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Densities of beneficial arthropods within pear and apple orchards affected by distance from adjacent native habitat and association of natural enemies with extra-orchard host plants

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Abstract

Beneficial arthropods were sampled using beat trays in 10 pear and 8 apple orchards in Washington and Oregon, USA. One border of each orchard was adjacent to non-agricultural land (extra-orchard habitat). Beneficial arthropods were also sampled on 45 species of plants in extra-orchard habitats adjacent to study orchards. Orchard samples were taken monthly at 2 or 3 distances (depending upon size of the orchard) from the edge adjacent to extra-orchard habitat. An overall mean of 33.8 beneficial arthropods was taken per 26-tray sample (43.8% spiders; 37.8% predaceous insects; and 18.5% parasitoids). In May, July, and August, densities of beneficial arthropods declined significantly as distance from extra-orchard habitat increased. The decline was most evident in spiders and parasitoids; no trend was noted for predaceous insects. Most of the decline occurred between 0–60 and 60–120 m into the orchard, with no significant decline between 60–120 and 120+ m. These results are consistent with the idea that some taxa of beneficial arthropods moved into orchards from extra-orchard habitat. The most common predaceous insects in orchards were Miridae (32.3% of beneficial insects), Coccinellidae (11.1%), Chrysopidae (6.9%), and Hemerobiidae (5.7%). Important parasitoids were *Trechnites insidiosus* (7.6% of beneficial insects) and *Pnigalio flavipes* (2.3%). The families Linyphiidae, Salticidae, Oxyopidae, Philodromidae, Theridiidae, and Clubionidae together comprised 87.3% of total spiders. Twenty-two taxa of spiders and 22 taxa of beneficial insects collected in orchards were also collected on plant species outside of the orchards. The predatory insects *Orius tristicolor*, *Deraeocoris brevis*, and *Nabis alternatus* and the spiders *Misumenops lepidus* and *Oxyopes scalaris* were collected on the largest number of extra-orchard plant species. Common parasitoids of orchard pests were never collected from extra-orchard host plants. Published by Elsevier Inc.

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1. Introduction

As pear and apple growers in the Pacific Northwestern region of the United States shift to more selective control technologies for major arthropod pests, there is often a noticeable increase in densities of natural enemies in the orchards (Epstein et al., 2000; Knight et al., 1997; Miliczky et al., 2000). In some instances, increased natural enemy density has been shown to result in higher levels of biological control (Knight et al., 1997). Unfortunately, response by natural enemies to lower insecticide use may be highly variable among orchards (Gut and Brunner, 1998), and this variability is poorly understood. Moreover, variability in response has led to reluctance by many growers to rely largely or exclusively on biological control as a means of controlling pests. Improved understanding of factors that affect orchard-to-orchard differences in densities of natural enemies would be useful.

One factor likely to affect densities of natural enemies in orchards is immigration. Among pear and apple

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growers in the northwestern United States a perception exists that the type of habitat adjacent to an orchard affects the level of biological control potentially realized in the orchard. That is, orchards adjacent to areas of non-agricultural land, specifically land of a relatively undisturbed character with a high proportion of native plant species, may experience higher levels of biological control than orchards surrounded by other orchards, other cropland, or land otherwise highly disturbed. This type of land is referred to here as extra-orchard habitat and in this study included areas of sagebrush steppe, riparian tracts along watercourses, and woodland habitat. The presumption is that extra-orchard habitat acts as a source of natural enemies that may move into the orchard, as suggested elsewhere for certain predatory bugs that often occur in pear orchards in the Pacific Northwest (Horton and Lewis, 2000). The idea that extra-orchard habitats, or comparable habitats adjacent to other crops, act as sources of natural enemies for agricultural systems has been expressed or tested directly for a number of crop ecosystems (Duelli et al., 1990; Ekbom et al., 2000; Sotherton, 1985; Thomas et al., 1992). It is assumed that some natural enemies rely on extra-crop habitats for resources not provided within the crop such as alternative prey or hosts, sites for mating, and refugia for molting and overwintering (Letourneau, 1998).

If natural enemies are indeed dispersing into orchards from extra-orchard habitats, we might expect densities of these arthropods to be highest in the section of the orchard adjacent to extra-orchard habitat, and that densities would decline as distance from the habitat increased. We tested this hypothesis in 18 reduced-pesticide pear and apple orchards located in central Washington and north-central Oregon by sampling trees along transects from the orchard perimeters into the orchard interiors. We looked for seasonal trends in densities of natural enemies along these transects that might lead to a better understanding of the phenology and extent of dispersal for key predator species. Concurrently, we sampled plant species in the extra-orchard habitats to determine if natural enemies of orchard pests also occurred on plants outside of the orchards.

2. Materials and methods

2.1. Description of the study sites

Eighteen orchards in Washington and northern Oregon were chosen for study: 10 pear and 8 apple. All were under reduced insecticide management programs and relied on mating disruption, rather than application of broad-spectrum insecticides, as the primary means of controlling codling moth, *Cydia pomonella* L. Three apple and three pear orchards were state-certified organic. One edge of each orchard was adjacent to a tract of extra-orchard habitat whose principal vegetation consisted of native plant species. The other three sides abutted other orchard habitat, other crops (grapes, for example), or disturbed land with few or no native plant species (weedy, non-producing agricultural land, for example). In no case was a second side of an orchard also adjacent to extra-orchard habitat as defined in the introduction. Ten orchards were located in Yakima County, Washington; three were in Chelan County, Washington; one was in each of Walla Walla, Grant, and Kittitas Counties, Washington; and two were in Hood River County, Oregon. Cardinal direction of the extra-orchard habitat relative to the orchard, varied from orchard to orchard.

Extra-orchard habitats adjacent to study orchards could be broadly categorized into 1 of 3 types. Two pear orchards were adjacent to riparian habitat along rivers where the vegetation included trees and shrubs such as *Populus trichocarpa* T. & G., *Salix* spp., *Symphoricarpos albus* (L.) Blake, *Prunus virginiana* L., and *Rosa woodsii* Lindl. Four pear blocks bordered mixed hardwood/coniferous woodland where trees included *Pinus ponderosa* Dougl., *Pseudotsuga menziesii* (Mirbel) Franco, *Acer macrophyllum* Pursh, and *Quercus garryana* Dougl. Understory shrubs and herbs at the wooded sites were quite diverse and all four had been logged to varying degrees. Sagebrush steppe was the habitat most frequently found adjacent to our study orchards (four pear, eight apple). Shrubs such as *Artemisia tridentata* Nutt., *Purshia tridentata* (Pursh), and *Chrysothamnus* spp. occurred at most sites but the number of associated species varied widely. During peak flowering, late April to late May, the number of species in flower varied from fewer than 15 to as many as 30.

2.2. Sampling

To determine how distance from extra-orchard habitat affected densities of natural enemies within the orchard, we divided each orchard into two (five small orchards) or three (13 large orchards) sections, with each section occurring at a successively greater distance from the extra-orchard habitat. The section of the orchard nearest the extra-orchard habitat extended 60 m from the orchard/extra-orchard habitat margin into the interior of the orchard along a line perpendicular to the orchard/extra-orchard habitat margin. The second section extended from 60 to 120 m into the orchard along the same line. In the 13 large orchards a third area was defined that included the section of the orchard more than 120 m from the extra-orchard habitat.

Orchards were sampled monthly from May to October by taking 26 beat trays (one tray per tree) in each section of an orchard. Two people (each sampling 13 trees per section) did all within orchard sampling. Beat tray samples were also collected from plants in the