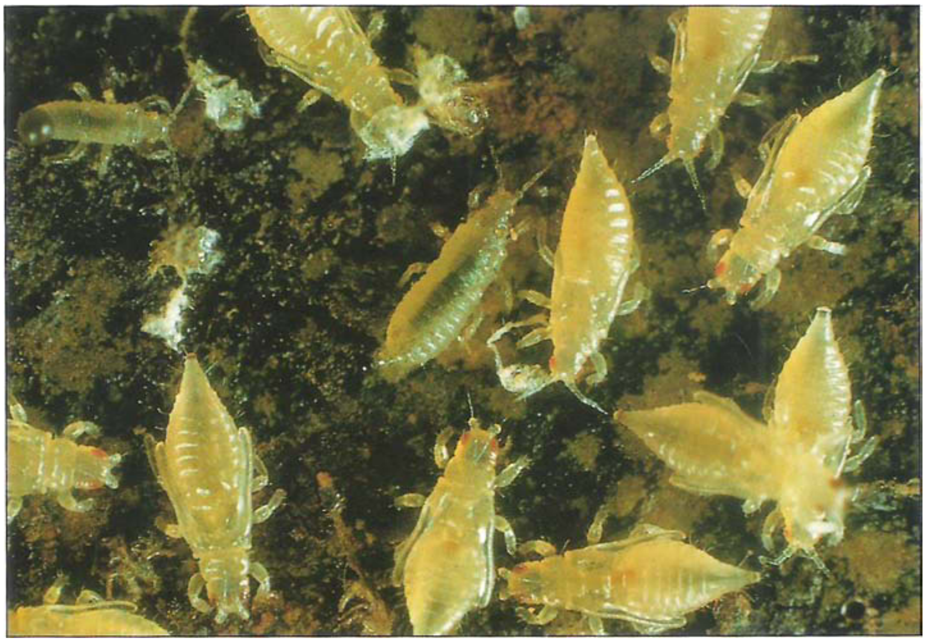

Immature stages of greenhouse thrips are pictured above. Upper left is small, first stage larva preferred by the parasite for egg deposition; at center is larger, second stage larva. Others are either prepupae, with antennae directed forward and short wing pads; or pupae, with antennae directed backwards and long wing pads.

Photo above shows the adult parasitic wasp *Thripobius semiluteus*, which attacks only certain species of plant-feeding thrips. Photo below shows a typical distorted parasitized thrips larva (right), a black parasitoid pupa (center), and a normal thrips pupa (left).

Imported parasite of greenhouse thrips established on California avocado

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The parasitic wasp,* Thripobius semiluteus, *introduced for biological control of greenhouse thrips, has been established and spreading for up to four growing seasons at some sites in Southern California avocado orchards. Studies show that declines in thrips numbers coincide with increasing parasitization by this wasp, which could become an important mortality factor of greenhouse thrips if its widespread establishment is achieved.

Greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché), has increased in importance as a pest of avocados in Southern California during the past decade. Damaging infestations, previously confined mainly to areas within a few miles of the coast, now are common in more interior districts. This insect causes scarring of fruit, especially on the Hass variety, reducing its market value. It also affects fruit quality if infestation occurs when the fruit is small. The problem has brought about an increased use of pesticides by California avocado growers, who generally have avoided spray applications and encouraged biological control of most insect and mite pests by resident natural enemies.

Only two native natural enemies of greenhouse thrips are relatively common in California avocado orchards: a predatory thrips, *Franklinothrips vespiformis* (Crawford), and a trichogrammatid egg parasite, *Megaphragma mymaripenne* Timberlake. Apparently, neither of these natural enemies provides effective control. Therefore, the introduction of exotic parasites, especially those attacking the larval stage, was considered to be the best approach to biological control of greenhouse thrips.

Two species of parasitic wasps, both in the family Eulophidae, have been introduced to California. *Goetheana parvipennis* (Gahan), introduced from Jamaica in 1962 and the Bahamas in 1983, failed to become established. However, *Thripobius semiluteus* Boucek, introduced from Australia in 1986 and Brazil in 1988, has become established in Southern California. The following is a progress report of our research on this species.

The Australian introduction of *T. semiluteus* was provided through the courtesy of Dr. Andrew Beattie, New South Wales Department of Agriculture, Rydalmere, N. S. W. in August 1986. An exploration trip by the senior author in six southern states of Brazil in April-May of 1988 resulted in only one collection of parasitized greenhouse thrips. Parasites emerging from this material were hand-carried to California and processed through quarantine at UC Riverside, at which time they were found to be the same species as the one from Australia. The Brazil collection is the first New World record for *T. semiluteus*, known previously only from India, Australia and the island of Sao Tome, off the coast of West Africa.

Biology of the parasite

Both the Australian and Brazilian strains of *T. semiluteus* are uniparental, which means all individuals are female. The adult female parasite inserts an egg inside the body cavity of a thrips larva, usually the first or early second stage (the stages of the thrips are egg, first- and second-stage larva, prepupa, pupa and adult). The parasitized thrips develops to a mature second-stage larva (apparently, it does not complete transformation to the prepupa) before it is killed by the developing parasite. At this time, the entire body cavity of the parasitized thrips is filled by the wasp larva. The parasite then transforms to a black pupa.

The life cycle of *T. semiluteus* averaged 23.6 (range 22-25) days at 73°F (23°C). The pupal stage comprises about 50% of this developmental time. In comparison, the greenhouse thrips has a longer life cycle: 35.6 (range 34-39) days at 73°F. The late second-stage thrips apparently are less favorable for parasite development, as more than 50% of the pupae developing from these thrips hosts failed to survive. No parasites developed in the thrips prepupal or pupal stages.

Colonization program

From late September 1986 to April 1990, more than 500,000 *T. semiluteus* were liberated in a total of 50 different orchards in Orange, San Diego, San Luis Obispo, Santa Barbara and Ventura counties. Periodic surveys in release orchards have resulted in recoveries of *T. semiluteus* in many of these plots. Plots in which parasite recoveries have not been made are mainly those in which thrips subsequently declined to such low numbers that a sufficient number of infested fruit or leaves could not be found for an adequate sample. Parasitization in some plots has been observed for as many as four consecutive seasons after the parasite releases.

Our surveys indicate that *Thripobius* is established in Southern California, and that it has survived both cold and hot weather extremes of the region (several degrees below freezing and in excess of 100°F). Extensive surveys in avocado blocks in the UC South Coast Field Station at Irvine, where approximately 20,000 *T. semiluteus* were released between 1986 and 1988, showed that within three growing seasons, the parasite had spread throughout two adjacent blocks (total 5.3 ac) and dispersed across an open field to become established throughout another block of 2 ac. In a 6-ac orchard in San Diego County, widespread establishment and up to 60% parasitization by *T. semiluteus* occurred within 2 years, following a release of approximately 11,000 wasps in 3 release sites. The rate of spread throughout an orchard probably is related to the density and extent of the distribution of the thrips populations. A heavy, widespread infestation serves as a natural "insectary" providing host material for rapid multiplication of the parasite.

TABLE 1. Population trends of greenhouse thrips (nos. per leaf) and estimated % parasitization by *Thripobius semiluteus* in areas of an orchard with parasites present, compared to a check area where parasites had not colonized, UC South Coast Field Station, Irvine, 1989

	Dates						
	7-6	7-24	8-8	8-22	9-5	9-18	10-4
With parasitoids*	10.3 21.9%	21.6 28.3%	35.8 8.4%	42.1 30.2%	12.5 62.9%	6.6 61.4%	2.1 56.9%
Check	4.5 0%	17.3 0%	57.6 0%	51.5 0%	47.9 0%	38.2 10%	41.8 2.9%

*Mean of 4 areas in orchard.

Potential impact of *T. semiluteus*

To acquire information on the potential effectiveness of *T. semiluteus*, populations of thrips and parasites were monitored at 2- to 3-week intervals in a 3-ac block of mixed experimental avocado cultivars at South Coast Field Station. Samples of 20 leaves were taken from each of four thrips-infested areas where parasites were established and one infested area where they had not become well established (check). Additional check areas were not available because the parasite had spread throughout most of the block. Leaves were transported to the laboratory and examined under a dissecting microscope, recording greenhouse thrips larvae, prepupae plus pupae and adults, as well as distorted, obviously parasitized thrips larvae and parasite pupae. A rough estimate of percent parasitization was calculated by the formula:

$$\frac{\text{parasite pupae + distorted thrips larvae (parasitized)}}{\text{parasite pupae + distorted thrips larvae + second-stage larvae + pupae}} \times 100$$

As parasites could not be detected in the hosts until a few days before pupation, this source of underestimation of parasitized hosts is probably partially compensated for by an overestimation due to longer duration of parasite pupae compared to the duration of the thrips pupal stages. Some laboratory rearing of thrips larvae in the samples for parasite emergence is in progress to help interpret these data.

A marked reduction in numbers of greenhouse thrips on September 5, 1989 coincided with an increase in estimated parasitization to about 60% (table 1). In comparison, the check area, with no or little parasite activity, had consistently high populations of thrips that persisted even beyond the dates shown.

Declines of thrips populations to low levels also have been noted in plots in several other orchards when the estimated percent parasitization increased to about 60%. Results to date suggest that *T. semiluteus* can suppress thrips populations, although thrips numbers probably will not always be reduced below the level at which some fruit scarring occurs.

Conclusions and future plans

These preliminary studies suggest that *Thripobius semiluteus* could become an important control agent of greenhouse thrips, if it becomes widely established. Widespread colonization now is possible because the parasite is commercially available.

Future investigations are planned to determine: (1) the ability of *T. semiluteus* to control thrips in terms of reduced fruit scarring; (2) the potential rate of spread of the parasite within and between orchards; and (3) its ability to carry over when thrips are reduced to extremely low levels from fruit harvest, high parasitization, or severe weather conditions. Results from such studies should suggest whether or not augmentative or supplementary releases might be needed to reestablish the parasite, and, if such releases appear to be beneficial, what release strategy (rates, timing and number of release sites per acre) would be feasible.

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