

severe enough only in the Strazzulla grove to require spraying.

Our population of citrus whitefly, citrus mealybug, and Texas citrus mite were significantly reduced for at least 8 weeks. Boling and Dean (3) had reported control of Texas citrus mite in nursery trees.

Excellent protection of tender foliage from spirea aphid attack in young plantings was obtained by Tashiro et al. (15) and Brooks (4). Aldicarb will protect mature trees, also.

The low rate of Temik aldicarb gave effective control of rust mite, whitefly, mealybug, aphid, and Texas mite. No significant differences in insect or mite control were observed due to method or application except for the superior performance of the chisel treatment vs. Texas citrus mite in 1977 (Table 2).

The potential of aldicarb to control citrus thrips (15, 16), citrus red mite (2, 11, 12, 13, 14, 15), armored scale (3, 5, 15), soft scale (3, 8), leaf miner (1), the citrus weevil *Diaprepes abbreviatus* (10), and disease vectors (6, 9) has been investigated in the United States and abroad.

Our investigations confirm the performance of aldicarb as a control agent for rust mite, Texas mite, and aphids and provides evidence of control for whitefly and mealybug on citrus.

Literature Cited

1. Beattie, G. A. C. 1978. Citrus leafminer control with systemic insecticides, 1976. *Insecticide and Acaricide Tests* 3:57. Entomol. Soc. Amer.
2. Beavers, J. B., J. G. Shaw and H. Tashiro. 1970. Evaluation of aldicarb against the citrus red mite on mature navel orange trees. *J. Econ. Entomol.* 63:651-2.
3. Boling, J. C. and H. A. Dean. 1968. Field evaluation of Temik against some insects and mites attacking citrus. *J. Econ. Entomol.* 61:313-15.
4. Brooks, R. F. 1968. Control of aphids on Florida citrus. *Proc. Fla. State Hort. Soc.* 81:103-8.
5. Brooks, R. F. and R. C. Bullock. 1966. Control of yellow scale, *Aonidiella citrini*, on Florida citrus. *Fla. Entomol.* 49:185-8.
6. Catling, H. D. 1969. The control of citrus psylla *Trioza erytreae* (Del Guercio). Homoptera: Psyllidae. *S. Afr. Citrus J.* 426:9, 11, 13, 15-16.
7. French, J. V. and L. W. Timmer. 1979. Control of rust mite and reduction of citrus nematode populations on Texas oranges with Temik®. *J. Rio Grande Valley Hort. Soc.* 33:55-62.
8. Hart, W. G. and S. J. Ingle. 1967. The effect of UC-21149 on infestations of brown soft scale on potted citrus. *J. Rio Grande Valley Hort. Soc.* 21:49-51.
9. Kaloostian, G. H., G. N. Oldfield and D. Gough. 1979. Control of citrus stubborn vectors in the laboratory. *Citrograph* 65(1):17, 25.
10. Schroeder, W. J. and R. A. Sutton. 1978. Citrus, *D. abbreviatus* control, Plymouth, Florida, 1975. *Insecticide and Acaricide Tests* 3:54. Entomol. Soc. Amer.
11. Selhime, A. G., C. R. Crittenden and R. F. Kanel. 1972. Systemic activity of aldicarb against citrus rust mites and citrus red mites on young orange trees. *Fla. Entomol.* 55:93-96.
12. Shaw, J. G. 1970. Effectiveness of 14 systemic insecticides against the citrus red mite on orange seedlings. *J. Econ. Entomol.* 63:1590-2.
13. ———, L. R. Espinosa and R. B. Hampton. 1970. Tests with three formulations of aldicarb for control of the citrus red mite. *J. Econ. Entomol.* 63:1631-2.
14. Tashiro, H. and J. B. Beavers. 1967. Residual activity of the systemic UC-21149 against the citrus red mite. *J. Econ. Entomol.* 60:1187-8.
15. ———, D. L. Chambers, J. G. Shaw, J. B. Beavers and J. C. Maitlen. 1969. Systemic activity of UC-21149 against the citrus red mite, citrus thrips, California red scale, and spirea aphid on non-larving orange trees. *J. Econ. Entomol.* 62:443-7.
16. Tuttle, D. M. and G. L. Arviso. 1978. Control of citrus thrips with Temik 15G, 1977. *Insecticide and Acaricide Tests* 3:58. Entomol. Soc. Amer.

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HISTORY AND ESTABLISHMENT OF THE PARASITE, PROSPALTELLA LAHORENSIS, FOR THE BIOLOGICAL CONTROL OF CITRUS WHITEFLY IN CENTRAL FLORIDA¹

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Abstract. The hymenopterous parasite, *Prospaltella lahorensis* Howard was introduced into central Florida in the fall of 1977 and winter of 1978 for the biological control of the citrus whitefly. By the fall of 1978, the parasite was well established in the Lakeland-Auburndale area on citrus and ornamental plants. During 1979-80, the parasite dispersed rapidly throughout Polk County, Florida, to approximately 50 km from the original release sites. Parasitization

ranged 0.0-8.2% on host plants sampled within the 50 km radius of the release sites in 1980. Within 13 km of the release sites parasitization exceeded 30%. Parasitization and frequency of parasite recovery were highest in commercial citrus indicating minimum effect on survival from conventional horticultural practices. Although results are encouraging it is premature to assess the degree of biological control to be achieved by the introduction of *P. lahorensis* on commercial citrus.

The citrus whitefly, *Dialeurodes citri* (Ashmead) has been found singly or coexisting with the cloudy-winged whitefly, *Dialeurodes citrifolii* (Morgan) and a few lesser important whitefly species in all citrus-growing regions of Florida (5, 12). It is native to countries of southeast Asia but is found in virtually all citrus-growing areas of the world (7). In the United States, it is distributed throughout most states inhabiting citrus and numerous introduced and native ornamental plants (7).

Citrus whitefly was probably introduced into Florida in the northern part of St. Johns County circa 1880 (7). Withstanding severe freezes from 1890-1900, it emerged as a major citrus pest at the turn of the century. Over a period of six years, reduction of yield due to whitefly nymphal feeding and its subsequent effect on tree vitality were re-

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ported to be 25-40% (7). Excessive buildup of sooty molds propagated in honeydew secretions of the whitefly on fruit also created serious packinghouse problems.

The importance of citrus whitefly on citrus has gradually declined since the beginning of the century; however, localized infestations on fresh fruit varieties continue to produce packinghouse problems today. Many feel that whiteflies are controlled when chemicals are applied for scale insects (5). If this speculation is true, decreased use of chemicals for scale control caused by recent successes in the biological control of scale insects will result in higher whitefly populations.

Considering the importance of citrus whitefly around 1900 it is not surprising that a major research effort for its biological control was initiated by State and Federal scientists. Five different natural enemies including the hymenopterous parasite *Prospaltella lahorensis* Howard were shipped from Lahore, Pakistan to Florida in the fall of 1911 (13). A few healthy adult *P. lahorensis* and a number of predaceous coccinellids identified as *Catana parcesetosa* Motsch (= *Cryptognatha flavescens*) survived the journey, but died in the laboratory before their release. *C. parcesetosa* was unsuccessfully introduced again from India in 1913. During the parasite and predator importation program, localized populations of entomogenous fungi, *Aschersonia aleyrodis* Webber and *Aegerita webberi* Fawcett were disseminated by artificial propagation and spraying of laboratory produced spores to establish and/or maintain the fungi in citrus groves (1, 2, 3, 4, 10). *A. aleyrodis* was quite effective as a microbial agent and is considered the major natural enemy of the citrus whitefly in Florida today (6). A closely related species, *A. goldiana* Sacc. and Ellis, can also be found attacking all whitefly species.

In 1922, the coccinellid, *Delphastus catalinae* Horn was introduced into Florida from California (12). This egg predator was established and survived on both *D. citri* and *D. citrifolii*. However, Muma (8) suggested that *D. catalinae* had subsequently "died out" since it was not found in an extensive state-wide survey around 1950 when the predatory ladybeetles, *Nephaspis gorhami* Lec., *Delphastus pusillus* Lec., *Delphastus pallidus* Lec. and *Scymnillodes subtropicus* Csy. were found attacking whiteflies in a descending order of importance.

Although a few insignificant predators of whitefly have been reported since 1953 (9), no parasites were known to attack citrus whitefly prior to the recent introductions. During 1972-73, Mr. Allen Selhime of the U.S.D.A., Orlando, attempted to introduce *P. lahorensis* into Florida from California where it had been successfully colonized in 1968. In 1975, additional introductions were attempted by Dr. R. I. Sailer in the Gainesville area. However, the parasite was not established at either of these locations.

Finally, in June 1977 additional releases of *P. lahorensis* on *Citrus* sp., *Viburnum odoratissimum* Ker-Gawl and *Ligustrum lucidum* Aiton in Gainesville resulted in colonization 20 days later (11). Approximately 60 adult females released in June were responsible for the successful colonization effort (11).

In October of 1977, Dr. Nguyen Ru of the University of Florida, IFAS, Gainesville, and Mr. Jerry Fojtik, University of Florida, IFAS, Lake Alfred, released *P. lahorensis* in Lakeland and Auburndale, Polk County, Florida. The purpose of this paper is to present data on the successful establishment of the parasite in these two locations and its distribution during the past 3 years.

Materials and Methods

P. lahorensis adults for colonization in central Florida

were collected upon emergence from parasitized whitefly larvae on citrus leaves taken in Gainesville in mid-October. From 25-30 adult parasites were confined in shell vials and taken directly to Auburndale, Florida where they were released directly into sleeve cages in the manner described by Ru and Sailer (11) to reduce premature dispersal.

The cages had been attached to branches within the tree canopy of four Valencia orange trees harboring moderate citrus whitefly populations. Trees were selected in the center of a 1-acre unsprayed grove within the Auburndale city limits. A second release of 30-40 adult female parasites was made in a similar manner in early January, 1978, on a large viburnum shrub adjacent to citrus trees in a residential section of Lakeland. At the same time, a potted viburnum infested with an undetermined number of parasitized whitefly nymphs was placed beneath the same shrub. The potted plant was taken from a greenhouse on the University of Florida campus where a culture of *P. lahorensis* was maintained through the winter of 1977-78. Cages were maintained in release trees for 1 week and then disassembled to allow for parasite dispersal.

Evaluation of the release program was begun on a regular basis in January, 1979, although periodic grove examinations were begun following release in the spring of 1978. Thirty leaf samples were collected twice a month from flush on which nymphal stages of whitefly were found to predominate. Initially, samples were taken from trees where *P. lahorensis* was released; however, additional samples were subsequently taken at 0.8, 1.6, 3.2 and 6.0 km from the original release sites. Once the parasite was found at a location, the sample radius was extended outward to estimate parasite dispersal. In the laboratory, live, dead, parasitized and diseased nymphal whitefly stages were counted per leaf. Parasitized nymphal stages were placed in gelatin capsules for parasite emergence and subsequent identification.

Results and Discussion

In both the Lakeland and Auburndale release sites, larvae and pupae of *P. lahorensis* were observed in 3rd instar whitefly nymphs and pupae on both citrus and viburnum in the spring of 1978. By the fall of 1978, recoveries were obtained up to 1.6 km from the respective release sites. Extensive sampling in the release trees during January and February, 1979, showed a range of parasitization of 0.0-8.0% and 0.0-25% in the Lakeland and Auburndale release sites respectively.

As shown in Table 1, percent parasitization by *P. lahorensis* (Fig 1) has gradually increased particularly within 13 km of the release sites. Parasite dispersal measured as percent parasitization (Table 1) has also increased to 50 km from the release site (Fig. 2). By comparison, the dispersal of *P. lahorensis* appears to be more rapid in central Florida than in Gainesville, where it moved 200 m in 3 months and California where it moved only 1609 m in

Table 1. Percent parasitization of citrus whitefly larvae by *Prospaltella lahorensis* at different distances from release sites in central Florida, 1979-80.

Release site	Mean percent parasitization							
	3km		6km		13km		26km	
	1979	1980	1979	1980	1979	1980	1979	1980
Auburndale	1.9	2.7	14.3	10.6	32.0	2.6	5.9	2.4
Lakeland	1.7	2.1	14.3	4.7	32.0	3.3	1.9	0.7

Parasitization based on the examination of 29,227 individuals.

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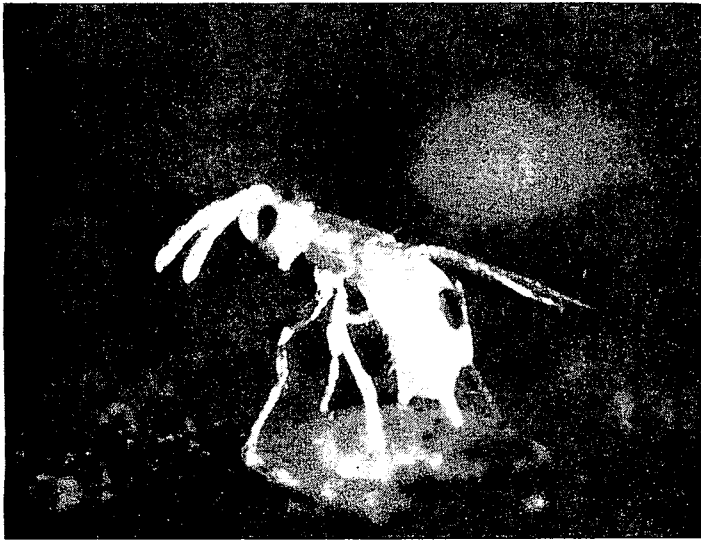


Fig. 1. *Prosopaltella lahorensis* adult female parasitizing a citrus whitefly nymph. (Photograph by Nguyen Ru).

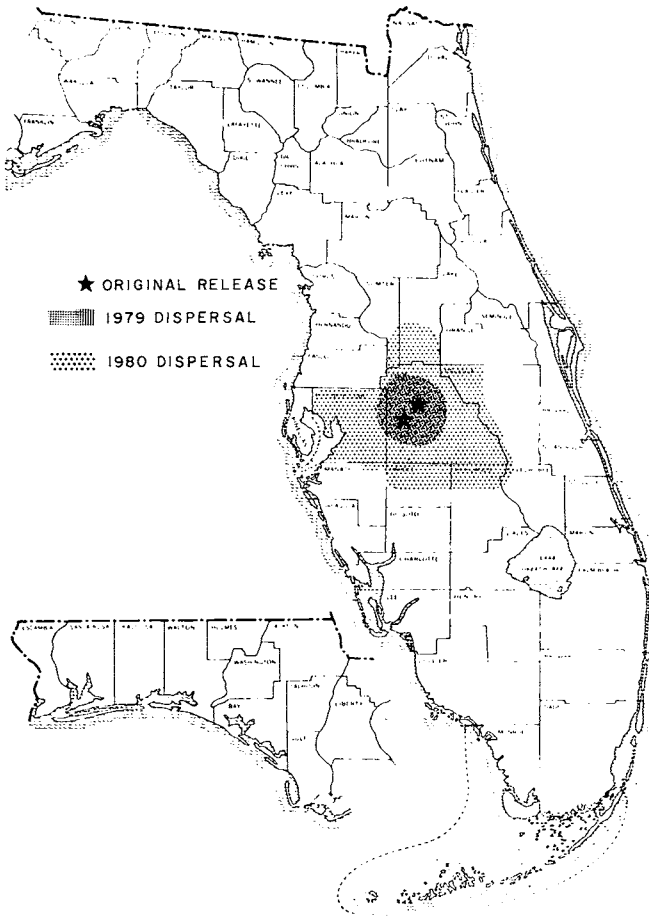


Fig. 2. Shaded areas on map represent the estimated dispersal of *Prosopaltella lahorensis* during 1979 and 1980 from two release sites (star designation) in central Florida.

about 9 years. The dense citrus monoculture of central Florida might explain its more rapid dispersal rate.

Overall parasitization within the 50 km area ranged from 0.0-8.2% on the various host plants and was slightly higher on citrus in 1980 (Table 2). Parasitization and frequency of parasite recovery were highest in commercial citrus in both 1979 and 1980 (Table 3). Although this difference in recovery frequency indicates a host plant preference for citrus by *P. lahorensis*, more importantly, it suggests that

Table 2. Parasitization of citrus whitefly on different host plants by *Prosopaltella lahorensis* in central Florida in 1979-80.

Host plant	Larval population sampled					
	Total		Parasites		% Parasitization	
	1979	1980	1979	1980	1979	1980
Citrus (commercial)	1474	674	47	55	3.2	8.2
Citrus (dooryard)	7592	2619	188	178	2.5	6.8
Viburnum	2955	12,738	101	168	3.4	1.3
Chinaberry	486	—	21	—	4.3	—
Gardenia	—	689	—	0	—	0.0

Table 3. Frequency of recovery of *Prosopaltella lahorensis* on different host plants from randomly selected sites in central Florida in 1979-80.

Host plant	Percent recovery		
	1979	1980	Total
Citrus (commercial)	45.5	52.8	49.3
Citrus (dooryard)	32.2	26.3	29.2
Viburnum	40.0	32.5	36.6
Chinaberry	66.7 ^z	0.0	50.0
Gardenia	0.0	0.0	0.0
Total	36.6	32.8	34.6 ^y

^zRepresents only 3 sample locations.

^yPercent parasite recovery based on 338 locations sampled throughout the season in 1979-80.

conventional horticultural practices are having a minimum effect on parasite survival.

In conclusion, it would appear that *P. lahorensis* has been successfully colonized in central Florida on citrus and ornamental plants; however, it is premature to assess the degree of biological control to be achieved by the introduction in commercial citrus.

Literature Cited

- Berger, E. W. 1907. Whitefly conditions in 1906. The use of the fungi. *Fla. Agr. Expt. Stat. Bull.*, 88, 85 pp.
- . 1921. Natural enemies of scale insects and whiteflies in Florida. *Quart. Bull. Fl. Stat. Plant Board*, 5, 141.
- Fawcett, H. S. 1910. An important entomogenous fungus. *Mycologia* 2:164-168.
- . 1944. Fungus and bacterial diseases of insects as factors in biological control. *Bot. Review*, 10, 6, 327-348.
- Griffiths, J. T. and W. L. Thompson. 1957. Insects and mites found on Florida citrus. *Fla. Agr. Expt. Stat. Bull.* 591; 35 pp.
- McCoy, C. W. 1978. Entomopathogens in arthropod pest control programs for citrus. IN: *Microbial Control of Insect Pests: Future Strategies in Pest Management Systems*. Allen, G. E., Ignoffo, C. M., Jaques, R. D., Eds., Gainesville, FL, pp. 211-223.
- Morrill, A. W. and E. A. Back. 1911. Whiteflies injurious to citrus in Florida. *U.S.D.A. Bull.* 92:109 pp.
- Muma, M. H. 1953. Ladybeetle predators of citrus whiteflies. *Citrus Magazine* 12, 13, 37.
- , A. G. Selhime and H. A. Denmark. 1971. An annotated list of predators and parasites associated with insects and mites on Florida citrus. *Fla. Agr. Expt. Stat. Bull.* 634A, 37 pp.
- Rolfs, P. H. and Fawcett, H. S. 1908. Fungus diseases of scale insects and whitefly. *Fla. Agr. Expt. Stat. Bull.*, 94, 17 pp.
- Ru, N. and R. I. Sailer. 1979. Colonization of a citrus whitefly parasite *Prosopaltella lahorensis* in Gainesville, Florida. *Fla. Entomol.* 62:59-65.
- Watson, J. R. and E. W. Berger. 1937. Citrus insects and their control. *Fla. Agr. Ext. Ser. Bull.* 88:33 pp.
- Woglum, R. S. 1913. Report of a trip to India and the Orient in search of the natural enemies of the citrus whitefly. *U.S.D.A. Bur. Ent. Bull.* 120:1-38.