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Epigeal and Flight Activity of Coleoptera in a Commercial Raspberry Plantation and Adjacent Sites in Southern Quebec (Canada): Introduction and Nitidulidae

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EPIGEAL AND FLIGHT ACTIVITY OF COLEOPTERA IN A COMMERCIAL RASPBERRY PLANTATION AND ADJACENT SITES IN SOUTHERN QUEBEC (CANADA): INTRODUCTION AND NITIDULIDAE

Claire Levesque and Gilles-Yvon Levesque[1]

ABSTRACT

We studied the epigeal and flight activity of Coleoptera in a commercial raspberry plantation and adjacent sites in southern Quebec, from 1987–1989. In this first paper, we present the results for the Nitidulidae. Pitfall traps yielded 521 beetles representing 15 species; *Glischrochilus quadrisignatus* represented 86% of catches in raspberry rows (old and young plants), and *Epuraea* spp. were the most abundant nitidulids in a woods-field boundary and in a pine woods. Nitidulids in flight interception traps comprised 2179 individuals of 28 species; *Meligethes nigrescens* was the most abundant species in open sites around the raspberry plantation, while *Epuraea avara* and *E. ovata* were common in the boundary and pine woods. Species composition in the boundary was quite variable in the relative abundance of species flying either in open sites or in wooded sites. We studied the seasonal activity of *Colopterus truncatus, E. avara, E. ovata, G. fasciatus, G. quadrisignatus, M. nigrescens*, and some other minor species. We suspect that during their mating period, overwintered adults of *M. nigrescens* could play a role in raspberry pollinization.

Red raspberry, *Rubus idaeus*, is cultivated in most of the temperate regions of the world (Gordon et al. 1990), however, few workers have studied the beetle fauna in raspberry plantations. Forty years ago, Hill (1952) recorded 137 species of insects on cultivated raspberries in Scotland, including 51 beetle species. More recently, Kieffer et al. (1983) reported at least 62 insect and spider families on the foliage during red raspberry harvest in the states of Washington and Oregon; the lathridiid beetle *Melanophthalma americana* (Mann.) constituted 26% of the total catches whereas the strawberry root weevil (*Otiorhynchus ovatus* [L.]) and lady beetles (*Coccinella* spp.) were the most common beetles contaminating mechanically harvested berries. In the 1984–1985 growing season, 42 arthropod species were associated with raspberry in Chilean Metropolitan Region (Guilleminot and Apablaza 1986); among the 9 beetle species monitored, the weevil *Naupactus xanthographus* (Germar) was a major pest while *Stethorus* sp. (Coccinellidae) and *Oligota pygmaea* Solier (Staphylinidae) were predators of the mite *Tetranychus urticae* Koch. In Canada, Campbell et al. (1989) reported about 40 beetle species known to attack wild and cultivated red raspberry.

Although many arthropods are found in red raspberry plantations, only a few cause yield loss or reduction in fruit quality. Current knowledge on pest

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monitoring and forecasting of pest intensity on red raspberry in the United Kingdom was recently reviewed by Gordon et al. (1990). The introduction and development of an IPM system in cane fruit will be studied in the future because consumers demand fruits largely free from pesticide residues. It should also be noted that predators, microbial-based compounds, natural plant products and insect behavior-modifying compounds (semiochemicals) are either available or being developed for pest control in many small fruits. However, very little research has been done to assess their effectiveness in raspberry crops (Gordon et al. 1990).

The development of an IPM program requires the knowledge of the most abundant insect species and their seasonal fluctuations in crops and adjacent sites. The aim of the present work was to evaluate the variations of the epigean beetle community in a red raspberry plantation in southern Quebec (Canada). 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; (3) the potential role of adjacent sites (boundary and wooded site) as refugia for injurious insects and as an overwintering site; (4) the flight period and dispersal activity of the beetles between the raspberry plantation and adjacent sites.

Nearly 60,000 adult beetles were caught during the study. Here, we present results only for the sap beetles or Nitidulidae. Most nitidulid species are saprophagous or mycetophagous, as they use decaying fruits, fermenting materials, carrion, and decaying fungi, but a few species are predaceous or even phytophagous (Campbell et al. 1989). Some species are of economic importance in some North American raspberry fields, such as the picnic beetle, *Glischrochilus quadrisignatus* (Say), and the strawberry sap beetle, *Stelidota geminata* (Say) (Campbell et al. 1989, Miller and Williams 1982). However, commonly found in woodlots, sap beetles can be vectors of forest pathogens causing wood rots (Peng and Williams 1990).

STUDY SITES

The beetles were collected in a commercial monocultural raspberry farm at Johnville, near Sherbrooke, in southern Quebec. This farm was surrounded by a hay field and a railroad on its northern boundary and by wooded sites dominated by eastern white pine (*Pinus strobus*) on other sides (Fig. 1). In the studied raspberry plantation (about 7 ha, on sandy soil), the cultivars were Boyne, Carnival, Killarney and Latham but we sampled only in the Boyne cultivar. Table 1 presents periods of flower and fruit development during this study. The water from a farm pond was used to irrigate the raspberry plantation. The grower applied chemical fertilizer, many chemical pesticide sprays, fructocane cutting after harvest, and regular mowing between raspberry rows. During the present study, there were no corn, strawberry or other raspberry plantations surrounding the area.

The epigean beetle fauna was sampled 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), (4) a wooded site dominated by eastern white pine (pine woods) (Fig. 1).

In addition, we studied flying beetles 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 the pond (B), about 5 m from young raspberry plants, (3) a woods-field boundary (C), and (4) a pine woods (D) (Fig. 1). These

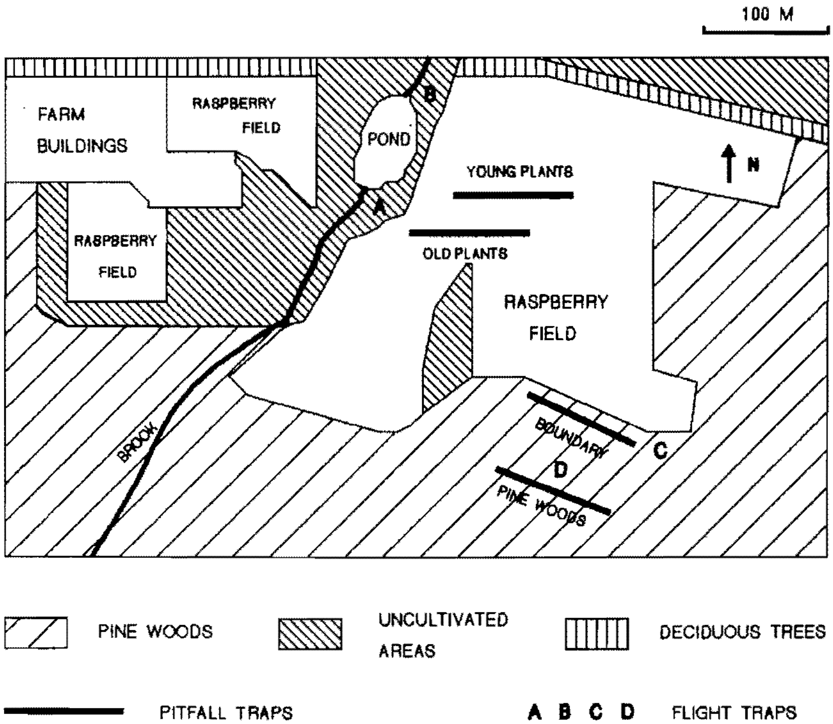

Figure 1. Sketch-map of the raspberry farm at Johnville.

traps were not located between rows of raspberry plants because of grower's activities and public access during harvest.

In the plantation, the most abundant plants between raspberry rows were grasses (Gramineae), dandelion (*Taraxacum officinale*), clovers (*Trifolium* spp.), vetch (*Vicia cracca*) and common milkweed (*Asclepias syriaca*). Plant species in uncultivated areas, in addition to the aforementioned plants, were sedges (*Carex* spp.), buttercup (*Ranunculus acris*), goldenrods (*Solidago* spp.), hawkweeds (*Hieracium* spp.), ox-eye daisy (*Chrysanthemum leucanthemum*) and plantains (*Plantago* spp.). Some poplars (*Populus* spp.) and willows (*Salix*

Table 1.—Periods of flower and fruit development of raspberry Boyne cultivar at Johnville (1987–1989).

Plant Stages	1987	1988	1989
Floral buds	May 27 – June 14	May 22 – July 3	May 21 – June 25
Flowers	June 7 – June 28	June 12 – July 10	June 11 – July 2
Green or pink fruits	June 21 – August 9	June 19 – August 7	June 21 – August 6
Ripe fruits	July 8 – August 19	July 10 – August 21	July 9 – August 13
Decaying fruits	July 26 – August 30	July 17 – August 28	July 23 – August 20

spp.) were present in the open site near the pond and along the brook. The boundary vegetation was diversified with wild raspberry (*Rubus idaeus*), wild strawberry (*Fragaria virginiana*), choke cherry (*Prunus virginiana*), meadowsweet (*Spireae latifolia*), small maples (*Acer* spp.), willows (*Salix* spp.), poplars (*Populus* spp.), fir (*Abies balsamea*), spruces (*Picea* spp.), and wild lily-of-the-valley (*Maianthemum canadense*). In the pine woods, the vegetation was very sparse; 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 the flight trap D.

MATERIALS AND METHODS

We used pitfall traps for ground surface-active beetles and flight interception traps for beetles flying close to the ground. These methods are widely used even if catch number is influenced by factors such as population density, locomotor activity (walking or flying) and behavior of the animals (Adis 1979, Alm et al. 1989, Baars 1979, Chapman and Kinghorn 1955, Chénier and Philogéne 1989, Desender 1986, Franke et al. 1988, Halsall and Wratten 1988, Hocking and Hudson 1974, Morrill et al. 1990, Scheller 1984, Turnbow and Franklin 1980).

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 the plantation, traps were inserted into the soil beneath the canopy as close to the cane of raspberry plants as possible. Collection of very small beetles was made easier with a piece of white plastic inserted under the jar. A plywood cover (20 by 20 cm) was placed 2.5 cm above the trap to avoid flooding the trap, excessive formalin evaporation and capture of flying beetles. The cover also furnishes a shelter for some beetle species before the raspberry canopy has fully developed. In each site, a row of twenty traps (5 m apart) was set from the beginning of May through the end of October and traps were emptied weekly.

Flight interception traps were modified from the large-area "window" trap design promoted by Peck and Davies (1980). Each consisted of a gray 1.5 mm mesh window screen (1.22 m height, 1.52 m width, about 1.85 m^2 of surface) fastened to a wooden frame. The frame itself was suspended by two lateral triangular wooden supports (1.83 m at the base, 1.25 m height), 2–4 cm over a set of two galvanized metal pans (25 by 61 cm at the top, 7.5 cm deep) which were placed directly on the ground. The insects were caught in the pans partially filled with 2% formalin into which a few drops of detergent were added. To increase resistance of these traps to strong winds, small boulders and plastic garbage bags partially filled with sand were put on the bases of lateral supports. We also placed small boulders on each side of the pans to prevent tampering by mammals. The pan interior was painted white to make collection of very small beetles easier and also to reduce formalin evaporation. The frame and the two lateral supports were painted green.

We installed one flight trap in each site (Fig. 1) but in the pine woods (D), the trap was operated in 1988 and 1989 only. The catching-surface of traps was perpendicular to dominant western winds in the two open sites and parallel to raspberry rows in the boundary and pine woods. Like the pitfall traps, the flight traps were set from May through October. Samples were collected twice a week and the formalin solution was replaced at each collection. The trap counts from individual sampling periods were combined on a weekly basis. Very few insects flew on days with substantial precipitation or strong winds.

In all traps, formalin was used as a killing and preserving agent as well as to prevent escape and predation, in spite of its potential selective effect as repellent or attractant to some beetle species (Adis 1979). Otherwise, we did not use a special bait to catch a particular species or family.

The climatic data were compiled by the Canadian Atmospheric Environment Service of the Sherbrooke Airport (45°26'N, 71°41'W, 241.0 m a.s.l.) which is 8 km away from the studied raspberry plantation and at a similar elevation. The degree-days (base: 5°C) were cumulated from 1 April through 31 October: the annual counts were 1692 in 1987, 1682 in 1988 and 1748 in 1989 while the annual normal (1951 -1980) was 1580 degree-days.

Because data did not meet the criteria for parametric testing, nonparametric tests were performed. We used the Renkonen's percent similarity (PS) that is simple to calculate and comparable to more complex indices (Huhta 1979, Wolda 1981). Percent similarity is calculated as follows:

$$PS = \Sigma \text{ minimum } (x_i, y_i)$$

where x_i and y_i are the percentages representing species "i" in the two annual collections. In addition, when we captured at least ten species in two sites, we calculated the Spearman's coefficient of rank correlation (r_{sc}) corrected for tied observations (Cancela da Fonseca 1968). The ρ nullity was tested against $\rho > 0$ with table of the coefficient of correlation (Jolicoeur 1991) since we were interested in the similarity between beetle faunae. In cases where the number of beetles captured by a method was low (< 50 individuals/site/year), we did not use any test.

RESULTS AND DISCUSSION

Relative abundance of nitidulid catches. We captured a total of 2700 Nitidulidae representing 29 species. Pitfall trapping resulted in the catch of 521 beetles of 15 species (Table 2). Total catches of nitidulid species in flight traps comprised 2179 individuals representing 28 species (Table 3).

In raspberry rows (old and young plants), *Glischrochilus quadrisignatus* and *G. fasciatus* (Oliv.) represented 86% and 8.7% of total catches in pitfall traps respectively (Table 2). A few adults of *G. quadrisignatus* were also collected in the boundary, but most of the species active at the ground surface in the boundary and pine woods belonged to the genus *Epuraea* (Table 2).

The pollen beetle *Meligethes nigrescens* Stephens was the most abundant species caught in flight traps near the raspberry plantation, particularly in the two open sites (65% of total catches in site A, 80% in site B) (Table 3). In flight traps A, B and C, we also captured many adults of *Carpophilus brachypterus* (Say), *Colopterus truncatus* (Randall), *G. fasciatus* and *G. quadrisignatus* (Table 3). However, the species of *Epuraea*, chiefly *E. avara* (Randall) and *E. ovata* Horn, represented 46% of total catches in the flight trap at the boundary and 81% in the pine woods (Table 3).

Flying nitidulids in open sites (A and B) were rather similar over the two years in a site (A or B) or between these two sites for one year (Table 4). We obtained a similarity of 75 to 82% for site A, 79 to 91% for site B, and 70 to 89% between sites A and B; the Spearman's coefficient was always significant ($P < 0.05$) for all comparisons. Species variations in flying nitidulids in the pine woods were of little importance between the years 1988 and 1989 (PS = 73%, $r_{sc} = 0.86$); the species composition was very different from that of the two open sites (PS = 2 to 6% only) (Table 4). However, the species composition at the boundary was quite variable during the three study years (PS = 50% for two years in site C), because of variations in the relative abundance of species flying either in open sites or in wooded sites (Table 4).

Table 2.—Total catches of nitidulid species in pitfall traps (1987-1989).

Species	Old Plants N	Old Plants %	Young Plants N	Young Plants %	Boundary N	Boundary %	Pine Woods N	Pine Woods %	Total N
Carpophilus brachypterus (Say)	7	3.3	3	1.3	0		0		10
Colopterus truncatus (Randall)	6	2.9	3	1.3	0		1	2.3	10
Epuraea avara (Randall)	0		0		4	9.5	10	23.3	14
Epuraea labilis Er.	0		0		1	2.4	0		1
Epuraea ovata Horn	0		0		0		1	2.3	1
Epuraea parsonsi Connell	0		0		1	2.4	1	2.3	2
Epuraea planulata Er.	1	0.5	0		4	9.5	23	53.5	28
Epuraea sp. 1	0		0		8	19.0	2	4.7	10
Epuraea truncatella Mann.	0		0		10	23.8	4	9.3	14
Glischrochilus fasciatus (Oliv.)	13	6.2	25	11.0	1	2.4	0		39
Glischrochilus quadrisignatus (Say)	180	86.1	196	86.3	9	21.4	1	2.3	386
Glischrochilus siepmanni W.J. Brown	1	0.5	0		1	2.4	0		2
Glischrochilus vittatus (Say)	0		0		1	2.4	0		1
Heterhelus pennatus (Murray)	0		0		2	4.8	0		2
Omosita colon (L.)	1	0.5	0		0		0		1
Total	209	100.0	227	99.9	42	100.0	43	100.0	521
Number of species	7		4		11		8		15

Glischrochilus fasciatus and *G. quadrisignatus* are generally considered to be secondary pests in raspberry plantations because adults feed on injuries inflicted by other insects or diseased berries (Campbell et al. 1989). According to Parsons (1967), several species of *Epuraea* (including *E. avara*) have been reared from fungi causing pine diseases over much of northern United States and Canada whereas *E. ovata* occurs under beech bark and in fungus (Parsons 1943). Larvae and adults of *Meligethes nigrescens* are known to feed on the pollen of various flowers, but not on raspberry pollen (Easton 1955, Connell 1956). In Oregon it is a pest of Dutch clover (*Trifolium pratense*) and hairy vetch (*Vicia* sp.), in Pennsylvania it has been injurious to muskmelon (*Cucumis melo*), while in Quebec it is sometimes numerous on clover (*Trifolium* spp.) (Campbell et al. 1989). Although *M. nigrescens* is a very common species throughout Europe (Easton 1955), Hill (1952) did not record this insect on cultivated raspberries in Scotland, but he reported the fairly common presence of *M. aeneus* (Fab.) and *M. viridescens* (Fab.); these two species probably did more good than harm to the raspberry plants, in that they helped in pollinization. However, the pollen beetle *M. aeneus* is a major pest on oil-seed rape throughout most of Europe (Nielsen and Axelsen 1988).

Seasonal activity of most abundant species. In three years, we captured adults of *G. quadrisignatus* in pitfall and flight traps from May through September, particularly between mid-May and mid-June (Fig. 2); 23 tenerals were trapped between 15 May and 9 August . At the boundary, eight of nine adults captured in pitfall traps were active in May while 16 of 23 adults captured in flight trap C were active in mid-July and August. We also observed a few adults on ripe fruits in the plantation sporadically. Our interpretation of these facts is as follows: (1) The adults overwintered in the sites around the plantation, principally in uncultivated areas. (2) When the temperature first began to rise, overwintered beetles flew towards the raspberry plantation where the reproduction occurred. (3) The new generation fed on ripe and decaying fruits without leaving the plantation except to feed on berries of wild plants in the boundary area. (4) We suspect either the presence of only one extended period of reproduction each year or two generations of this species in

Table 3.—Total catches of nitidulid species in flight traps (1987–1989).

Species	Open Site Near Center N	%	Open Site Near Pond N	%	Boundary N	%	Pine Woods[a] N	%	Total N
Brachypterolus pulicarius (L.)	1	0.1	1	0.1	0		0		2
Brachypterus urticae (Fab.)	0		0		1	0.4	0		1
Carpophilus brachypterus (Say)	36	4.8	34	3.7	12	4.7	0		82
Carpophilus marginellus Mots.	5	0.7	0		0		0		5
Colopterus truncatus (Randall)	31	4.1	33	3.6	17	6.7	0		81
Conotelus obscurus Er.	27	3.6	23	2.5	3	1.2	0		53
Cryptarcha ampla Er.	0		0		1	0.4	0		1
Cryptarcha concinna Melsh.	0		0		1	0.4	0		1
Epuraea aestiva (L.)	1	0.1	0		3	1.2	0		4
Epuraea avara (Randall)	2	0.3	5	0.5	76	29.9	56	21.3	139
Epuraea labilis Er.	8	1.1	7	0.8	7	2.8	1	0.4	23
Epuraea ovata Horn	1	0.1	1	0.1	9	3.5	119	45.2	130
Epuraea parsonsi Connell	0		0		1	0.4	1	0.4	2
Epuraea planulata Er.	1	0.1	0		6	2.4	7	2.7	14
Epuraea rufa (Say)	0		0		2	0.8	0		2
Epuraea sp. 2	2	0.3	0		0		0		2
Epuraea truncatella Mann.	0		0		12	4.7	29	11.0	41
Glischrochilus fasciatus (Oliv.)	39	5.2	24	2.6	6	2.4	1	0.4	70
Glischrochilus quadrisignatus (Say)	88	11.7	33	3.6	23	9.1	1	0.4	145
Glischrochilus sanguinolentus (Oliv.)	0		0		8	3.2	26	9.9	34
Glischrochilus siepmanni W.J. Brown	1	0.1	5	0.5	9	3.5	3	1.1	18
Glischrochilus vittatus (Say)	0		0		6	2.4	12	4.6	18
Heterhelus pennatus (Murray)	2	0.3	1	0.1	3	1.2	0		6
Lobiopa undulata (Say)	1	0.1	3	0.3	0		0		4
Meligethes nigrescens Stephens	489	65.2	727	79.7	42	16.5	7	2.7	1265
Nitidula bipunctata L.	1	0.1	0		0		0		1
Nitidula rufipes (L.)	1	0.1	0		0		0		1
Omosita colon (L.)	13	1.7	15	1.6	6	2.4	0		34
Total	750	99.8	912	99.7	254	100.2	263	100.1	2179
Number of species	20		14		22		12		28

[a]not sampled in 1987.
Note: *G. sanguinolentus* include the two subspecies *G. s. sanguinolentus (Oliv.)* and *G. s. rubromaculatus (Reitter).*

some years at Johnville. Our results agreed partially with previous observations on the biology of this species (Campbell et al. 1989). At 21.1–29.4°C, the life cycle (egg to adult) averaged 31–36 days and the new adults remained in the soil for an average of 11.2 days before emerging (Foott and Timmins 1979). Emergence began on 15 June in southwestern Ontario and peaked from mid-July to early August (Foott and Timmins 1977). *Glischrochilus quadrisignatus* is univoltine in southwestern Ontario and bivoltine in the United States (Campbell et al. 1989). Luckmann (1963) suspected that in some locations, particularly in late September or October, conditions could be favorable for a sufficient length of time to initiate oviposition. According to Peng and Williams (1990), hibernation is unnecessary for oviposition in *G. quadrisignatus* because these beetles can produce eggs when suitable food and favorable environmental conditions are available. Although photoperiod was not considered in this study, it may limit the production of a second generation alone or in combination with other factors (Luckmann 1963). The effects of photoperiod on the larval development and possibly on larval hibernation are uncer-

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

		Open Site Near Center (A)			Open Site Near Pond (B)			Boundary (C)			Pine Woods (D)	
Site	Year	1987	1988	1989	1987	1988	1989	1987	1988	1989	1988	1989
A	1987		74.5	81.8	69.7			38.7				
	1988	0.464*		78.3		83.3			50.8		5.4	
	1989	0.619**	0.586**				89.3			30.4		2.3
B	1987	0.809***				91.3	81.1	30.0				
	1988		0.570*		0.523*		79.0		48.2		6.2	
	1989			0.880***	0.484*	0.561*				28.2		2.4
C	1987	0.482*			0.463*				46.8	55.0		
	1988		0.141			0.522*		0.337		51.4	33.7	
	1989			0.097			0.154	0.212	0.434*			47.0
D	1988		-0.586			-0.587			0.290			73.3
	1989			-0.582			-0.597			0.222	0.860***	

* $0.1 \leq p < 0.05$
** $0.001 \leq p < 0.01$
*** $p < 0.001$

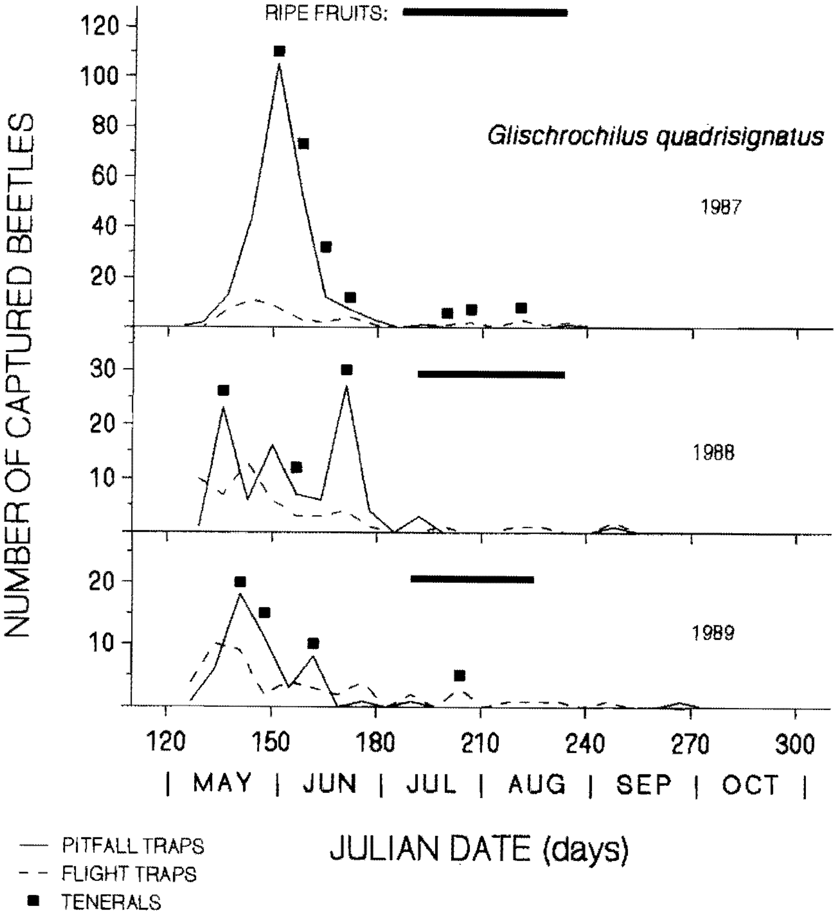

Figure 2. Seasonal abundance of *Glischrochilus quadrisignatus* in pitfall traps and flight traps, in 1987, 1988 and 1989. The period of ripe raspberries is indicated.

tain. It is possible that a part of the population hibernates in the larval stage in the soil of the raspberry field and mature to the adult stage by May. Alm et al. (1989) hung baited flight traps in crabapple trees (*Malus* sp.) in Ohio; they caught beetles, using fruit volatiles as bait, from 29 May to 5 September with a peak of captures in July. According to the same authors, adults of *G. quadrisignatus* were also attracted to butyl acetate and propyl proprionate. Our observations on the flight of the new generation were probably linked to the absence of bait in traps and not to summer temperatures.

Adults of *M. nigrescens* flew from early May to the end of October (Fig. 3). Flight activity began in May when at least 100 degree-days above 5°C were accumulated. The first peak of captures occurred in late May and June, in part

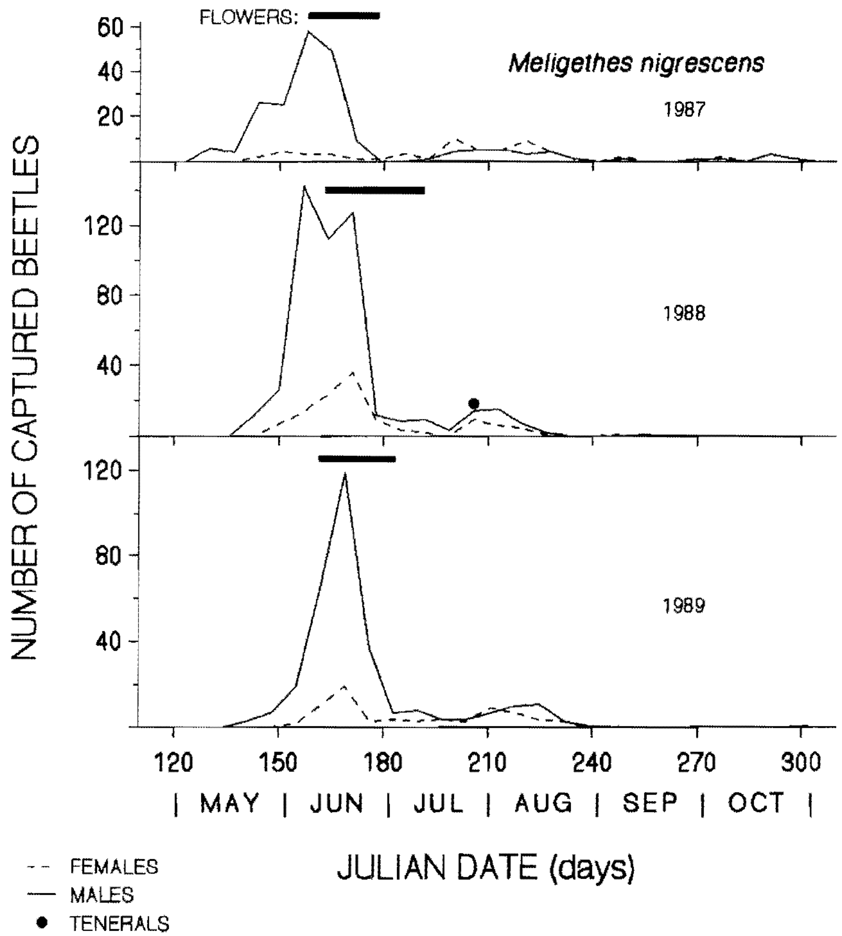

Figure 3. Seasonal abundance of females and males of *Meligethes nigrescens* in flight traps, in 1987, 1988 and 1989. The period of raspberry flowers is indicated.

during the period of raspberry flowering (Fig. 3). During this period of maximal activity in May-June (1987–1989), we captured 873 males and only 143 females (6.1 ♂ : 1 ♀). If males and females flew at the same height, it was then the mating period. From mid-July to late August, we observed a small increase in activity (Fig. 3); males and females were almost in the same proportions (1.2 ♂ : 1 ♀) during this second period which was probably linked with emergence of new adults since we captured a teneral female on 24 July 1988. In 1989, the flowering periods were, respectively, 21 May-7 June for dandelion, 25 June-6 August for vetch, and 25 June-27 August for clover. We believe that overwintered adults moved to the raspberry plantation and fed on dandelion and raspberry pollens during the mating period, that the larvae fed on vetch and clover pollens, and that the new adults fed also on clover pollen and could move progressively to new food sources (such as goldenrod pollen) near the plantation before hibernation. Where adults of this species feed on raspberry pollen, we are uncertain of their effectiveness as pollinators or if there might be competition with bees for the pollen of raspberry or other plant species in the plantation. No damage associated with this species has ever been detected. According to Parsons (1943), this species occurs in April-July in North America. In Delaware, adults were common on the flowers of *Brassica* sp., *Cornus* sp. and *Magnolia macrophylla* from 15 April to 17 May; they were also collected occasionally on the Rosaceae flowers (*Prunus* spp., *Malus* spp.) from 18 April to 1 May (Connell 1956). In Europe, the pollen beetle *M. aeneus* has one annual generation with two larval stages and pupate in the soil (Nielsen and Axelsen 1988). In England, overwintered beetles mate from mid-May until the emergence of new generation adults; these did not mate before hibernating, since pollen is probably their main food (Williams and Free 1978).

In 1989, adults of *Colopterus truncatus* (30 ♀♀, 19 ♂♂) flew from mid-May to early October and the peak captures occurred in June-July (Fig. 4). Apparently, they overwintered as adults. According to Parsons (1943), this species occurs mainly in April-July. In Wisconsin, McMullen and Shenefelt (1961) collected this species in pitfall traps baited with banana: the adults were active in May and chiefly in September-October.

In 1987–1989, adults of *E. avara* (89 ♀♀, 50 ♂♂) flew from early May to early August and occasionally again in September; peak captures occurred in May-June (Fig. 4). In May 1987, we captured 13 adults (8 ♀♀, 5 ♂♂) in pitfall traps. Overwintering by these adults was probable. According to Parsons (1943), this species occurs in May-August, chiefly in June. In Wisconsin, banana bait pitfall trapping resulted in the catch of adults mainly in May-June (McMullen and Shenefelt 1961).

In 1988–1989, adults of *E. ovata* (62 ♀♀, 67 ♂♂) flew from early May to mid-August (Fig. 4). In 1988, the first peak of catches occurred in May and is possibly linked to the activity of overwintering beetles (Fig. 4). We also observed a small increase of activity in July, possibly due to the emergence of new adults although we did not capture tenerals. According to Parsons (1943), this species occurs in May-September, chiefly in June.

In 1989, we collected 31 ♀♀ and 20 ♂♂ of *G. fasciatus* in unbaited flight traps, mainly in May (Fig. 4). In 1987–1989, 34 ♀♀ and 5 ♂♂ were caught in pitfall traps, chiefly in May. We suspect that: (1) the adults overwintered in uncultivated areas around the plantation, and (2) when the temperature first began to rise, overwintered beetles flew to the raspberry plantation where reproduction probably occurred. Because of the absence of bait in traps, we could not prove that the new generation fed on ripe and decaying raspberries. *Glischrochilus fasciatus* was apparently univoltine at Johnville. According to Parsons (1943), this species may be collected from April to October, but mainly in April and May. In Wisconsin, in banana bait pitfall traps, adults were very abundant in May-June and again in September-October; nevertheless, *G. fasciatus* tends to show a small increase of activity in mid-summer, indicating perhaps two generations (McMullen and Shenefelt 1961). According to Peng and Williams (1990), hibernation is unnecessary for oviposition of *G. fasciatus* because these beetles can produce eggs when suitable food is available and environmental conditions are favorable.

Seasonal activity of some other species. During the three years of this study (1987–1989), one or two periods of flight activity were observed in *Carpophilus brachypterus* (Say), *E. labilis* Er., *E. planulata* Er., *E. truncatella* Mann., *G. sanguinolentus rubromaculatus* (Reitter), *G. sanguinolentus san-*

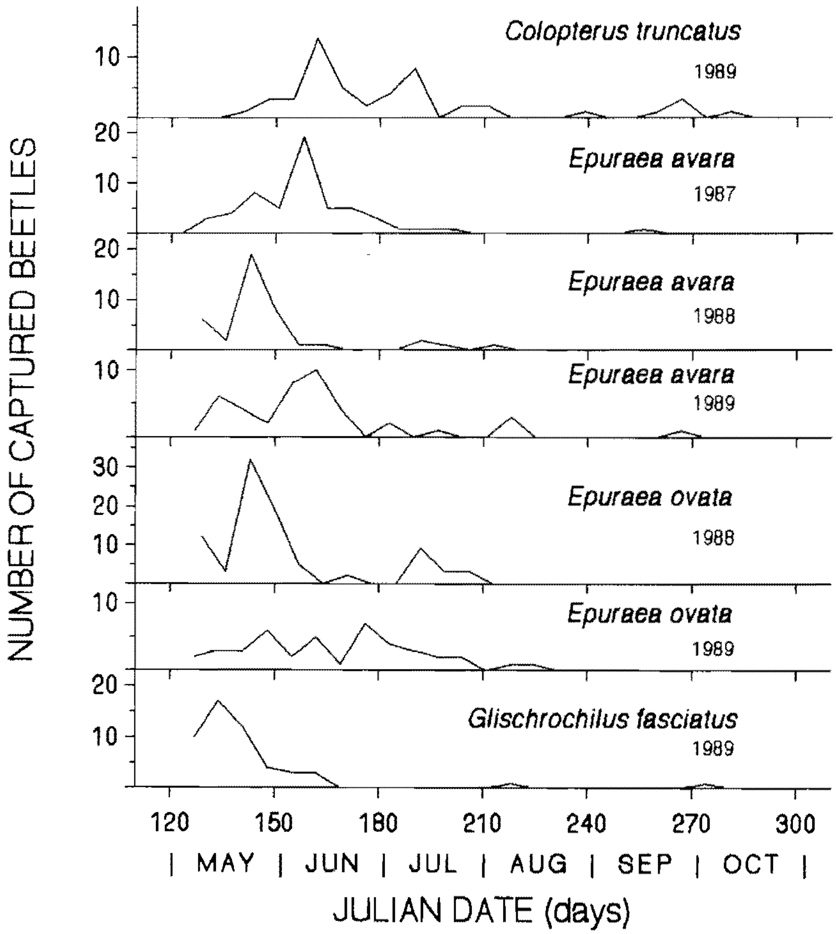

Figure 4. Seasonal abundance of *Colopterus truncatus, Epuraea avara, Epuraea ovata* and *Glischrochilus fasciatus* in flight traps.

guinolentus (Oliv.), *G. siepmanni* W.J.Brown, *G. vittatus* (Say) and *Omosita colon* (L.) (Table 5). The peak of captures occurred generally in May-June although adults of *E. truncatella* flew mainly in October. In addition, we captured adults of *C. brachypterus, E. planulata* and *E. truncatella* in pitfall traps chiefly in May-June. We also collected one teneral of *G. siepmanni* in a pitfall trap in September 1987. For these nine taxa, adult overwintering and spring reproduction were probable. However, larval hibernation was possible in *Conotelus obscurus* Er. because adults flew during summer, chiefly in July-August (Table 5). Our results generally agreed with previous observations on the biology of these ten species (Parsons 1943, Connell 1956, Peng and Williams 1990). In Delaware, larvae of *C. obscurus* were common on the

Table 5. — Seasonal abundance and number of females and males of some nitidulid species (1987–1989).

Species	Traps	M	J	J	A	S	O	♀♀ : ♂♂
Carpophilus brachypterus	Flight	41	16	7	12	6		53 : 29
Carpophilus brachypterus	Pitfall	8	2					10 : 0
Conotelus obscurus	Flight		2	16	33	2		31 : 22
Epuraea labilis	Flight	6	9	7		1		8 : 14
Epuraea planulata	Flight	11	3					5 : 9
Epuraea planulata	Pitfall	12	15	1				21 : 6
Epuraea truncatella	Flight	10	2	1			28	23 : 18
Epuraea truncatella	Pitfall	9	4			1		9 : 5
Glischrochilus sanguinolentus rubromaculatus	Flight	9	5		2	1	2	13 : 6
Glischrochilus sanguinolentus sanguinolentus	Flight	8	4	1	1	1		10 : 4
Glischrochilus siepmanni	Flight	15	2				1	
Glischrochilus vittatus	Flight	11	2				5	7 : 11
Omosita colon	Flight	26	8					

flowers of *Hibiscus* sp. from 4 August to 17 September (Connell 1956). In Illinois and New Jersey, adults of *O. colon* were caught in carrion-bait traps from April to November, chiefly in April-July (Johnson 1975, Shubeck et al. 1977).

In flight traps and pitfall traps, we captured more females than males of *Carpophilus brachypterus* (1.8 ♀: 1 ♂ in flight traps and only females in pitfall traps) and *E. truncatella* (~1.5 ♀: 1 ♂ for two methods) (Table 5); we have no explanation for these results. We observed that the sex-ratio for trapped adults of *E. planulata* varied with the method, 1 ♀: 1.8 ♂ in flight traps and 3.5 ♀: 1 ♂ in pitfall traps; we suspect that the epigeal activity of females was linked to oviposition behavior.

Suggestions for further studies. We suggest: (1) the determination of the exact role of *M. nigrescens* in the raspberry pollinization; (2) the effects of the photoperiod, alone or in combination with the temperature, on the life cycle of nitidulid species, particularly in *G. quadrisignatus*; and (3) an examination of factors influencing the sex-ratio of some species at flight traps (e.g. type and height of traps, use and type of preserving agent (formol or other), or the absence of bait in traps).

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