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The Role of Exotic Natural Enemies in the Biological Control of Insect and Mite Pests of Avocado in California

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Abstract. **Successful establishment of exotic natural enemies against avocado pests in California has occurred in two of the three programs attempted. Essentially complete control of longtailed mealybug *Pseudococcus longispinus* (Targioni Tozzetti) was achieved by the establishment of two parasites. Control of greenhouse thrips *Heliothrips haemorrhoidalis* (Bouche) by an introduced parasite can be considered partially successful, although insufficient time has elapsed for a critical evaluation. None of the predaceous mites (Phytoseiidae) introduced against avocado brown mite *Oligonychus punicae* (Hirst) have become established. Indigenous natural enemies are considered extremely important in the control of avocado pests in California.**

Avocado orchards in California usually are not sprayed with pesticides and, therefore, the environment is favorable for biological control of most arthropod pests. Damaging infestations of a particular pest usually are not area-wide or even orchard-wide, and, with the recent exception of greenhouse thrips, such infestations rarely occur in a given orchard two or more consecutive years. I believe that the generally low populations of pest arthropods on California avocado largely can be attributed to regulation by their natural enemies. In some cases, this is a result of natural biological control by native natural enemies, while in other instances; the degree of biological control has improved following the introduction and establishment of exotic natural enemies. Introduction programs have been conducted against imported pests, and searches usually are made in what is thought to be the native home of the pest.

The objectives of this paper are to: (1) review the programs involving importations of natural enemies for biological control of avocado pests in California; (2) discuss the apparent impact of introduced natural enemies in biological control of avocado pests, in relation to biological control by indigenous enemies; and (3) propose some conclusions and prospects.

Major Pest Species and Biological Control Status

Table 1 shows the most common arthropod pest species on avocados in California. Four of the 7 species listed have not had specific natural enemy introduction (classical biological control) programs directed against them.

The two Lepidoptera, *Sabulodes aegrotata* (Guenée) and *Amorbia cuneana* Walsingham, presumably are native North American species, and no natural enemy exploration and introduction programs have been directed against them. Both species have guilds of natural enemies, mostly in the parasitic Hymenoptera, which usually seem to be effective in maintaining them below damaging levels (Fleschner *et al.,* 1957; Oatman *et a/.,* 1983). However, augmentative releases of *Trichogramma platneri* Nagarkatti have been shown to be effective in suppressing populations of these pests (Oatman and Platner, 1985) and they are used by some growers for supplemental control.

Latania scale, *Hemiberlesia lataniae* (Signoret) has been recorded as a pest of avocado since 1928. It occurs mainly on twigs and branches but occasionally on the fruit and causes downgrading of fruit (Ebeling, 1959). However, noticeable infestations are unusual, and generally they can be attributed to upset situations in which natural enemies are eliminated by pesticides. Several groups of natural enemies apparently are important in the regulation of this scale insect, including the twice-stabbed lady beetle *Chilocorus stigma* Say, the wasp *Aphytis proclia* (Walker), and the mite *Hemiscarcoptes cooremani* Thomas (Fleschner, 1954; Ebeling, 1959). Thus, latania scale is rarely considered a problem.

Although the six-spotted spider mite *Eotetranychus sexmaculatus* (Riley) can be damaging at relatively low population densities (Fleschner *et al.,* 1955; Ebeling, 1959), it is seldom noticed because populations rarely exceed an average of 2 to 3 mites/leaf. Maintenance of these low levels is attributed to the phytoseiid mites *Euseius hibisci* (Chant) and *Amblyseius (Typhlodromalus) limonicus* Carman and McGregor (Fleschner *et al.,* 1955; McMurtry, 1985). Ironically, *Typhlodromus rickeri* Chant, a species introduced from citrus in India in 1961 for biological control of citrus mites, became established on avocado and is associated mainly with six-spotted mite in Santa Barbara County. It has been collected in orchards several km distant from any release sites (McMurtry, 1989).

Of the three pests for which natural enemies have been introduced into California, one has been reduced to unimportant pest status. Long-tailed mealybug *Pseudococcus longispinus* (Targioni Tozzetti) was once considered a serious pest of avocados in San Diego County. In 1941, two parasitic wasps in the family Encyrtidae, *Anarhopus sydneyensis* Timberlake from Australia and *Hungariella peregrina* Compere from Brazil and Argentina, previously established on mealybug infestations on ornamentals and citrus in southern California, were released in San Diego County on avocado. Both species became established and they affected biological control of long-tailed mealybug on avocado within 2 years. This was considered a complete success on avocado (Flanders, 1944). Presently, this mealybug occurs throughout the avocado growing areas of California, but only in low numbers (personal observation). Occasionally, high numbers can be found under paper bands on grafted limbs or between leaves webbed together by *Amorbia cuneana,* where the insects are protected from their natural enemies.

Avocado Brown Mite *Oligonychus punicae* (Hirst) occasionally builds up to numbers over 200/leaf, causing bronzing of leaves and partial defoliation of some trees. Native phytoseiid mites, effective against six-spotted mite, do not keep it in check. More important is the small coccinellid beetle *Stethorus picipes* Casey, which is effective in controlling moderate to high mite populations (McMurtry and Johnson, 1966; McMurtry, 1985). We speculated that a phytoseiid mite species that was a more specific predator of *Oligonychus* species might suppress avocado brown mite populations sooner than the larger *Stethorus,* which requires a higher density of mites in order to reproduce. I have explored areas where avocado and presumably the mite as well are native. The regions searched included Mexico, Guatemala and Costa Rica. None of 6 species (Table 2) of Phytoseiidae introduced from those regions became established, including 3 relatively specialized predators in the *Gatendromus occidentalis* species group.

Competition from the native *Euseius hibisci* (Chant) could be the reason for failure of any of the exotic species to become established. Avocado brown mite is present in detectable levels in California avocado orchards only from about July to September. Therefore, any introduced phytoseiid mites must compete with the native species for other food resources the rest of the year. *E. hibisci* reproduces more readily on alternate food sources, such as pollen, than do the more specialized predators of spider mites (McMurtry and Rodriguez, 1987; McMurtry, 1989).

Many factors, including the host plant, may affect the ability of an exotic natural enemy to become established in a new environment. For example, *Euseius stipulatus* (Athias-Henriot), introduced from citrus in the Mediterranean area, displaced the native *E. hibisci* on citrus in coastal southern California. Although releases were also made on avocado in the same areas, *E. stipulatus* did not become established on that crop (McMurtry, 1989).

Another interesting sidelight of our program was the introduction of *Euseius quetzali* McMurtry, the dominant species of phytoseiid mite on avocado in the highlands of Guatemala. Although this species was never recovered from our release plots on avocado, subsequent collections suggest that it is indigenous on oak and other native plants in the state (Congdon and McMurtry, 1986). These observations demonstrate that different geographic areas as well as host plants may be favorable for different species.

Greenhouse thrips *Heliothrips haemorrhoidalis* (Bouché) has relatively few natural enemies attacking it in California, including only one Hymenoptera, *Megaphragma mymaripenne* Timberlake, a parasite of the egg stage. Our studies indicated that *M. myrmaripenne* is of questionable value in regulation of greenhouse thrips populations (Hessein and McMurtry, 1988). The other known natural enemies are all predators, including a predatory thrips *Franklinothrips vespiformis* (Crawford) and the green lacewing *Chrysoperla carnea* (Stephens), both also of questionable value in thrips control. Therefore, it was desirable to launch an importation program in an attempt to improve the natural enemy complex. For example, a parasite that attacks the larval stage might lower the average population level of greenhouse thrips. The number of

known parasites of Thysanoptera (thrips) is not large. Just 3 families of Hymenoptera are involved: larval parasites in the family Eulophidae (27 species); trichogrammatid egg parasites in the genus *Megaphragma* (4 species); and an egg parasite in the Mymaridae (1 species) (Loomans and van Lenteren, 1990).

Greenhouse thrips has a cosmopolitan distribution, but it is probably native to tropical America, the only place from where males have been recorded (W. H. Ewart, pers. comm.). Our first introduction of a parasite into California was *Goetheana parvipennis* (Gahan). This eulophid wasp was introduced from West Africa to Trinidad in 1935, and it became established there and in other areas of the Caribbean on the cacao thrips *Selenothrips rubrocinctus* (Giard) (Callan, 1943). We imported it in 1962 from Trinidad, but establishment was not achieved. We arranged for another importation in 1983, this time from the Bahamas, where it was known to be parasitizing greenhouse thrips as well as cacao thrips (Bennett and Baranowski, 1982). Other than a few recoveries shortly after the releases, results were negative, and again, establishment failed. Although we can only speculate on the reasons for failure, it is possible that greenhouse thrips is not the most favorable host. Hessein and McMurtry (1988) found that *G. parvipennis* had fairly low fecundity on this host.

Thripobius semiluteus Boucek, the other eulophid parasite we introduced, has been recorded from West Africa (Sao Tome), India and Australia from thrips of the genera *Brachyurothrips, Panchaetothrips* and *Heliothrips,* all in the subfamily Panchaetothripinae (Boucek, 1976, 1988). A laboratory culture was obtained from Australia in 1986, through the cooperation of Dr. G.A.C. Beattie of the New South Wales Department of Agriculture. Exploration in six southern states of Brazil in 1988 revealed parasitized greenhouse thrips in just one location (Lavras, Minas Gerais). A culture was established in our laboratory and later identified as *T. semiluteus.* This is the first record of the species in the New World (LaSalle and McMurtry, 1989).

T. semiluteus was produced in our insectary beginning in the latter half of 1986, and was colonized on avocados infested with greenhouse thrips in most regions of southern California where the thrips occurs. Recoveries of *T. semiluteus* were made soon after the initial releases in 1986, and the parasite has persisted and spread for up to 4 growing seasons in some locations. It also has shown indications of reducing thrips populations. Detailed studies in two orchards indicated that thrips population declines occurred when the estimated percent parasitization increased to about 60% (McMurtry *et al.,* 1991). Further spread of *T. semiluteus* has been facilitated by initiation of commercial production and release beginning in 1990. Additional studies over several more seasons are needed to assess the impact of *T. semiluteus* on greenhouse thrips in California.

Conclusions

1. Programs of exploration for and introduction of exotic natural enemies of California avocado pests have been relatively few compared to citrus. However, avocado in California has fewer introduced pests than citrus.

2. Establishment of exotic natural enemies and subsequent reduction of a pest has occurred in 2 of the 3 programs attempted, one of which was considered a complete success (long-tailed mealybug). The establishment of *Thripobius semiluteus* on greenhouse thrips probably can be considered a partial success, although insufficient time has elapsed to assess its overall impact on greenhouse thrips in California.

3. Indigenous natural enemies are extremely important in the control of avocado pests in California. Minimal use of foliar pesticides has promoted utilization of natural enemies and biological control of avocado pests in the state.

Future prospects

Additional exploration for parasites of greenhouse thrips might be profitable. There still may be prospects for finding and establishing more effective natural enemies against avocado brown mite, such as a general predator in the mite family Phytoseiidae with somewhat more affinity for feeding on spider mites. In regard to the two Lepidoptera, exploration for more effective natural enemies would not be considered a high priority because these are native species and natural control can be supplemented with releases of *Trichogramma.* Improved mass production technology should make this approach more economical and reliable.

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Table 1. Common arthropod pest species on California avocado.

Omnivorous Looper	*Sabulodes aegrotata* (Guenée)
Western Avocado Leafroller	*Amorbia cuneana* Walsingham
Lantania Scale	*Hemiberlesia lataniae* (Signoret)
Long-tailed Mealybug	*Pseudococus longispinus* (Targioni Tozzetti)*
Greenhouse Thrips	*Heliothrips haemorrhoidalis* (Bouché)*
Six-spotted Mite	*Eotetranychus sexmaculatus* (Riley)
Avocado Brown Mite	*Oligonychus punicae* (Hirst)*

* Natural enemies introduced

Table 2. Phytoseiidae from avocado introduced into California for biological control of avocado brown mite.

Species:	Introduced from:
Typhlodromus (Galendromus) helveolus Chant	Costa Rica, Mexico
Typhlodromus (Galendromus) porresi McMurtry	Mexico
Typhlodromus (Galendromus) annectens DeLeon	Mexico
Amblyseius herbicolus Chant	Costa Rica
Amblyseius chiapensis DeLeon	Costa Rica, El Salvador
Euseius quetzali McMurtry	Guatemala