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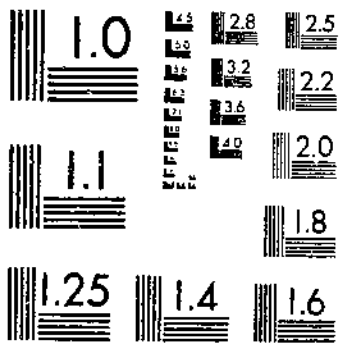
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EXPLOITING THE ECOLOGICAL INTERACTION OF THE GREEN PEACH APHID ON PEACH TREES

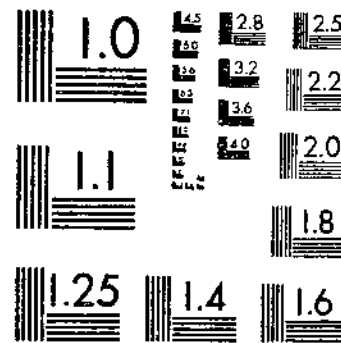
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Exploiting the Ecological Interaction of the Green Peach Aphid on Peach Trees

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Abstract

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An alternative or noninsecticide control program was developed, which resulted from an intense ecological and biological investigation of the green peach aphid (GPA), *Myzus persicae* (Sulzer), in peach orchards. The GPA displayed a complex life cycle with many tenuous ecological interactions, which were broken or disrupted with the most suitable technological tools available.

Keywords: Green peach aphid, *Myzus persicae*, peach trees, integrated pest management, biological control, cultural control, weed control.

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Exploiting the Ecological Interaction of the Green Peach Aphid on Peach Trees

By George Tamaki¹

Introduction

The green peach aphid (GPA), *Myzus persicae* (Sulzer), is a major agricultural pest; therefore, considerable insecticide pressures have been applied on the population, and reports of insecticide resistance are common (1, 2, 3, 5).² The need for the development of alternative methods of GPA control is very apparent, but it is not a simple matter of plugging new technological advances in insect control, such as insect pheromones, insect growth regulators, or other new third generation insecticides or techniques, into the system.

One approach to insect control is to search for the weakness or the fragility of bonds in any of the ecological interactions in the insect life cycle, then exploit or attempt to break the weak link in the ecological interaction with the most suitable technological tools. As past failures in insect control verify, killing techniques utilized without knowledge of the biological and ecological interactions of the pest rarely succeed. The major reason for such failure is the resilience of insect populations to adapt to our ingenuity to kill them. Populations of insects such as the GPA have continually bounced back after being decimated by insecticides because of their high reproductive potential, short developmental period, physiological resistance mechanisms, and the suppression of their natural enemies; however, emphasis is given at times to integration of available pest-control techniques or agents as the ideal approach before enough ecological and biological information are available. Therefore, we often match our strongest tools against the insects' ability to survive and reproduce. In the long term, we will achieve more success by exploiting insect weaknesses with strategy than by attacking them head on.

In this article, control of the GPA will be restricted to the peach orchards, which contain the primary host and overwintering source of the GPA. The status of the GPA as a pest and its generalized life cycle in the Yakima Valley will be reviewed for a more meaningful discussion of the ecological interactions of the GPA in the peach orchards.

Distribution and Damage

The GPA ranks as one of the most important agricultural insect pests in the world because of its worldwide distribution and the type of damage inflicted on so many crops. The GPA is found in almost every country in the world, from tropical to temperate zones, including Alaska. The host range of the GPA includes over 875 plant species; many of the vegetable, ornamentals, and field crops grown throughout the world are included on this list (4, 8).

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²Italic numbers in parentheses refer to Literature Cited, p. 6.

In addition to its wide host-plant range and worldwide distribution, the GPA is an important pest because it can injure cultivated plants in a variety of ways. It is capable of causing direct injury by extracting sap from the plant. With its high reproductive rate and rapid development, it is not unusual to find hundreds or thousands of aphids per plant. With these high numbers, plants may soon be extensively injured or even killed. A few individuals feeding on leaf and flower buds or young fruit (22) can also deform ornamentals and fruits.

Only one viruliferous GPA is needed to transmit virus diseases to plants. The GPA is known as the most important insect vector of plant diseases (9) because it transmits over 100 different plant virus diseases (23). In the Western States, two of the more important diseases transmitted by the GPA are potato leafroll virus and the yellows virus diseases on sugarbeets.

General Life Cycle

Another interesting aspect of the GPA is its complex life cycle with five distinct morphological forms (ovipara, male, fundatrix, aptera virginopara, and alate virginopara) and two different behavioral forms (gynopara and hiemalis) (fig. 1).

The different morphological forms can be divided into sexual and asexual groups. The sexual forms are present in the autumn. The oviparae (female) are wingless and develop on peach leaves, where they reach adulthood. They mate with winged males that arrive from the summer host plants. The oviparae then lay overwintering eggs behind the peach buds.

In spring, when the eggs hatch, a third distinct form develops, which is called the fundatrix (stem mother). The fundatrices are asexual and wingless. The progenies of the fundatrices are wingless and asexual (aptera virginopara), but their fragile, soft appearance makes them morphologically distinct from the sturdy-bodied stem mother. Later, winged asexuals (alate virginopara) are produced, which represent the fifth distinct form.

In autumn, with shorter photoperiods and cooler temperatures, the gynoparae (winged asexual aphids), physiologically different from the summer winged forms, emigrate to peach trees. These winged gynoparae give birth to the oviparae on peach leaves. The other physiological form is the hiemalis (specialized aptera viviparae), which overwinters on secondary host plant (6). In Yakima Valley, these hiemalis overwinter in protective microhabitat sites in deep drainage ditches fed by warm underground springs (24).

Ecological Life Cycle Interactions

A generalized life cycle can be used to describe the seasonal activity of the different life stages and morphological forms of the GPA (fig. 1); however, such an illustration is limited because

it does not present any of the ecological interactions of the GPA. The ensuing discussion will concern the ecological life cycle interactions of the GPA on their primary host, peaches, and subsequent development of an integrated pest management (IPM) program.

Autumn

In mid-September in Yakima, the winged gynoparae of the GPA begin to settle on the peach leaves, where they feed and give birth to wingless sexual oviparae (fig.2).

Not until about the first part of October do the aphids begin to build up noticeably, but the population quickly peaks about mid-October, with as many as 80 winged aphids and 600 sexual females on a single leaf (13). The extremely rapid buildup of the GPA in a very short period is attributed to the continuous arrival of the winged asexuals and their high reproductive rate. In most instances, large populations of aphids attract many natural enemies; however, in the fall, instead of a multitude of different predator species attacking the GPA, the predaceous syrphid larva are predominant. Most other predator species, such as coccinellid beetles, are either

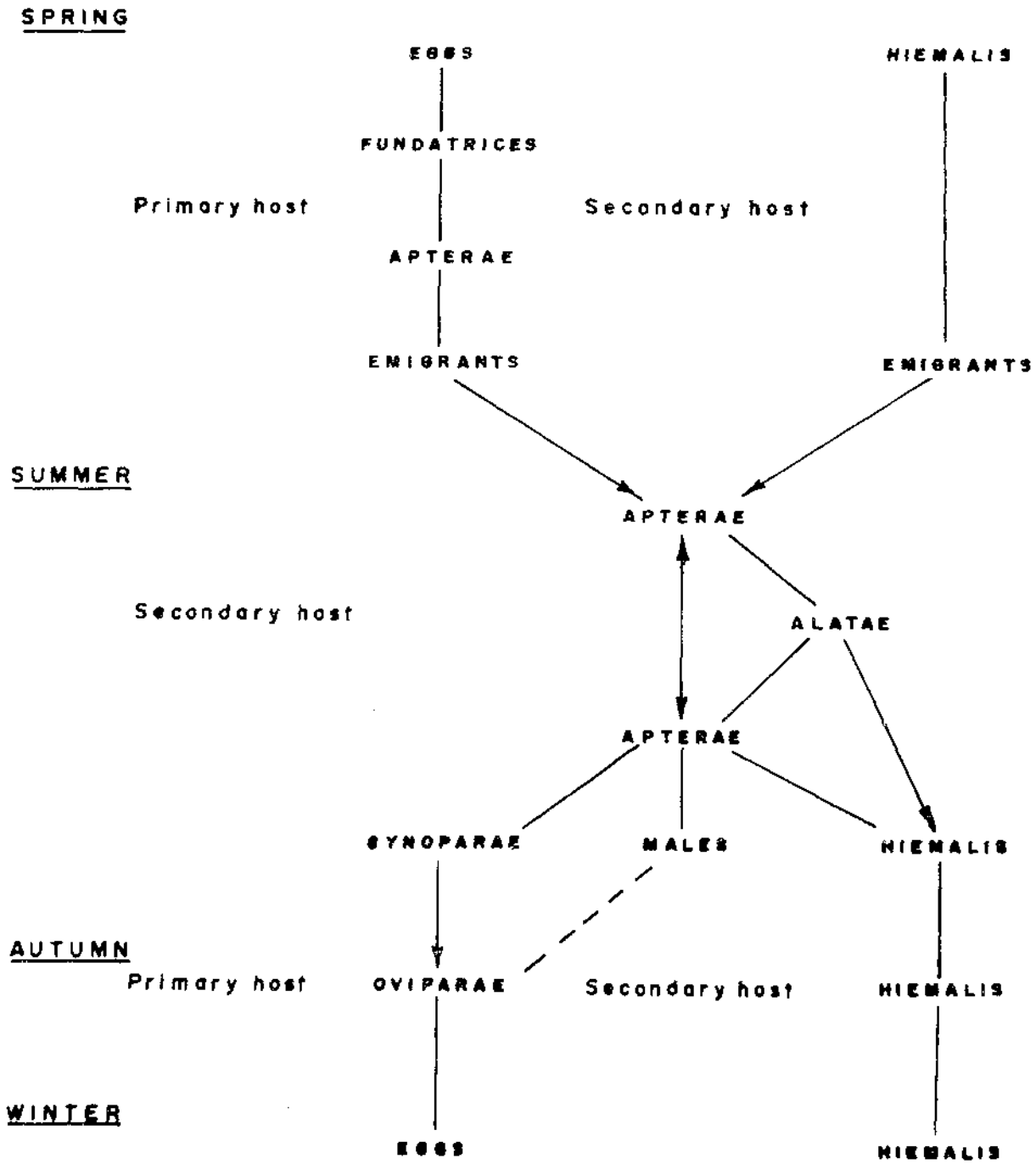


Figure 1.—Life cycle of the green peach aphid.

AUTUMN

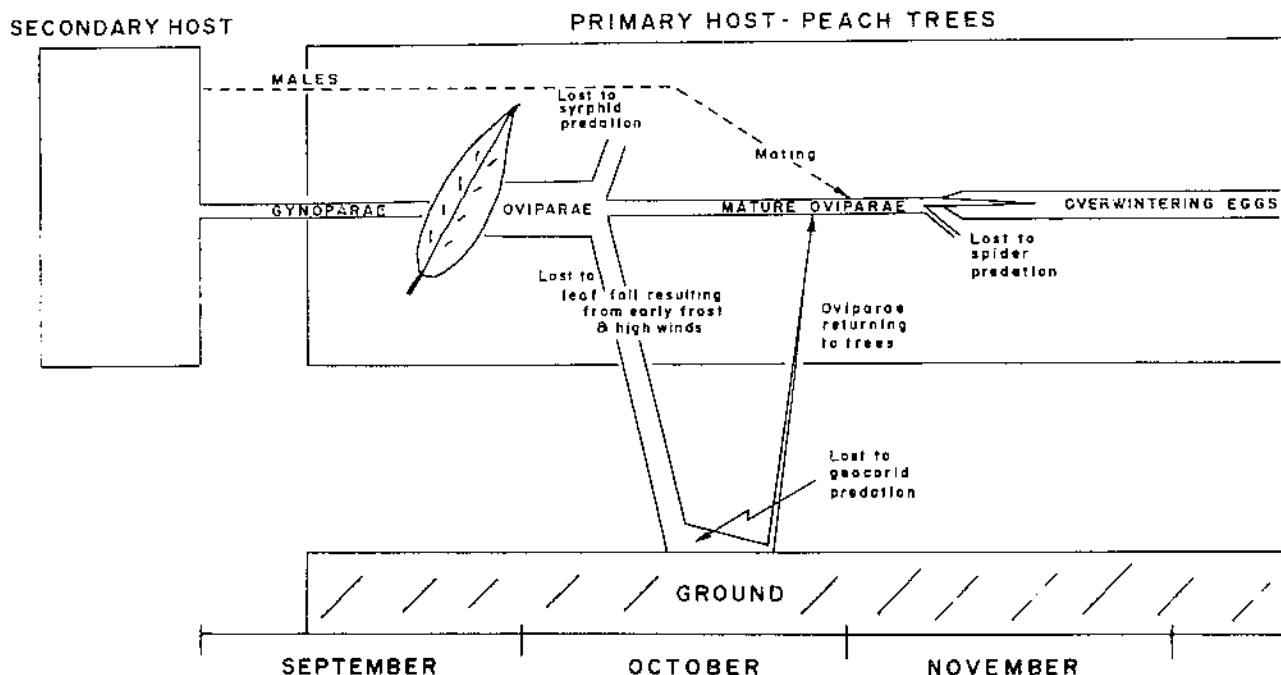


Figure 2.—Ecological interaction of the life cycle of the green peach aphid in autumn.

inactive or in diapause because of the cool temperatures in late September and October. Apparently, these cool fall temperatures do not affect the syrphids because the adult flies continue to lay eggs in aphid colonies on peach leaves, and the emerging larvae feed on the aphids. In field samples, the syrphid flies laid more eggs as the aphid densities increased to 30 to 40 aphids per leaf (21). The estimated rate of consumption of small to large syrphid larvae was 5 to 80 aphids per day.

Another important mortality factor is weather. Frost and heavy winds cause considerable premature leaf fall, and the falling leaves take GPA with them. For instance, in 1970, bad weather and subsequent leaf fall accounted for a 95-percent reduction of the GPA population in early autumn (13). In 1971, weather conditions were not conducive to early leaf fall, the population of aphids continued to increase, and syrphid predation accounted for a 42-percent reduction of the aphid populations.

Here we recognized the *first potential weak link* in the life cycle of the GPA: the requirement of the wingless females to complete their development on the peach leaves before natural leaf fall. We decided to hasten leaf fall by 1 to 2 weeks with a chemical defoliant and thereby interrupt GPA development. By the end of September, leaf fall on sprayed trees was 94 percent, whereas leaf fall on the unsprayed trees was only 19 percent. Oviposition was reduced by as much as 96 percent on treated trees compared with that on untreated trees (18).

Another ecological interaction occurred when the aphids fell to the ground at leaf fall. Although wingless, they could climb back up the tree trunks and feed on the few remaining leaves.

Masking tape was placed around the trunks of the trees, and a double ring of sticky material was placed on the tape to enable us to distinguish the direction of the aphids' movement. Many aphids were caught returning to the trees. A more interesting phenomenon, however, was the activity taking place on the floor of the orchard; the large bigeyed bug, *Geocoris bullatus*, a ground predator, was feeding on the normally arboreal aphid. Large bigeyed bugs were observed in extremely high numbers (up to 25 per 0.3 m²) on the floor of the peach orchards in the fall, whereas their numbers were much lower in the adjacent pear, apricot, and apple orchards. This predator species is not known to be an arboreal predator but is occasionally observed on the lower main trunks. Only at the time of leaf fall do bigeyed bugs and the GPA become spatially and temporally synchronized (10). We repeatedly observed the bigeyed bugs searching the fallen peach leaves and spearing the GPA with the tip of their styletlike mouth parts.

To quantitatively evaluate the role of these ground predators, we constructed a 6.1- by 6.1-m cheesecloth fence around each tree. In half of these trees, the floors within the barriers were sprayed before leaf fall with a nonpersistent insecticide, naled,³ to kill *Geocoris*. The rest of the trees with barriers were left unsprayed to determine the impact of ground predators on the number of GPA returning to the peach trees. In the treatment left unsprayed, 58 percent or 10,574 fewer aphids returned to each tree, an indication that the bigeyed bug plays a major role in reducing the number of aphids returning to peach trees.

³ 1,2-dibromo-2, 2-dichloroethyl dimethyl phosphate.

Winter

In the orchard, the GPA overwinters in the egg stage underneath peach buds. Since peach twigs are severely thinned and most of the remaining twigs are cut back (by orchard owners), the distribution of the eggs from the tip of the twig is important. In three winter seasons, and after inspection of over 5,000 buds from different areas, we determined that 60 percent of the single buds (generally leaf buds) are found on the first 25 cm of the current year's wood, whereas only 20 percent of the multiple buds (usually consisting of two blossom buds separated by a leaf bud) are found within the same area (17). The distribution of these single and multiple buds influences the distribution of GPA eggs. For instance, in years of low egg deposition, most eggs were laid on the single bud towards the tip of the twig; whereas, in years of heavy egg deposition, most eggs were laid on the multiple buds, further from the tip. Egg deposition along the twig was determined by the availability of oviposition sites.

The cultural practice of pruning 65 to 85 percent of the current wood twigs each year serves as a cultural control for the eggs of the GPA. The percentage of eggs pruned out is inversely dependent on egg density, which means that a higher percentage of eggs are pruned off in years of light oviposition compared with that in years of heavy oviposition. Thus, the *second potential weak link* is that suppression of autumn populations of GPA encourages greater oviposition near twig tips with concomitant increases in the chances of the eggs being pruned off.

To study the overwintering of many pest species and their natural enemies, we used burlap bands covered with aluminum, which we stapled around large scaffold branches of peach trees as artificial overwintering sites for beneficial arthropods. By the end of winter, over 90 percent of the arthropods using these bands were beneficial species; the phytophagous species overwintering in the bands were consumed by predators by the next spring (15). Although the bands were originally intended to harbor natural enemies of the GPA, they appear more useful in housing large populations of natural enemies of phytophagous mites. Additionally, the bands could be used to transfer predatory mites to trees or orchards with large overwintering populations of phytophagous mites but few predators.

Spring

The rate of survival of the overwintering eggs depends mostly on the severity of the winter, since egg predation during the cold months is minimal. Over several years, the percentage of viable eggs at the end of February ranged from 50 to 85 percent (11).

Eggs of GPA hatch from February to April (fig.3).

The early emerging nymphs are exposed to harsh weather and limited protective sites since the buds are still dormant. The nymphs from the eggs are referred to as stem mothers (fundatrices), and in contrast to the usual fragile apterae, have a sturdy appearance with heavy mouth parts that allow them to feed through the closed buds.

SPRING

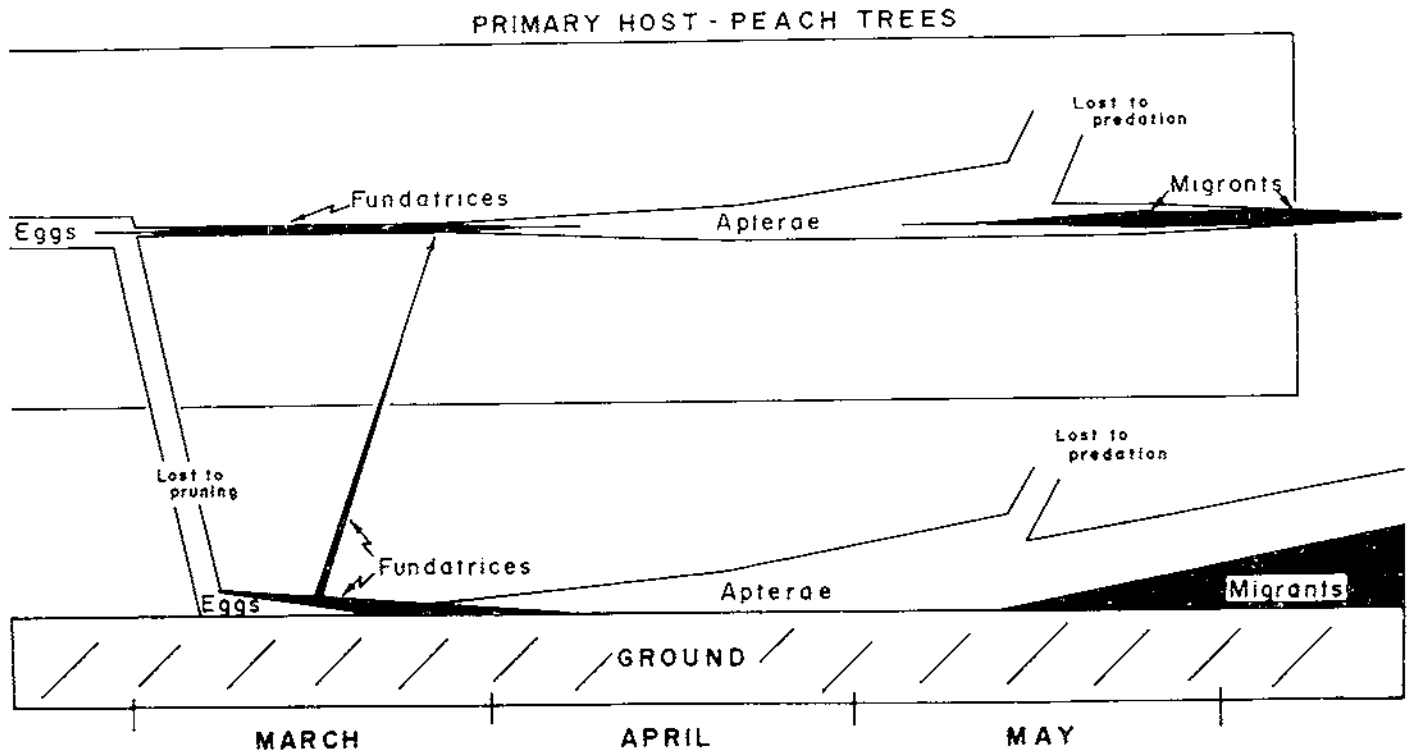


Figure 3.—Ecological interaction of the life cycle of the green peach aphid in spring.

Although these nymphs are hardy, only a few reach adulthood. For instance, in 1970, from 444 overwintering eggs on 51 twigs, only 9 nymphs reached reproductive maturity. Likewise, in 1971, none of the 236 eggs observed reached adulthood.

The high reproductive potential is evident, however, when mature stem mothers are caged on twigs and protected from natural enemies and heavy winds. For example, sleeve cages on twigs that averaged one stem mother and 12 progeny in late April average 3,217 aphids in mid-June. During the peak abundance in late May, 676 winged aphids were removed, and the population declined rapidly because nearly 100 percent of the progeny were winged. At the time of peak abundance, uncaged colonies of GPA on twigs averaged 68 aphids per twig.

Uncaged twigs had fewer aphids than caged twigs mainly because of natural enemy activity. In the spring, lady beetles (Coccinellidae) were active as well as syrphid flies. The lady beetles probably had a greater impact on the aphid population in the spring than syrphids because of their more voracious feeding habits, powers of dispersal, and the fact that both larvae and adults feed on aphids. Unlike summer months, when lady beetles encounter high populations of GPA, the predators in spring are frequently able to suppress populations on peach trees before the accelerated growth phase of the pest population. For example, the predators caused 98 percent reduction in the populations of uncaged aphids relative to that of the caged aphids (11).

Alate Viviparae and Disruption of Emigration

After several generations of wingless aphids, the first winged aphids appear in early May, with peak wing production at the end of May. By mid-June, all GPA have left the peach trees. These winged aphids are of great concern because they infest vegetable, field, and ornamental crops. The phenomenon of total wing production by the GPA during a short time was recognized as the *third potential weak link* or a crucial point in its life cycle.

In 1961, Lees (7) reported that juvenile hormone extracts (hormones that prevent the development of adult characters) applied to immature aphids reduced many adult characters and produced such effects as small and crumpled wings. On May 9, 1972, synthetic juvenile hormones were applied to GPA on peach trees when the first winged GPA appeared (12). Maturation of winged migrants was reduced by as much as 75 percent, and migration was delayed for as long as 15 days. We established that the earlier the plants become infected with virus diseases, the greater will be the loss in yield or severity of damage (19). Thus, any delay in GPA spread from the peach tree will delay aphid buildup on secondary hosts and delay the spread of the viruses.

Explosive GPA Population on Cover Vegetation of the Orchard

In late June 1973, after the GPA had left the peach trees, we found large numbers of GPA on the cover vegetation of the peach orchard (14). In the Yakima Valley, the floors of peach orchards are frequently cultivated or planted to orchard grass.

Such well-maintained permanent grass covers eliminate weed host of the GPA; however, in orchards where grass covers are not used, weeds grow profusely between cultivations. Suitable host plants that occur early in the season include lambsquarters, *Chenopodium album* L., redroot pigweed, *Amaranthus retroflexus* L., and field bindweed, *Convolvulus arvensis* L. Populations of GPA on these weeds were studied because these aphids are a potential vector of virus diseases of many cultivated plants (20).

Population estimates of GPA numbers were obtained by determination of the number of weed species per acre and the average number of aphids per weed species. During peak abundance, on June 2, weeds on the floor of the orchard were estimated to be infested with 217 million GPA per acre with 28 million winged or immature winged aphids (16). The production of aphids on the floor of the orchard is considerably greater than that produced on the peach trees.

Our next investigation was to determine how and when the GPA becomes established on weeds. In the past, it had been accepted that the stem mother hatching from the overwintering egg is capable of developing and surviving only on *Prunus* spp., and the establishment of the stem mothers on broadleaf weeds had not been reported. When growers prune 65 to 85 percent of the twigs, approximately the same percentage of overwintering eggs are also pruned off. These branches are shredded and left in the orchard. Through a series of field cage experiments at the time of pruning and egg hatch, we found that the stem mothers develop and reproduce on broadleaf weeds in the orchard (20). Therefore, the pruned twigs must be removed and destroyed before egg hatch. Also, many of these perennial or winter annual broadleaf weeds are known to serve as hosts of many virus diseases of plants, but there is no evidence that peach trees serve as a virus reservoir for beet yellows diseases.

Thus, we found that the *fourth potential weak link*, and most easily exploitable weak link of all the ecological interactions, was the replacement of broadleaf weeds on the floor of the orchard with permanent grass.

Presently, an IPM pilot study is being conducted to suppress—without the use of insecticides—the GPA in its spring habitats where large populations of viruliferous aphids are generated on weed hosts. These weed hosts also serve as a reservoir for many virus diseases of vegetable, ornamental, and sugarbeet crops. The two loci of GPA population increase are weeds found on the floor of cultivated orchards and weeds found on the banks of drainage ditches. The aphids then move into the field crops early in the growing season. The major control effort is based upon the permanent replacement of weed hosts of GPA with grass cover.

Conclusion

IPM projects are being initiated for many pests and crops. IPM is a sound concept, but it is difficult to develop a practical IPM program. One key to a successful program will be the ecologically oriented field researchers who study the ecological interactions of plant and pest development in search of exploiting their weak links with the most suitable technological tools available.

Literature Cited

- (1) Attia, F. E., and J. T. Hamilton. 1978. Insecticide resistance in *Myzus persicae* in Australia. *Journal of Economic Entomology* 71:851-853.
- (2) Beranek, A. P. 1974. Stable and non-stable resistance to dimethoate in the peach-potato aphid (*Myzus persicae*). *Entomologia Experimentalis et Applicata* 17:381-390.
- (3) Bonnemaïson, L. 1972. Observations sur la résistance de *Myzus persicae* Sulz. au Parathion Méthyle. *Phytiatrie Phytopharmacie* 21:71-94.
- (4) Essig, E. O. 1948. The most important species of aphids attacking cruciferous crops in California. *Hilgardia* 18(11):407-422.
- (5) Georghiou, G. P. 1963. Comparative susceptibility to insecticides of two green peach aphid populations, collected 16 years apart. *Journal of Economic Entomology* 56:655-657.
- (6) Hille Ris Lambers, D. 1966. Polymorphism in Aphididae. *Annual Review of Entomology* 11:47-78.
- (7) Lees, A.D. 1961. Clonal polymorphism in aphids. *Symposia of the Royal Entomological Society of London* 1:68-79.
- (8) Leonard, M. D., H. G. Walker, and L. Enari. 1970. Host plants of *Myzus persicae* at the Los Angeles County and State arboretum, Arcadia, California. *Proceedings of the Entomological Society of Washington* 72:294-312.
- (9) Ossiannilsson, F. 1966. Insects in the epidemiology of plant viruses. *Annual Review of Entomology* 11:213-232.
- (10) Tamaki, G. 1972. The biology of *Gecoris bullatus* inhabiting orchard floors and its impact on *Myzus persicae* on peaches. *Environmental Entomology* 1:559-565.
- (11) ———. 1973a. Spring populations of the green peach aphid on peach trees and the role of natural enemies in their control. *Environmental Entomology* 2:186-191.
- (12) ———. 1973b. Insect developmental inhibitors: effect of reduction and delay caused by juvenile hormone mimic on the production of winged migrants of *Myzus persicae* (Hemiptera:Aphididae) on peach trees. *Canadian Entomologist* 105:761-765.
- (13) ———. 1974. Life system analysis of the autumn population of *Myzus persicae* on peach trees. *Environmental Entomology* 3:221-226.
- (14) ———. 1975. Weeds in orchards as important alternate sources of green peach aphids in late spring. *Environmental Entomology* 4:958-960.
- (15) ——— and J.E. Halfhill. 1968. Bands on peach trees as shelters for predators of the green peach aphid. *Journal of Economic Entomology* 61:707-711.
- (16) ——— and D. Olsen. 1979. Evaluation of orchard weed hosts of green peach aphid and the production of winged migrants. *Environmental Entomology* 8:314-317.
- (17) ——— and D. M. Powell. 1968. Egg distribution as a factor in suppressing the green peach aphid by pruning. *Journal of Economic Entomology* 61:1437-1439.
- (18) ——— and R. E. Weeks. 1968. Use of chemical defoliant on peach trees in integrated program to suppress populations of green peach aphids. *Journal of Economic Entomology* 61:431-435.
- (19) ——— L. Fox, B. A. Butt, and A. W. Richards. 1978. Relationships among aphids, virus yellows and sugarbeet fields in the Pacific Northwest. *Journal of Economic Entomology* 71:654-656.
- (20) ——— L. Fox, and R. L. Chauvin. 1980. Green peach aphid: orchard weeds are host to fundatrix. *Environmental Entomology* 9:62-66.
- (21) ——— B. J. Landis, and R. E. Weeks. 1967. Autumn populations green peach aphid on peach trees and the role of syrphid flies in their control. *Journal of Economic Entomology* 60:433-436.
- (22) ——— D. M. Powell, and G. S. Long. 1979. Green peach aphid really isn't. *Western Fruit Grower* 99(1):W-28, W-30.
- (23) Van Emden, H. R., V. F. Eastop, R. O. Hughes, and M. J. Way. 1969. The ecology of *Myzus persicae*. *Annual Review of Entomology* 14:197-270.
- (24) Wallis, R. L. and J. E. Turner. 1969. Burning weeds in drainage ditches to suppress populations of green peach aphids and the incidence of beet western yellows disease in sugarbeets. *Journal of Economic Entomology* 62(2):307-310.

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