NATURAL ENEMIES OF *MYZOCALLIS CORYLI* (HOM.:APHIDIDAE) IN OREGON HAZELNUT ORCHARDS

R. H. MESSING AND M. T. ALINIAZEE
Departmet of Entomology, Oregon State University, Corvallis, Oregon

ABSTRACT

Fifty-five species of aphidophagous predators were found in a survey of the hazelnut orchards of western Oregon. Important predators of the filbert aphid, *Myzocallis coryli* (Goetze), include: *Adalia bipunctata* (L.), *Cycloneda polita* Csy. (Coleoptera: Coccinellidae); *Deraeocoris brevis* (Uhler) (Hemiptera: Miridae); and species of *Hemerobius* and *Chrysopa* (Neuroptera: Hemerobiidae and Chrysopidae).

One parasitoid, *Mesidiopsis* sp. (Hymenoptera: Aphelinidae) was found to attack the aphid. In addition, one pathogenic fungus, *Triplosporium fresenii* (Nowakowski) Batko (Entomophthorales: Entomophthoraceae) was found to cause an epizootic in an orchard with a high aphid density.

INTRODUCTION

Myzocallis coryli (Goetze), the filbert aphid, is a serious pest of hazelnut (filbert), *Corylus avellana* (L.), orchards of North America. Recurring aphid outbreaks are experienced by commercial orchards, with population densities reaching as high as 500 aphids per leaf. Although the effects of such large aphid populations are not well documented, it is generally believed that aphid feeding causes reduction in nut size and percent kernel fill. In addition, aphids secrete large quantities of honeydew which may cause leaf scorch, sooty mold growth, staining of nuts, and fouling of orchard equipment (AliNiazee, 1980).

M. coryli is a monecious species, spending its entire life cycle on the filbert tree. It is the only aphid found on North American hazelnuts, and is considered to be of European origin (Richards, 1968).

Commercial hazelnut production in North America is concentrated in the Pacific Northwest, with the Willamette Valley of Oregon accounting for about 95% of production, with smaller acreages in Washington and British Columbia (Baron and Stebbins, 1978). Growers typically rely on one to three applications of insecticide annually to control the aphid. However, the aphid has developed populations resistant to carbaryl, the most commonly used insecticide in hazelnut orchards (AliNiazee, 1983a). There is also indication of resistance against some commonly used organophosphate compounds (AliNiazee, unpublished data), thus complicating the control program. Some growers are already encountering increasing difficulties with insecticidal control of *M. coryli*.

A number of predacious insects are associated with the filbert aphid in western Oregon, and several of these have been presumed to be important in natural biological control of this pest (AliNiazee, 1980). However, the complex of aphidophagous insects has not been systematically examined. The present study was designed to determine the presence and abundance of aphidophagous predators in the hazelnut agro-ecosystem, and to provide information on their relative importance and synchrony with the filbert aphid.

METHODS

During 1980 and 1981 a total of twelve hazelnut orchards were surveyed for natural enemies of *M. coryli*. Orchards were chosen from the major hazelnut producing areas in northern, central, and southern portions of the Willamette Valley. Orchard conditions ranged from intensively managed to essentially abandoned. In 1981, nine orchards were sampled a minimum of three times each (in April, June, and November). In addition, more detailed information was gathered by sampling three orchards near Corvallis once every week for six months, to determine the relative abundance and phenology of natural enemies.

Sampling was conducted using the limb-tapping method of Lord (1949). Three limbs were sampled per tree on ten randomly chosen trees on each sample date. In one orchard, a ten minute visual search per tree was used to supplement the limb-tapping method.

Predator feeding behavior was observed by examination of insects both in the field and under laboratory conditions. Predators were placed in petri dishes containing moistened filter paper and filbert leaves infested with the aphids. In some cases predators were reared from early instars to adults by providing fresh aphids and moisture every few days.

Aphid mummies were held individually in small gelatin capsules until parasitoid emergence; spores of a pathogenic fungus were slide-mounted for identification.

RESULTS AND DISCUSSION

A list of aphidophagous predators collected during this study is presented in Table 1. This list includes rarely encountered species and "incidentals" as well as those more abundant and widespread. A total of 55 predacious species from twelve insect families was found in the hazelnut system (Table 1). The most important predators are discussed below, by family:

TABLE 1. Predaceous insects associated with **Myzocallis coryli** in hazelnut orchards in Oregon. 1980-1981.

Family	Species
	COLEOPTERA
Cantharidae:	*Podabrus pruinous* Lec.
Coccinellidae:	*Anatis rathvoni* (Lec.)
	Adalia annectans Crotch
	Adalia bipunctata (L.)
	Adalia frigida Schn.
	Calvia duodecimmaculata Gebl.
	Calvia quatuordecimgutta (L.)
	Chilocorus sp.
	Coccinella californica Mann
	Coccinella transversoguttata Brown
	Coccinella trifasciata subversa Lec.
	Coccinella trifasciata perplexa Muls.
	Coccinella unidecimpunctata L.
	Coccinella sp.
	Cycloneda polita Csy.
	Exochomus quadripustulatus (L.)
	Exochomus sp.
	Hippodamia convergens G. M.
	Hippodamia quinquesignata ambigua Lec.
	Hippodamia sinuata spuria Lec.
	Hippodamia sinuata disjuncta Timb.
	Mulsantina picta Rand
	Scymnus sp.
	DERMAPTERA
Forficulidae:	*Forficula auricularia* L.
	DIPTERA
Syrphidae:	*Eupeodes volucris* (O.S.)
	Metasyrphus fumipennis (Thomsen)
	Syrphus opinatar (O.S.)
	Syrphus ribesii (L.) or *torbus* (O.S.)
Cecidomyiidae:	*Aphidolestes* sp.
	HEMIPTERA
Anthocoridae:	*Anthocoris antevolans* White
	Orius tristicolor White
Miridae:	*Atractotomus* sp.
	Campyloneura virgula (H.S.)
	Compsidolon salicellum (H.S.)
	Deraeocoris brevis (Uhler)
	Deraeocoris fasciolus Knight
	Diaphnocoris sp.
	Heterotoma meriopterum (Scop.)
	Lupus decolor (Fallen)
	Paraproba nigrinervis (V.D.)
	Phytocoris sp. A
	Phytocoris sp. B
	Pilophoris sp.
Nabidae:	*Nabis alternatus* Parshley
	NEUROPTERA
Chrysopidae:	*Chrysopa placita* Banks
	Chrysopa nigricornis Burmeister
	Chrysopa rufilabris Burmeister
	Chrysopa carnea Steph.
Hemerobiidae:	*Hemerobius humulinus* Linn.
	Hemerobius ovalis Carpenter
	Hemerobius pacificus Banks
	Hemerobius stigma Steph.
	ORTHOPTERA
Gryllidae:	*Oecanthus nigricornis* (Walker)
	Oecanthus niveus (DeGeer)
	RAPHIDIOPTERA
Raphidiidae:	*Agulla* sp.

Coccinellidae

Twenty-two species of coccinellids were collected in association with the filbert aphid, but only two, *Adalia bipunctata* (L.) and *Cycloneda polita* Casey, were consistently abundant in all orchards surveyed. *Coccinella californica* Mann., *C. trifasciata* LeC., and *Hippodamia convergens* G.M. were moderately abundant, while the remaining species were infrequent or rare.

A. bipunctata adults were active in the orchards from April through October (see Table 2), and some localized aggregations were found as early as March 17. This suggests that at least part of the population may be overwintering in the orchards, as has been reported in Europe (Hodek, 1973). *A. bipunctata's* life cycle was well synchronized with that of the filbert aphid, which generally hatches from overwintering eggs during the first week in March. Predation during this early period (March-April), the "initiation phase" of aphid population growth, is more likely to contribute to substantial biological control than predation later in the season. Obrycki *et al.* (1983) have shown that *A. bipunctata* overwintering adults in New York have a low post-diapause developmental threshold of 7°C., which explains the early season activity of this predator in the field.

Populations of *A. bipunctata* in Oregon peaked in early July, with a second, smaller peak in October indicating a partial second generation. Hagen (1962) also reported a second generation in California. Obrycki *et al.* (1983) found two to three generations per year in New York.

C. polita adults were found in large numbers in most orchards; however, they did not colonize until May, when aphids were already entering their "exponential growth phase". Thus, their impact on biological control seems less pronounced. A single population peak was noticed, which indicates a univoltine life cycle for this species.

The three other coccinellids, *C. trifasciata*, *C. californica*, and *H. convergens* were frequently found in the orchards, but in much lower numbers than either *A. bipunctata* or *C. polita*. Moreover, they occur during the mid-season after a substantial increase in aphid populations had already occurred.

Miridae:

Of the twelve species of mirids collected,

TABLE 2. Mean number of predators per sample for three hazelnut orchards. Willamette Valley, Oregon, 1981.

Species	Life-stage	x number of predators/sample[1]					
		April	May	June	July	August	September
A. bipunctata	Adult	2.4	2.2	1.7	6.3	0.2	0.3
C. polita	Adult	0.9	1.7	0.6	2.4	0.2	0.1
C. trifasciata	Adult	0.2	<0.1	<0.1	0.6	0.5	0.2
H. convergens	Adult	<0.1	0	0	0.2	0.1	0.1
All coccinellids	Larva	0.8	2.8	21.8	6.5	<0.1	0
D. brevis	Adult	0.7	0.6	0.2	1.9	1.1	0.9
D. fasciolus	Adult	0	0.5	0.7	3.7	0.1	0
Deraeocoris spp. (indistinguishable)	Nymph	0	4.6	7.6	6.7	1.3	0.5
H. meriopterum	Adult	0	0	0	1.6	0.4	0
H. meriopterum	Nymph	0	0	6.3	2.2	0	0
P. nigrinervus	Adult	0	<0.1	4.9	2.2	<0.1	<0.1
C. salicellum	Adult	0	0	0	4.1	0.6	0
P. nigrinervis plus C. salicellum sp. (indistinguishable)	Nymph	0	0.7	6.5	10.5	0.1	0
Chrysopa spp.	Adult	0.1	<0.1	<0.1	0.1	0.1	0
Hemerobius spp.	Adult	0.1	0.2	0.2	0.1	0.1	<0.1
All lacewings	Larva	2.3	1.1	2.4	0.9	0.1	<0.1
A. antevolans	Adult	0.5	0.2	4.6	0.8	<0.1	0
A. antevolans	Nymph	0	0.9	0.9	0.8	0.1	<0.1
All syrphids	Adult	0.1	0.1	0.6	0.6	0	0

[1] One tree-sample = all insects collected on a 76 x 76 cm beating sheet held beneath three tapped limbs, mean of ten trees per orchard.

Deraeocoris brevis (Uhler) was the most important aphid predator. *D. brevis* overwinters in the adult stage in ground litter or in cracks and crevices on the trees, and is active from April through November. It emerges early enough to have an impact on aphids before the exponential growth phase. It is multi-voltine, with four generations per year reported in British Columbia (McMullen and Jong, 1967). *D. brevis* accounted for 20-60% of all predators collected in most of the surveyed orchards.

Other abundant mirids were *Paraproba nigrinervis* (V.D.) and *Deraeocoris fasciolus* Knight, the populations of which peaked in mid-July; and *Heterotoma meriopterum* (Scop.) and *Compsidolon salicellum* (H.S.), which peaked in early August. These four species appear to be univoltine, overwintering in the egg stage, and are abundant only during the period of peak aphid density. *C. salicellum* has not previously been reported in the United States, and this is a new record.

Although all of these mirids were observed to feed on aphids, they are apparently only facultative carnivores, as they were observed to survive quite well with only filbert leaves as food. This may be an important feature enabling them to bridge gaps in aphid abundance.

Chrysopidae and Hemerobiidae:

Four species of *Chrysopa* and four of *Hemerobius* were found in the hazelnut system, and contributed substantially to total predator numbers. *Chrysopa placita* Banks larvae (identified by their habit of carrying aphid cast skins and other debris on their backs) appeared earlier than *C. carnea* Steph.

Although different *Hemerobius* larvae could not be distinguished in the field, Neuenschwander (1976) reported *H. pacificus* to have a very low temperature threshold for activity; thus, it was likely active early in the spring. *H. stigma* may be an incidental in hazelnuts, as it is reported to be associated "exclusively" with conifers, whereas *H. humulinus* is known to show a marked preference for hazel (Killington, 1937).

Other predators:

Anthocoris antevolans White was abundant in only two of the orchards surveyed, but did not colonize until late May when aphid numbers were very high. It overwinters in the adult stage, is multivoltine, and is an important predator of pear psylla, *Psylla pyricola* Foerster, in commercial pear orchards of British Columbia and the western United States (McMullen and Jong, 1967).

Different syrphid species could not be distinguished in the field, but were sporadically abundant in several orchards. They were not found until late in the season.

The earwig, *Forficula auricularia* L., was very abundant in most of the orchards. Earwigs have been shown to be predaceous on aphids in some situations (Carrol and Hoyt, 1984).

Other Natural Enemies:

A parasitic Hymenopteran belonging to the genus *Mesidiopsis* (Aphelinidae) was found in most orchards, but in very low numbers. Little is known about the bionomics and ecology of this parasitoid; the species identity is also unknown. In France, *M. coryli* is known to be parasitized by *Mesidiopsis subflavescens* (Ferriére, 1965).

In a single orchard in 1981, a fungal pathogen was responsible for a wide-scale epizootic which severely decimated the filbert aphid population. The causal organism has been identified as *Triplosporium fresenii* (Nowakowski) Batko (= *Neozygites fresenii* (Nowakowski) Witlaczil by Dr. R. Humber, USDA-SEA, Ithaca, N.Y. The epizootic occurred in early June in an orchard where aphid populations had reached a density of 120 aphids/leaf. This is the first record of association of this pathogen with filbert aphids in North America.

Although an abundant and diverse predator complex attacks the filbert aphid throughout the growing season in Oregon, populations in commercial orchards may still reach several hundred aphids per leaf, and growers consistently rely on insecticides for control. In European hazelnut orchards *M. coryli*, although present, is not considered as serious an economic pest. This is perhaps due to the effectiveness of a richer parasitoid complex (Viggiani, 1983; Stary, 1978).

The use of insecticides for the control of aphids and other filbert insects causes major disruption of the predator complex, and may be partially responsible for the buildup of aphid densities in commercial orchards of Oregon. If left untreated, the diversity and abundance of the naturally occurring predatory fauna in the hazelnut system seems to be capable of reducing aphid numbers to low levels (AliNiazee, 1983b), although some economic loss might still occur. Although precise economic injury levels for the filbert aphid have not been determined, a working level used in Oregon IPM programs is 20-40 aphids per leaf. In completely unmanaged filbert orchards and on wild native hazel *(Corylus cornuta)*, aphid numbers rarely, if ever, reach this level. This may be due largely to the action of predators; however, low leaf nitrogen levels (due to lack of fertilizer, pruning, etc.) also limit aphid populations under these conditions.

In orchards which are not sprayed with insecticides but which are otherwise managed intensively (including fertilizer, pruning and weed control), aphid populations often exceed economic injury levels. Although the predator complex contributes substantially to aphid control, causing a severe crash in aphid populations late in the season (Messing, unpublished data), it apparently cannot contain the early season exponential growth phase of aphid populations. We, therefore, believe that inclusion of another early season mortality factor in addition to the predator complex might enhance biological control of this pest considerably, and in this context the authors are attempting to import and establish host-specific parasitoids of *M. coryli* from western Europe.

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CODLING MOTH (LEPID.: TORTRICIDAE): DISRUPTION OF SEXUAL COMMUNICATION WITH AN ANTIPHEROMONE [(*E*,*E*)-8,10-DODECADIEN-1-O1 ACETATE]

D. O. HATHAWAY, H. R. MOFFITT AND D. A. GEORGE
Yakima Agricultural Research Laboratory
U.S. Department of Agriculture, Agriculture Research Service
Yakima, Washington 98902

ABSTRACT

When broadcast applications of [*E*, *E*]-8,10-dodecadien-1-ol acetate an antipheromone of the colding moth, *Cydia pomonella* (L.), were made to apple or pear orchards, the catch of male codling moths was reduced in traps baited with either synthetic sex pheromone or virgin females. When the antipheromone, at a rate of 11.25g AI/0.4 ha was applied broadcast to pear trees using a ground dispenser, male response to pheromone- or female-baited traps was completely inhibited for 9 days with no significant reduction thereafter. Based on these and earlier results, it is concluded that (*E*,*E*)-8,10-dodecadien-1-ol acetate inhibits male codling moth response, whether the sources are placed in close proximity to the attractive agent or distributed in a broadcast application. These results contradict previous arguments that antipheromones as a group may not be effective in the field when used to permeate large volumes of air.

The codling moth, *Cydia pomonella* (L.), is key pest of apples and pears in most parts of the world and is generally controlled by multiple applications of organophosphorous insecticides (Quist 1966). However, use of some of these organophosphorous insecticides can significantly increase populations of the McDaniel spider mite, *Tetranychus mcdanieli* McGregor, on apples and pear psylla, *Psylla pyricola* Foerster, on pears by reducing populations of their natural enemies (Hoyt 1969). Development of alternatives to the standard insecticide program which would control the codling moth and also allow biological control of other important insect or mite pests is highly desirable.

It has been shown that pheromonal communication between the sexes, as measured by catches in traps baited with either synthetic sex pheromone or live virgin female moths, and subsequent mating of codling moth can be disrupted by exposing moths to high concentrations of the synthetic sex pheromone, (*E*,*E*)-8,10-dodecadien-1-ol (hereinafter referred to as 8,10-D) (Moffitt 1974, Hathaway, *et al.* 1979). In field studies, satisfactory levels of control have been achieved in pears using the pheromone as a mating disruptant (Moffitt, *et al.* 1979).

Antipheromones, i.e. nonpheromone chemicals that directly block or inhibit responsiveness of insects to their natural pheromones, have been reported for a number of Lepidoptera (Shorey 1977). Hathaway, *et al.* (1974, 1979), showed that (*E*,*E*)-8,10-dodecadien-1-ol acetate (hereinafter referred to as 8,10-Da) reduces the catch of male codling moths in traps baited with either synthetic sex pheromone or virgin females. In these laboratory and small scale field studies, substrates were impregnated with the inhibitor and placed by hand in close proximity to the pheromone sources in the tree. Shorey (1977), in his review of the manipulation of insect pests of agricultural crops

Footnotes

[1]Mention of a commercial product does not constitute a recommendation for use by the U.S. Department of Agriculture. Received for publication 19 June, 1985.