–12. (in Norwegian)

Hill, A. R. 1952. A survey of insects associated with cultivated raspberries in the east of Scotland. Entomol. Mon. Mag. 88:51–62.

Hoebeke, E. R., and D. R. Whitehead. 1980. New records of *Rhinoncus bruchoides* (Herbst) for the Western Hemisphere and a revised key to the North American species of the genus *Rhinoncus* (Coleoptera: Curculionidae: Ceutorhynchinae). Proc. Entomol. Soc. Washington 82:556–561.

Hunt, D. W. A., and K. F. Raffa. 1989. Attraction of *Hylobius radicis* and *Pachylobius picivorus* (Coleoptera: Curculionidae) to ethanol and turpentine in pitfall traps. Environ. Entomol. 18:351–355.

_____. 1991. Orientation of *Hylobius pales* and *Pachylobius picivorus* (Coleoptera: Curculionidae) to visual cues. Great Lakes Entomol. 24:225–229.

Kieffer, J. N., C. H. Shanks, and W. J. Turner. 1983. Populations and control of insects and spiders contaminating mechanically harvested red raspberries in Washington and Oregon. J. Econ. Entomol. 76:649–653.

Leibee, G. L., B. C. Pass, and K. V. Yeargan. 1981. Seasonal abundance and activity of *Sitona hispidulus* adults in Kentucky. Environ. Entomol. 10:27–30.

Levesque, C., and G.-Y. Levesque. 1986. Activité et succession saisonnière de coléoptères épigés d'une forêt décidue du sud du Québec. Nat. Can. 113:39–46.

______. 1992. Epigeal and flight activity of Coleoptera in a commercial raspberry plantation and adjacent sites in southern Québec (Canada): Introduction and Nitidulidae. Great Lakes Entomol. 25:271–285.

______. 1993. Abundance and seasonal activity of Coleoptera Elateroidea in a raspberry plantation and adjacent sites in southern Québec (Canada). Coleopt. Bull. 47:269–277.

Loan, C. C. 1963. The bionomics of *Sitona scissifrons* (Coleoptera: Curculionidae) and its parasite *Microctonus sitonae* (Hymenoptera: Braconidae). Ann. Entomol. Soc. Am. 56:600–612.

Luff, M. L., and M. D. Eyre. 1988. Soil-surface activity of weevils (Coleoptera, Curculionoidea) in grassland. Pedobiologia 32:39–46.

Markkula, M., and P. Köppä. 1960. The composition of the *Sitona* (Col., Curculionidae) population on grassland legumes and some other leguminous plants. Ann. Entomol. Fenn. 26:246–263.

Martin, J. L. 1964. The insect ecology of red pine plantations in central Ontario. II. Life history and control of Curculionidae. Can. Entomol. 96:1408–1417.

McNamara, J. 1991. Superfamily Curculionoidea. pp. 323–365. *In:* Y. Bousquet (ed.), Checklist of beetles of Canada and Alaska. Research Branch, Agriculture Canada, Publication 1861/E, Ottawa.

Moreland, C. R. 1953. Some aspects of the ecology of the clover seed beetle *Miccotrogus picirostris* (F.) (Coleoptera: Curculionidae). Ann. Rep. Entomol. Soc. Ontario 84:91–101.

Peck, S. B., and A. E. Davies. 1980. Collecting small beetles with large-area "window" traps. Coleopt. Bull. 34:237–239.

Prescott, H.W., and R.C. Newton. 1963. Flight study of the clover root curculio. J. Econ. Entomol. 56:368–370.

Rieske, L. K, and K. F. Raffa. 1990. Dispersal patterns and mark-and-recapture estimates of two pine root weevil species, *Hylobius pales* and *Pachylobius picivorus* (Coleoptera: Curculionidae), in Christmas tree plantations. Environ. Entomol. 19:1829–1836.

Shanks, C. H., Jr. 1991. Root weevils. p. 64 *In:* M. A. Ellis, R.H. Converse, R.N. Williams, and B. Williamson (eds.), Compendium of raspberry and blackberry diseases and insects. APS Press, The American Phytopathological Society, St. Paul, Minnesota.

Stein, W. 1970. Hibernation of curculionids in meadows and red-clover fields. Oecologia 4:218–220.

Warner, R. E., and F. B. Negley. 1976. The genus *Otiorhynchus* in America North of Mexico (Coleoptera: Curculionidae). Proc. Entomol. Soc. Washington 78:240–262.

Welty, C., and M. W. Houseweart. 1985. Site influences on *Hylobius congener* (Coleoptera: Curculionidae), a seedling debarking weevil of conifer plantations in Maine. Environ. Entomol. 14:826–833.

Witter, J.A., and R.D. Fields. 1977. *Phyllobius oblongus* and *Sciaphilus asperatus* associated with sugar maple reproduction in northern Michigan. Environ. Entomol. 6:150–154.

Yunus, C.M., and C.A. Johansen. 1967. Bionomics of the clover seed weevil, *Miccotrogus picirostris* (Fabricius) in southeastern Washington and adjacent Idaho. Washington Agric. Exp. Stn., Tech. Bull. 53.

Zalom, F. G., C. Pickel, and N. C. Welch. 1990. Recent trends in strawberry arthropod management for coastal areas of the western United States. pp. 239–259. *In:* N.J. Bostanian, L.T. Wilson and T.J. Dennehy (eds.), Monitoring and integrated management of arthropod pests of small fruit crops. Intercept, Andover, England.