

Known distribution of two strains of *Trioxys pallidus* in California in August 1970.

Trioxys pallidus . . .

AN EFFECTIVE WALNUT APHID FROM IRAN

ROBERT VAN DEN BOSCH

THE WALNUT APHID, *Chromaphis juglandicola* Kaltenbach, is an Old World species which apparently invaded California at about the turn of the present century. Although attacked by native lady beetles, green lacewings, and other natural enemies, the aphid frequently becomes extremely abundant. Consequently, walnut growers in many areas routinely treat their groves with insecticides to control it. For years, nicotine sulfate was the most widely used aphicide, but since the middle 1940's it has been supplanted by a variety of synthetic organophosphates and chlorinated hydrocarbons.

Although chemical control has been effective against the aphid, it has several disadvantages. The use of insecticides adds substantially to the cost of walnut production. The materials used are broadly toxic and frequently affect non-target species, including predators and parasites. Where natural enemies are destroyed there is danger of a rapid resurgence of the aphid and outbreaks of other pests. Insecticide drift and its threat to the general environment is a recurrent problem where chemicals are used. Finally, the aphid, through genetic selec-

tion, tends to develop resistance to insecticides.

These several disadvantages of insecticides indicated a need for change in walnut aphid control strategy. Biological control was the tactic selected. If effective natural enemies from the aphids' native habitat could be successfully introduced into California, they might bring about permanent suppression of the pest and reduce or eliminate the need for chemical control. This is the classical biological control technique, which has proved successful against a number of pests.

The biological control program was initiated in 1959, when a parasitic wasp, *Trioxys pallidus* Haliday, was successfully imported into California from France. The wasp performed particularly well on the coastal plain of southern California, and spread rather rapidly over the areas of milder climate. Studies in San Diego County showed that the parasite was capable of destroying a very high percentage of the aphid population under favorable conditions.

The French *T. pallidus* was also widely colonized in northern and central California and gained a temporary foothold

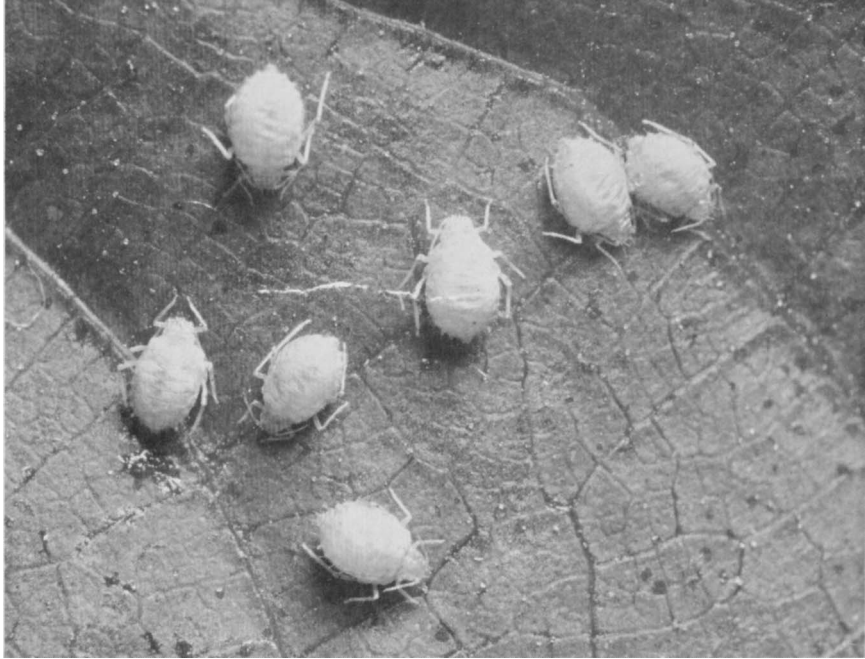
at several places. However, it never became abundant and it is questionable whether permanent establishment could be claimed at any locality. For example, in the San Joaquin Valley where more than 250,000 wasps were released, recoveries were not made beyond the seasons of colonization.

The disappointing performance of the French strain of *T. pallidus* in central and northern California was a clear indication that it lacked genetic characteristics enabling it to thrive or even survive in areas of extreme summer heat and low humidity. Consequently, a decision was made to seek a new strain from an area climatically similar to the Great Central Valley. This search was conducted on the central plateau of Iran, where *T. pallidus* had been observed and collected in 1960. Iran has a summer climate nearly identical to that of the San Joaquin Valley.

Iranian imports

Wasps were obtained from Iran in the late spring of 1968, and colonized in several areas of central California during the summer and autumn of that year. Results were spectacular. In Contra

NEW PARASITE



Walnut aphids mummified by *Trioxys pallidus*. The cocoon of the parasite is contained within the skin of the dead aphid.

B. D. FRAZER

C. S. DAVIS

P. S. MESSENGER

RICHARD HOM

Costa County where small colonizations were made in June and July on very low aphid populations, recoveries were made at all liberation sites. As the season advanced, the wasps multiplied and spread rapidly. For example, in Martinez, in the autumn, recoveries were made literally everywhere in town, even though only small colonizations had been made in a restricted area near the Civic Center. Similar rapid increase and spread occurred in Lafayette and Walnut Creek, and in a commercial grove near Hanford, Kings County.

Winter survival

In the spring of 1969 a survey in Contra Costa County indicated that *T. pallidus* had survived the winter and was continuing to multiply and spread. At this time an intensive evaluation of the wasp-aphid interrelationship was initiated in a small (non-commercial) walnut grove near Lafayette.

Colonizations of the wasp were continued in 1969 with a particular effort being made to effect its establishment in the Central Valley. Colonizations were also made in several of the valleys bordering San Francisco Bay.

Abundant spread

A survey of release plots at Stockton, Modesto, Hanford, and Cotton Center (Tulare County) in October 1969, showed the wasp was present at all places. It was particularly abundant in the plot near Hanford, from which it had spread at least 8 miles to the southeast.

During this survey and previous ones, no attempt was made to assess the impact of the Iranian *T. pallidus* on the walnut aphid. However, during the 1969 and 1970 seasons, the parasite's effect has been closely evaluated in the insecticide-free study plot at Lafayette. At the initiation of the study, the wasp had just invaded the plot from a neighboring valley where it had been colonized in 1968. Thus, it had no measurable effect on the 1969 spring population surge of the aphid. But as the season advanced, it multiplied rapidly and was responsible for a marked reduction in the numbers of aphids during the summer and autumn. The degree of control was such that very few aphids remained unparasitized and able to deposit overwintering eggs. As a result there was a very low population of aphids hatching from over-

wintering eggs in the spring of 1970. Furthermore, over 90 per cent of these were parasitized by wasps which had survived the winter.

Effects striking

The striking effect of the parasite is illustrated by a comparison of aphid abundance in mid-May 1969, when an average of 2,550 were counted per 30 leaf samples, and in mid-May 1970 when the aphids averaged only eight per 30 leaves. Despite continued low-host density in June and July, *T. pallidus* remained quite active, parasitizing an average of about 50 per cent of the aphids. However, activities of the Argentine ant in August drastically affected the parasite-aphid relationship on some trees, and as a result there was a great increase in aphid abundance. Data from the Lafayette plot show that neither predation nor hyperparasitism have materially affected the wasp.

In 1970 the Iranian *T. pallidus* was again released at a number of localities in northern and central California. But before any site was colonized, the trees were examined for parasitized aphids and/or parasite adults. Quite surpris-

ingly, *T. pallidus* was found in most plots intended for colonization, even though some of these were many miles from previously known areas of establishment. Furthermore, moderate to heavy parasitization was recorded from aphids collected at a number of these places. This indicates that the wasp is now spreading explosively over all of the major walnut growing areas of northern and central California, and rapidly assuming major status as a natural enemy of the walnut aphid.

Iranian strain

All of this recent development is believed to involve the Iranian strain of *T. pallidus*, since it has occurred in areas where parasite numbers had previously been low or the wasp had been non-existent. It is impossible to confirm this through morphological study because no known structural differences occur between the two strains. However, biological study has revealed that the two strains do not interbreed, and so it will be possible to determine the identity of field collected material through mating tests with laboratory stocks of the two strains.

The Iranian strain of *T. pallidus* has the potential to effect wide-scale control of the walnut aphid in California. Its performance at Lafayette shows that under optimum conditions it can reduce the aphid population to a very low level and maintain it there. Native hyperparasites have not seriously hindered its activities. It appears to be fully adapted to the climatic conditions of California's interior valleys. On the other hand, cultural practices, and especially the adverse effects of insecticides applied for control of pests such as codling moth and walnut huskfly, may seriously hinder the wasp. This latter situation will be closely studied and efforts will be made to effect full integration of chemical control with *T. pallidus* and the natural enemies of the several other walnut pests.

Robert van den Bosch and Powers S. Messenger are Professors of Entomology and Entomologists; and Richard Hom is Laboratory Technician, Division of Biological Control, Department of Entomology and Parasitology, University of California, Berkeley. Bryan D. Frazer is Research Officer in the Canada Department of Agriculture, currently on educational leave in the Department of Entomology and Parasitology, U.C., Berkeley. Clarence S. Davis is Extension Entomologist, U.C., Berkeley.

Effects of foliar sprays for FROST PROTECTION WITH YOUNG CITRUS

R. M. BURNS



A NUMBER OF new chemical sprays were tested for frost protection of young citrus during the winter of 1969-70. Fifteen commercial compounds were sprayed on container-grown grapefruit nursery trees and young lemon trees in the field. Most of the compounds were antitranspirants (film-forming, stomata closing, and reflecting types). Growth inhibitors used were maleic hydrazide (MH), potassium salt of 6-hydroxy-3-(2H)-pyridazinone (KMH), and ethyl hydrogen 1-prophylphosphonate (NIA-10637). Freezing the grapefruit nursery trees in a cold chamber resulted in no significant differences in the amount of cold protection given by any of the sprays. Temperatures in the field where the young lemon trial was located never reached freezing, but there were significant differences in growth response to the different sprays.

Many chemicals

Many chemicals have been tested in an attempt to induce cold tolerance or frost protection in citrus and other agricultural crops. In some trials, a few degrees of increased frost tolerance have

Two different chemical treatments with growth regulators for frost protection show a tree in good to fair condition after freezing temperatures (photo above) and one in poor condition with very little new growth (photo below).