NEW RECORDS AND DISCUSSION OF PREDATORS OF THE PEAR PSYLLA, *PSYLLA PYRICOLA* FORSTER, IN BRITISH COLUMBIA[1]

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ABSTRACT

The following species are presented as new records of insect predators of the pear psylla, **Psylla pyricola** Förster, in British Columbia: **Anthocoris nemoralis** (F.) **Campylomma verbasci** (Meyer), **Deraeocoris brevis piceatus** Knight, **D. fasciolus** Knight, **Diaphnocoris provancheri** (Burque), **Adalia frigida** Schn., **Calvia duodecemmaculata** Gebl., **Coccinella transversoguttata** Fald., **Hippodamia quinquesignata** Kirby, **Platypalpus** sp. near **pluto** Mel., **Hemerobius pacificus** Banks. The biologies of some of the most common predators of the pear psylla are briefly discussed.

INTRODUCTION

The role of predaceous insects in the natural control of *Psylla pyricola* Förster has been documented and discussed by several workers. Until Madsen (1961) presented observations on predation of *P. pyricola* by *Anthocoris melanocerus* Reuter in British Columbia and speculated on its importance in the natural control of this species there were very few published records of predators of *P. pyricola* in North America. Previously, Slingerland (1896) observed predation by *Chrysopa oculata* Say and *Adalia bipunctata* (L.) in New York. More recently *Chrysopa carnea* Fitch, *C. ploribunda* Fitch, *Hemerobius angustus* (Banks), *Anthocoris antevolens* White and *Orius* sp. were recorded as predators in studies evaluating the natural control of *P. pyricola* in California by Madsen, Westigard and Sisson (1963) and Nickel, Shimizu and Wong (1965). In British Columbia, Wilde (1962) and Wilde and Watson (1963) reported the following species as predators of *P. pyricola; C. carnea, C. oculata, A. antevolens, A. melanocerus, Orius tristicolor* White, *Hippodamia convergens* Guerin-Meneville, *Magilla fuscilabris* Mulsant and the larva of a syrphid fly, *Sphaerophoria* sp.

Additional records of species predaceous on *P. pyricola* are presented below. The biologies of these and some of the previously known predators are discussed.

METHODS

Most of the records of predation were obtained from two pear orchards. One, located at the Research Station, Summerland, has a grass sod cover crop and has received all the standard horticultural practices except for the application of pesticides for the past 18 years. The other, located at Penticton, has a weedy cover crop and has been maintained as a commercial orchard. During the past three years portions of the orchard have been treated with various insecticides and parts left untreated for experiments on the integrated control of pests of pear.

The presence and relative abundance of active stages of predators in pear trees were determined by the limb-jarring method (Lord, 1949). The orchards were sampled in this manner at weekly or biweekly intervals from early March to mid-October. Observations on acts of predation were usually made first in the orchard, often with the aid of a hand lens, and then confirmed in the laboratory. Nymphs and adults of suspected predators were caged with various stages of *P. pyricola* and observed through a low-power microscope.

During the growing season the eggs of predators and preferred oviposition sites were identified by observing oviposition in the orchard.

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Also eggs suspected of being those of predators were reared in the laboratory to stages that permitted identification.

Information on overwintering habits were obtained by several methods. Corrugated cardboard bands were placed on trees in the early autumn to serve as artificial hibernation sites. These were examined during the winter. Cracks and crevices in the bark on tree trunks and limbs were also examined. During the winter, orchard trash, sod and top soil were processed through Berlese type funnels to aid in the assessment of preferred overwintering sites. For species that overwinter in the egg stage, branches and twigs containing suspected eggs of predaceous species were placed in water filled jars in a greenhouse during the late winter. The nymphs that hatched from the eggs were reared to an identifiable stage.

NEW RECORDS OF PREDATORS OF *PSYLLA PYRICOLA* FORSTER IN BRITISH COLUMBIA

The following species represent new predator records obtained during the course of this study:

Anthocoris nemoralis (F.) (Heteroptera:Anthocoridae)

Campylomma verbasci (Meyer) (Heteroptera:Miridae)

Deraeocoris brevis piceatus Knight (Heteroptera:Miridae)

Deraeocoris fasciolus Knight (Heteroptera:Miridae)

Diaphnocoris provancheri (Burque) (Heteroptera:Miridae)

Adalia frigida Schn. (Coleoptera: Coccinellidae)

Calvia duodecemmaculata Gebl. (Coleoptera:Coccinellidae)

Coccinella transversoguttata Fald. (Coleoptera:Coccinellidae)

Hippodamia quinquesignata Kirby (Coleoptera:Coccinellidae)

Platypalpus sp. near *pluto* Mel. (Diptera:Empidae)

Hemerobius pacificus Banks (Neuroptera:Hemerobiidae)

DISCUSSION

Chrysopidae. Very little information has been published on the biologies of *Chrysopa* spp. in British Columbia. Current investigations indicate that one or more species are important predators of *P. pyricola.* Adults of *C. carnea* and *C. oculata* are common in pear orchards. By direct observation in pear orchards and laboratory rearing, the larvae of both species are known to prey on eggs and nymphs of *P. pyricola.* However, information on the relative abundance of the two species on pear trees is lacking. In the light of a statement by Putman (1932) that *C. oculata* is restricted almost entirely to low vegetation in Ontario peach orchards, the value of this species in an arboreal habitat is questionable. In pear orchard cover crops, *Chrysopa* spp. larvae are abundant on weeds infested with aphids and other arthropods in cover crops. But again, the species concerned and their relative abundance are not known.

Chrysopa spp. larvae are present in pear orchards and prey on eggs and nymphs of *P. pyricola* from early May through October. They are most abundant in July and August. Additional records of prey species on pear trees include all stages of the European red mite, *Panonychus ulmi* (Koch), and the two-spotted spider mite, *Tetranychus telarius* (L.), larvae of the fruit-tree leaf roller *Archips argyrospilus* (Walker), the apple aphid *Aphis pomi* DeGeer and nymphs of unidentified leafhoppers (Cicadellidae).

Hemerobiidae. Of the brown lacewings, *Hemerobius pacificus* Banks is the only species that has been verified as preying on eggs and nymphs of *P. pyricola* in British Columbia, but other species may also be involved. In the pear orchards studied, brown lacewings were only about one-tenth as abundant as were green lacewings. In contrast, Nickel, Shimizu and Wong (1965) stated that *H. angustus* was more common than *C. carnea* in

pear orchards near San Jose, California.

Anthocoridae. The distribution, life histories and habits of several species of Anthocoridae in British Columbia, including *Anthocoris antevolens, A. melanocerus* and *Orius tristicolor* have been discussed by Anderson (1962a). *A. melanocerus* and *A. antevolens* are two of the most abundant predators of *P. pyricola* in unsprayed pear orchards. Both species overwinter as adults. Nymphs are frequently found in hibernation but they are killed by winter temperatures. In pear orchards, adults are most commonly found during the winter beneath bark scales and in cracks on the lower scaffold limbs and trunks of trees. Accumulations of dry orchard trash on the ground are also favored as overwintering sites. Adults of both species exhibit aggregational behavior during hibernation and both species occur in the same aggregations.

Dispersal from overwintering sites in early spring is gradual and usually begins when daily maximum temperatures exceed 50°F. After dispersal the adults search for sources of prey and then remain to feed and oviposit where food sources are adequate. In pear orchards, eggs laid by overwintered *P. pyricola* and overwintered eggs of *P. ulmi* appear to be the main prey and attraction.

The sex ratio, males to females, of both *A. antevolens* and *A. melanocerus* is approximately 1:10 in overwintered populations. The females are fertilized in the fall and additional mating in the spring is not required. The sex ratios of summer generations is approximately 1:1. Oviposition starts before pear buds are opened. At this time, eggs are inserted into bud scales. Later in the season, eggs are laid into any soft green tissue, most frequently in the lamina, veins and petioles of leaves. The eggs are inserted into the tissue, just beneath and parallel to the surface with only the operculum exposed.

Anderson (1962a) gave the time required to complete one generation under laboratory conditions for *A. antevolens* as five to six weeks and for *A. melanocerus* as four to five weeks. Field observations during 1965 and 1966 indicated that at Penticton and Summerland there were four generations per year of each species. Females maturing after the first week of September do not reproduce but enter a state of reproductive diapause in preparation for overwintering.

Anthocoris spp. must be considered as among the most important natural control agents of *P. pyricola*. They are abundant and their seasonal distribution is more closely synchronized with that of *P. pyricola* than other predators. They are the only abundant species which prey on *P. pyricola* in the latter half of March and the first half of April.

Other records of predation by *Anthocoris* spp. on pear trees include all stages of *P. ulmi* and *T. telarius*, eggs of the codling moth, *Carpocapsa pomonella* (L.), small larvae of *A. argyrospilus* (Walker) and nymphs of unidentified leafhoppers (Cicadellidae). Both species also feed on a variety of small arthropods and reproduce on weeds in pear orchard cover crops.

Anthocoris nemoralis is not a native of British Columbia but was introduced at Summerland from Europe as a predator of *P. pyricola* by the Canada Department of Agriculture in co-operation with the Commonwealth Institute of Biological Control. In June, 1963, 50 were released in an experimental pear orchard. By August, 1966, the species was very abundant at the release site and had dispersed to other orchards at least 1.5 miles distant.

Psyllids are preferred prey for *A. nemoralis* (Anderson, 1962b). In England there are only two generations per year. This species differs from most other *Anthocoris* spp. in that the sex ratio of males to females in the overwintering generation is ap-

proximately 1:1 (Anderson, 1962c). The biology of this species in its new environment has not yet been studied. Since *A. nemoralis* probably occupies a niche very similar to that of *A. melanocerus* and *A. antevolens,* observations on competition between these species will be of interest.

Orius tristicolor is a minor predator of *P. pyricola.* In pear orchards it is more abundant near the ground on cover crop plants than in the canopy of pear trees. Adults have been observed feeding on *P. pyricola* eggs and small nymphs. Nymphs of *O. tristicolor* are rare on pear foliage.

Miridae. The mullein plant bug, *Campylomma verbasci,* is an important predator of *P. pyricola* during the month of May. The species overwinters in the egg stage. The eggs are inserted into the bark of current season twig growth during the latter half of September to mid-October. The over wintered eggs hatch in early May just before pears bloom. There are three or possibly four generations per year. Most of the adults of the first generation leave pear orchards to reproduce on a variety of wild and cultivated herbaceous plant species. Some remain in pear orchards but the later generations are never so numerous as the first generation. In the fall, adults of the last generation return from herbaceous hosts to oviposit overwintering eggs on pear and apple trees.

C. verbasci plays an important role in the natural control of *P. pyricola* because it occurs in large numbers on pears when most other predaceous species are relatively scarce. Besides feeding on eggs and nymphs of *P. pyricola,* prey records for *C. verbasci* on pear include all stages of *P. ulmi* and *T. telarius.*

In addition to being predaceous *C. verbasci* is phytophagous. Reports of injury to apple are well authenticated (Ross and Caesar, 1920; Pickett, 1939 and Leonard, 1965). During the course of the present observations no adverse effects were noted on pear fruits, even when relatively large numbers (30-35 per cluster) of nymphs were present and feeding in clusters of immature fruit during May. *C. verbasci* is recorded as a vector of the fire blight organism, *Bacillus amylovorus* (Burr) Trev. by Stewart and Leonard (1915). This could negate its value as a predator.

As a predator of *P. pyricola, Deraeocoris brevis piceatus* ranks second in importance to *Anthocoris* spp. This species is most abundant during midsummer and early fall. It overwinters as an adult, most commonly in heavy dry trash in and around orchards and also in crevices in the bark of trees. The sex ratio of overwintered adults is approximately 1:1 and mating in the spring is required for the production of fertile eggs. Overwintered adults become active in early April when they seek out and feed on their prey. Oviposition habits are similar to those described for *Anthocoris* spp. The earliest hatched nymphs of the first generation appear during the first week of May. Oviposition by overwintered females is extended over a period of several weeks so that very young nymphs of the first generation are present when the earliest hatched individuals have completed development. There are at least four generations per year. Reproduction ceases in mid-September and all adults maturing after this time undergo a reproductive diapause. Feeding by adults continues until cold weather in October or November forces the adults into protective hibernation sites. Infrequently, nymphs have been observed in artificial hibernation sites but none have overwintered successfully.

Records of prey of *D. brevis piceatus* on pear include eggs and nymphs of *P. pyricola,* all stages of *P. ulmi* and *T. telarius,* small larvae of *A. argyrospilus,* eggs of *C. pomonella,* nymphs and adults of the apple grain aphid, *Rhopalosiphum fitchii* (Sanderson), and *A. pomi,* and nymphs of unidentified leafhoppers (Cicadellidae).

In pear orchards, eggs and nymphs of *P. pyricola* appear to be the chief prey of this species. In laboratory studies, eggs rather than nymphs of *P. pyricola* were preferred as prey.

In the laboratory as well as in orchards nymphs and adults were occasionally observed feeding on leaves and immature fruit. No apparent injury occurred. The significance of this partial phytophagous habit to the nutrition and development of this species, as well as the other species of Miridae discussed, has not been determined. A partial phytophagous habit may be of importance in sustaining populations of predaceous insects when arthropod prey are absent or at low densities (Collyer, 1953).

Deraeocoris fasciolus is a common predator of *P. pyricola* that is most abundant in mid-summer to early fall. Little is known about the biology of this species in British Columbia. It overwinters in the egg stage. The eggs are inserted deep into the bark of rough twigs and fruit spurs of pear trees. Newly hatched nymphs first appear about mid-May. There are two generations per year. Prey records include eggs and nymphs of *P. pyricola* and all stages of *P. ulmi*.

Diaphnocoris provancheri overwinters in the egg stage. There are two generations per year. The nymphs of the first generation first appear in pear orchards during the third week of May. The adults of the second generation mature and oviposit overwintering eggs in the bark of fruit spurs and one and two-year old twigs during the second and third weeks of September. Records of prey on pear includes eggs and nymphs of *P. pyricola* and all stages of *P. ulmi* and *T. telarius*. Both adults and nymphs are phytophagous as well as predaceous but plant feeding is restricted to foliage. No discernable injury to pear trees has been observed.

Coccinellidae. As individual species and as a group the Coccinellidae rank as minor predators of *P. pyricola*. At no time during this investigation have the numbers of Coccinellidae in predator samples exceeded one per cent of the total predaceous fauna.

Empidae. Adults of *Platypalpus* sp. near *pluto*, a dance fly, prey on adult *P. pyricola*. This species is frequently numerous in unsprayed pear orchards. The flies have been observed seizing adult *P. pyricola* resting on foliage and in flight. No attempt has been made to assess the importance of predation by this species toward natural control of *P. pyricola*. However, it is the only species that has been observed to prey consistently on the adult stage of *P. pyricola*. Clausen (1940) mentions that the larvae of Empidae are either predaceous or scavengers in moist soil or decaying wood habitats.

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CONE INSECTS OF GRAND FIR, *ABIES GRANDIS* (DOUGLAS) LINDLEY, IN BRITISH COLUMBIA

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ABSTRACT

Insects cause considerable seed loss in cones of grand fir, **Abies grandis** (Doug.) Lindl. on Vancouver Island. Three species of midge, a scale feeder, a gall former, and a seed-feeding midge; two species of seed chalcid, **Megastigmus pinus** Parf. and **M. rafni** Hoff.; and a cone maggot, **Earomyia abietum** McAlpine, were responsible for most of the damage. Coneworms were not important.

INTRODUCTION

Insects that destroy seed of grand fir, *Abies grandis* (Douglas) Lindley, have received little attention. Keen (1958) reported that insects, mainly chalcids and midges, destroyed 10 to 25% of the seed at Ashland, Oregon.

Information on insect species, and the type and extent of their damage was gathered on Vancouver Island in the summer of 1963. Cones collected weekly from 14 June to 19 August near Cowichan Bay contained midges, seed chalcids, cone maggots, and a few coneworms.

Grand fir flowers in spring and the cones mature by early September. Cones are erect, varying in length from 2.0 to 4.5 inches at maturity. In autumn they disintegrate.

LIFE HISTORY AND HABITS

Midges

Three species of midges, consistently present in cones, were distinguished by morphological characteristics and by their location in the cone (Fig. 1). Larvae of the scale midge feed on the inner surface of the cone scales, and have anal hooks which are absent in the cecidogenous midge and the seed midge. Morphological differences of the sternal spatulas of full-grown third instar larvae are compared in Fig. 2.

SCALE MIDGE. This is probably the insect which Keen (1958) refers to as the cone resin midge. The full-grown larva is orange and lives freely on the inner surface of the cone scale, often between the seed wing and scale, causing darkening of the scale at the feeding site. Larvae usually occur singly, but may be in clusters. Larvae are present throughout the summer; they averaged 28 per cone in eight cones dissected during June and July. In autumn the larvae drop to the ground to overwinter. The larvae do not affect the seeds directly so their damage is apparently light

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