# SELECTIVE TOXICITY OF SOME PESTICIDES TO *HIBANA VELOX* (ARANEAE: ANYPHAENIDAE), A PREDATOR OF CITRUS LEAFMINER

Divina M. Amalin[1], Jorge E. Peña[1], Simon J. Yu[2] and Robert McSorley[2]
[1]TREC-IFAS, University of Florida, 18905 SW 280 St. Homestead, FL 33031

[2]Department of Entomology and Nematology, University of Florida
Gainesville, FL 32601

Abstract

The toxicity of fourteen different pesticides used in 'Tahiti' lime, *Citrus aurantifolia* (Christman) Swingle, to the spider, *Hibana velox* (Becker) was tested under laboratory conditions. Among the nine pesticides tested using a coated glass vial method, the five broad-spectrum insecticides (azinphos-methyl, chlorpyrifos, ethion, carbaryl, dicofol) were all highly toxic to *H. velox*, causing 100% mortality even at the lowest concentration. Avermectin and Provado® (a.i., imidacloprid) applied as sprays had moderate toxicity; whereas, Admire® (a.i., imidacloprid) applied as a drench and Tri-Basic® (copper fungicide) caused the lowest percent mortality (10-30%) even at the highest concentration. With a leaf-dip method, petroleum oil exhibited a low toxicity to *H. velox*. However, when combining petroleum oil with avermectin, a synergistic effect elevated the toxicity to moderate. Azadirachtin, *Bacillus thuringiensis*, and diflubenzuron showed low impact on *H. velox*. Less than 20% mortality was recorded at the highest concentrations for all of these products.

Key Words: toxicity test, *Hibana velox*, *Phyllocnistis citrella*, predatory spider, citrus leafminer

Resumen

El efecto tóxico de catorce pesticidas comúnmente usados en limón 'Tahiti', *Citrus aurantifolia* (Christman) Swingle, se evaluó en la araña, *Hibana velox* (Becker) bajo condiciones de laboratorio. Entre los pesticidas evaluados usando un método de frasco de cristal cubierto, los cinco pesticidas de amplio espectro ([azinphos-methyl, chlorpyrifos, ethion, carbaryl, dicofol]) fueron altamente tóxicos hacia *H. velox*, causando 100% de mortalidad aun a la concentración más baja. Los insecticidas, Avermectina y Provado® [(i.a., imidacloprid)] aplicados en forma atomizada demostraron tener baja toxicidad; mientras que aplicaciones hasta empape de Admire® [(i.a., imidacloprid)] y Tri-Basic® (funguicida de cobre) causaron el porcentaje de mortalidad mas bajo (10-30%) hasta en las concentraciones mas altas. Al usar el método de sumergir las hojas del limón en la solución con insecticida, el aceite de petróleo mostró baja toxicidad hacia *H. velox*. Sin embargo, al combinar el aceite de petróleo con Avermectina, el efecto de sinergismo elevó la toxicidad de baja a moderada. Las concentraciones mas altas de Azadirachtina, *Bacillus Thuringiensis*, y diflurobenzuron mostraron bajo impacto, al causar una mortalidad menor del 20% de los especimenes de *H. velox*.

The citrus leafminer (CLM), *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae), is a widely distributed and major pest of *Citrus* spp. as well as other species in the family Rutaceae (Heppner 1993). Insecticides provide a rapid means of suppressing CLM populations, especially during heavy infestations. However, chemical control of CLM is difficult to achieve due to the development of resistance by CLM (Tan & Huang 1996), harmful effects on natural enemies (Huang & Li 1989) and due to CLM adults' prolonged and overlapping emergence which may require multiple sprays (Peña & Duncan 1993). Nevertheless, chemical control is still considered an adjunct to nonchemical control (cultural and biological control), particularly for the protection of the main leaf flushes that are important in tree growth and fruit production.

Several species of spiders are found commonly inhabiting lime, *Citrus aurantifolia* (Christman) Swingle, orchards in south Florida. A preliminary survey revealed that three species of hunting spiders, *Chiracanthium inclusum* Hentz, *Hibana velox* (Becker), and *Trachelas volutus* (Gertsch) and one species of jumping spider, *Hentzia palmarum* (Hentz), fed on the larvae and prepupae of CLM (Amalin et al. 1996). In addition to insecticides used for CLM control (Beattie et al. 1995, Heppner 1993), citrus trees, particularly in nurseries, are regularly treated with pesticides to protect them from other arthropod pests and diseases (Villanueva-Jimenez & Hoy 1997, Knapp 1996). These materials could threaten survival and sustainability of native and introduced natural enemies (Browning 1994, Peña & Duncan 1993, Villanueva-Jimenez 1998).

The use of selective pesticides is a major consideration in developing an integrated control program. Utilizing pesticides that are relatively harmless to spiders and other predatory arthropods could increase the effectiveness of natural predation and thereby reduce the overall population of injurious insects in lime orchards.

In this laboratory study, we tested the susceptibility of the hunting spider, *Hibana velox* (Araneae: Anyphaenidae), to some pesticides commonly used in lime orchards.

## Materials and Methods

Toxicity tests of 14 pesticides recommended for citrus (Knapp 1996) were conducted in the laboratory on spiderlings of *H. velox*. Table 1 shows the target insect pests and diseases of the selected 14 pesticides. Test organisms were obtained by collecting egg sacs of *H. velox* in the field. The egg sacs were transported to the laboratory for spiderling emergence. After emergence, the spiders were then reared in the laboratory using artificial diet (Amalin et al. 1999). Two-week-old spiderlings were utilized in the tests. Two methods were developed for the bioassay: coated glass vial and leaf-dip methods. The selective efficiency of these two methods in assessing pesticide effect on *H. velox* was compared.

### Coated glass vial Method

Surface coating (Fig. 1) was done by exposing the spiders to surface coated glass vials (15 mm diameter × 60 mm long) with pesticide solution. Each vial was coated with pesticides by dispensing 80 ul of the pesticide solution. The vials were rolled manually until the whole surface was coated with the solution and air-dried at room temperature for an hour or until they were completely dry. The spiders were placed individually in the surface coated vials. A cotton swab saturated with artificial diet was inserted in each vial and sealed with cotton. The artificial diet consisted of a mixture of 230 ml soybean beverage, 230 ml homogenized whole milk, 2 fresh chicken egg yolks, and 5 ml honey (Amalin et al. 1999).

TABLE 1. PESTICIDES TESTED FOR THE LABORATORY BIOASSAY AND THE PESTS THEY ARE RECOMMENDED TO CONTROL (KNAPP 1996).

| Trade names | Common name | Arthropod pests | Diseases |
|---|---|---|---|
| Agrimek (technical grade) | Abamectin | citrus rust mites, broad mites, citrus leafminer | |
| Agrimek + Petroleum oil | Abamectin + Petroleum oil (FC435) | citrus rust mites, broad mites, citrus leafminer | |
| Petroleum oil | FC435 | citrus rust mites, broad mites, citrus leafminer, scale, whitefly, spider mites | greasy spot, sooty mold |
| Admire 2F, Provado 1.6F | Imidacloprid Imidacloprid | citrus leafminer citrus leafminer | |
| Copper WP | Tri Basic | | phytophthora, foot rot, root rot, brown rot, greasy spot, melanose, citrus scab, alternaria brown spot |
| Micromite 25W | Diflubenzuron | citrus rust mites, citrus root weevil, citrus leafminer | |
| Dipel DF | *Bacillus thuringiensis* | orange dog | |
| Ethion 4EC | Ethion | citrus rust mites, citrus snow scale | |
| Guthion 2L | Azinphos-methyl | scales, whitefly, mealybug, adult citrus root weevil, cricket | |
| Kelthane 50WP | Dicofol | spider mites, citrus rust mites | |
| Lorsban 4EC | Chlorpyrifos | scale, mealybugs, orange dog, katydid, grasshopper, termites, fireants, aphids, crickets | |
| Neemix 4.5F | Azadirachtin | citrus leafminer | |
| Sevin 4L | Carbaryl | citrus root weevil, orange dog, katydids, grasshoppers, crickets | |

Three concentrations of each pesticide (for both technical and formulated grade) were tested, i.e. simulated field rate (SFR), twice SFR, and half SFR. Simulated field rate is based on 50 gal of spray per acre, in amounts adequate to cover but not to the point of run off. The SFR for each insecticide used is shown in Table 2. The different concentrations were prepared using deionized water for all the pesticides except for the technical grade of abamectin, and Admire® for which acetone was used as a solvent. A bioassay using the coated glass vial method was conducted for nine pesticides,

Fig. 1. Coated glass vial method.

i.e. abamectin (a compound produced by soil actinomycetes), azinphos-methyl, carbaryl, chlorpyrifos, dicofol, ethion, Admire® (a.i., imidacloprid, drench formulation), Provado® (a.i., imidacloprid, spray formulation), and Tri-Basic® (a copper fungicide).

### Leaf-dip Method

Dipping was done by cutting lime leaves into 25 mm diameter circles. The leaf circles were dipped separately for approximately 30 seconds into different concentrations of five pesticides, i.e., azadirachtin (neem extracts), *Bacillus thuringiensis* (insecticidal bacterium), diflubenzuron (insect growth regulator), abamectin + petroleum oil (FC-435), and petroleum oil alone. After dipping, the leaves were air-dried for

TABLE 2. SIMULATED FIELD RATE FOR EACH INSECTICIDE USED.

| Pesticides | Simulated field rate (SFR) |
|---|---|
| Abamectin | 10.0 ug/ml |
| Azinphos-methyl | 2.5 ul/ml |
| Carbaryl | 2.5 ul/ml |
| Chlorpyrifos | 2.5 ul/ml |
| Dicofol | 3.0 ul/ml |
| Ethion | 3.0 ul/ml |
| Imidacloprid-Provado® | 0.27 ul/ml |
| Imidacloprid-Admire® | 30.0 ug/ml |
| Tri-Basic® | 4.5 mg/ml |

approximately 2 h or until dry and placed singly on the bottom of a 30-hole (25 × 30 mm) cup tray (Fig. 2). A single spiderling was added to each arena and fed with the artificial combination diet provided on a cotton swab. The cup openings were covered with a plastic lid.

### Experimental Protocol

For both methods, ten individual spiderlings were tested for each concentration. The control was deionized water for all pesticides except abamectin and Admire for which acetone was used as a control. The arenas were placed in an incubator conditioned at 27°C and 80% RH. The tests were repeated 30 times for each concentration for all the pesticides used. The spiders were held in the treated substrates for 72 h and the spider mortality was compared with the control from day 1 to day 3 after treatment. The percent spider mortality was calculated for each concentration for all pesticides. The mean percent spider mortality in treatment was adjusted for that of control using Abbott's formula (1925).

## Results and Discussion

A wide range of toxicity was exhibited by the different pesticides included in the bioassay tests. Among the nine pesticides tested using the coated glass vial method, Admire®, and Tri-Basic® resulted in a low percentage of spider mortality (10-30%), producing the lowest mortality even at the highest concentration (twice of SFR) (Fig. 3). This suggests that both pesticides have low or no acute impact on *H. velox*. Abamectin and Provado® had moderate toxicity to *H. velox*. Abamectin had more than 50% spider mortality at the highest concentration, whereas Provado® had almost 40%. Both showed less than 35% spider mortality using the SFR (Fig. 3). The organophos-

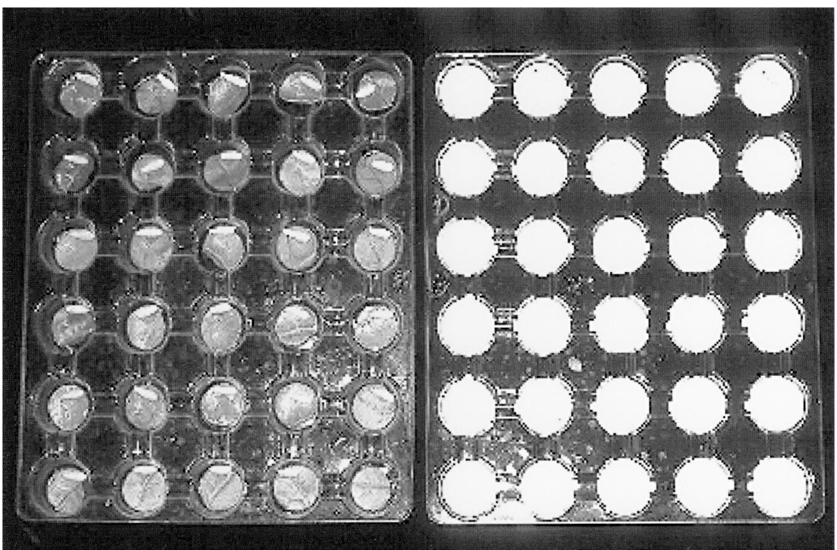

Fig. 2. Leaf-dip method.

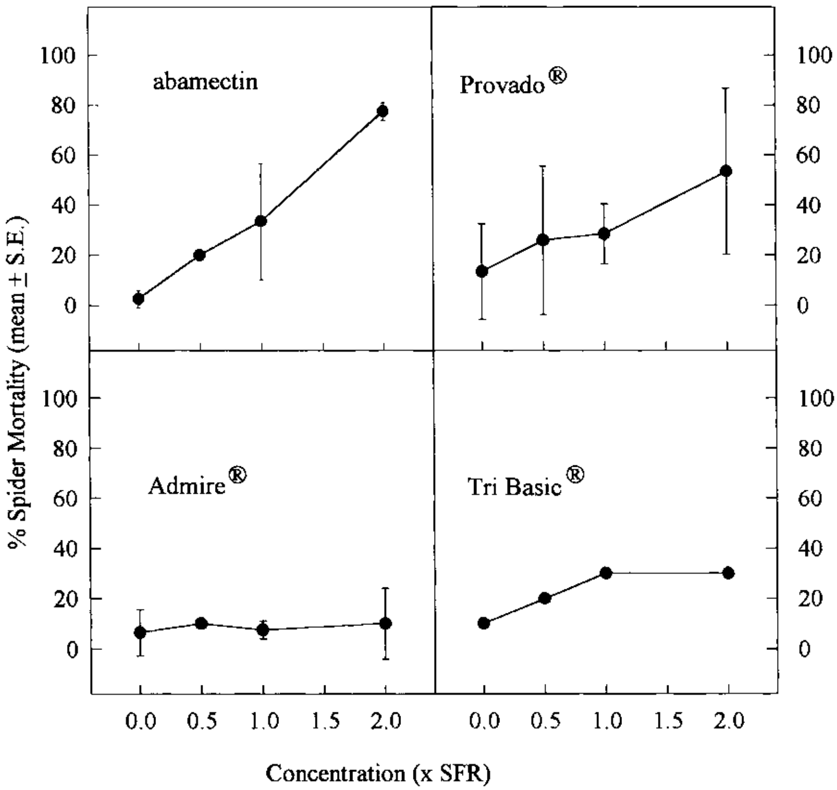


Fig. 3. Percent mortality of spiders exposed to three different concentrations of abamectin, Provado®, Admire®, and Tri-Basic® using a coated glass vial method.

phates (azinphos-methyl, chlorpyrifos, and ethion), the carbamate (carbaryl), and the organochlorine (dicofol), were all highly toxic, causing 100% spider mortality even at the lowest concentration (half of SFR). In the leaf-dip method, oil alone exhibited a low toxicity to *H. velox*. Only 15% mortality was recorded from the highest concentration, 5% from the SFR, and 0% from the lowest concentration (Fig. 4). However, petroleum oil + abamectin caused moderate toxicity. This demonstrates that abamectin has a moderate effect, which was similar using abamectin alone (Fig. 3). The naturally derived products (azadirachtin, *Bacillus thuringiensis*, and diflubenzuron) showed low toxicity to *H. velox*. Less than 20% mortality was recorded at the highest concentration for all of these products (Fig. 4).

Other laboratory studies have also shown that broad-spectrum insecticides such as organophosphates, carbamates and organochlorines have significant lethal effects on spiders in general. For instance, in Israel, laboratory residue studies using grapefruit leaves as the substrate showed that the organophosphate chlorpyrifos was highly toxic to *Chiracanthium mildei*, a hunting spider known to occur abundantly in citrus orchards, whereas natural products (i.e. *Bacillus thuringiensis* and neem extracts) were virtually non-toxic to spiders (Mansour 1987). Saxena et al. (1984) found

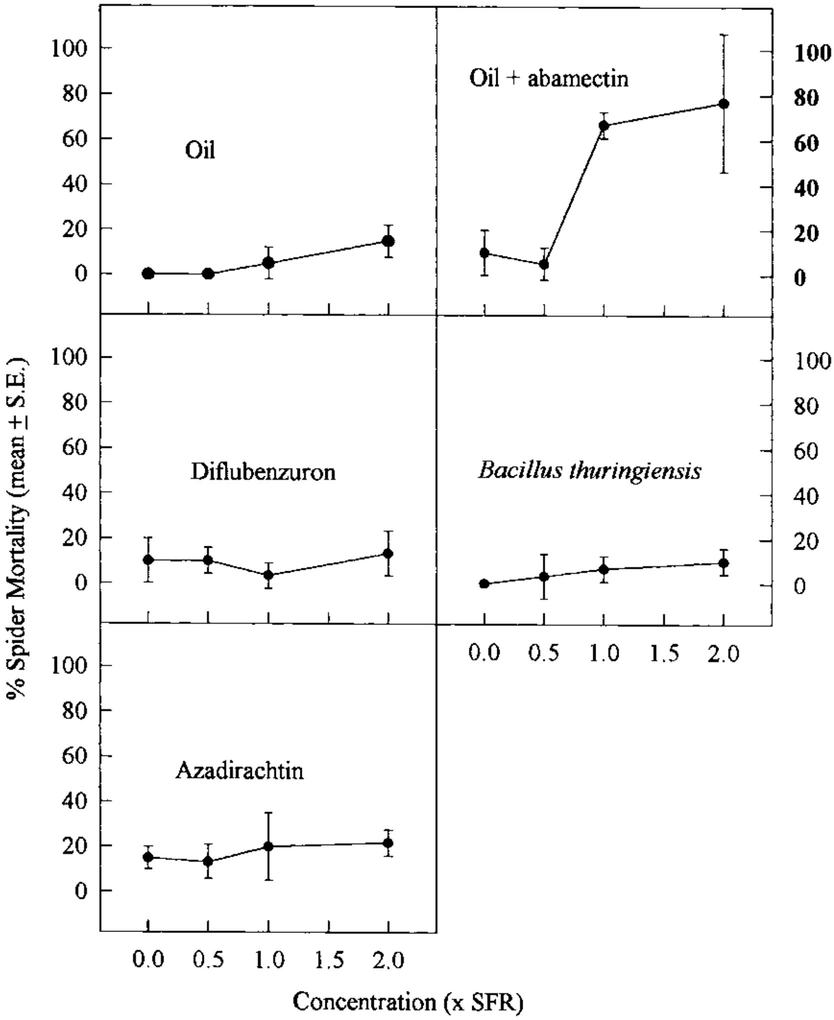


Fig. 4. Percent mortality of spiders exposed to three different concentrations of naturally derived pesticides using a leaf-dip method.

that topical application of 50 g of a neem seed kernel extract did not affect the spider, *Lycosa pseudoannulata*, a major predator of brown planthopper in Southeast Asia.

Fungicides have been shown to have little or no toxicity for spiders (Stark et al. 1995). Thus, results of our toxicity tests with these different groups of pesticides on *H. velox* are comparable to findings of previous laboratory bioassays conducted on other species of spiders.

Villanueva-Jimenez (1998) evaluated the nontarget effects of some of the pesticides used by citrus nursery growers in Florida on adults of *Ageniaspis citricola* Logvinovskaya, an introduced parasitoid of CLM. He found that naturally derived products (neem, azadirachtin) and the insect growth regulator (diflubenzuron) were not toxic to *A. citricola*. Similarly, we found that these types of products had low toxic effect on *H. velox*. The impact of imidacloprid on *H. velox* and *A. citricola* also showed similar trends in our study to that of Villanueva-Jimenez (1998). Provado® applied to foliage was highly toxic, while Admire® used as drench was less toxic to both *A. citricola* and *H. velox.* Ethion, a broad-spectrum organophosphate, was highly toxic to both *H. velox* and *A. citricola*. Abamectin was moderately toxic to *A. citricola* and *H. velox*. Petroleum oil was the safest pesticide for spiders. It was also the safest for *A. citricola* (Villanueva-Jimenez 1998). Previous studies showed that petroleum oil has a short residual activity on natural enemies (Beattie & Smith 1993, Erkilic & Uygun 1997, Beattie et al. 1995), and is cost-effective (Beattie 1992, Beattie et al. 1995). Thus, petroleum oil may be ideal as a component for a pest management program for CLM on limes.

The similarity of our results with the results of other studies on predacious arthropods and parasitoids indicate that the impact of pesticides on the existing pest/natural enemy complex must be taken into consideration when controlling CLM. The broad-spectrum pesticides should be used cautiously. The use of naturally-derived products and petroleum oil should be recommended as an adjunct control measure with biological control to effectively manage the population of CLM.

## ACKNOWLEDGMENTS

We thank Drs. Joseph Knapp, Bruce Schaffer, and Josep Jacas for the review of the manuscript. We also thank Bayer Corporation for supplying us with imidacloprid technical grade sample. Florida Agricultural Experiment Station Journal Series No. R-07175.

## REFERENCES CITED

ABBOTT, W. S. 1925. A method of computing the effectiveness of an insecticide. J. Econ. Entomol. 18: 265-267.

AMALIN, D. M., J. E. PEÑA, AND R. MCSORLEY. 1996. Abundance of spiders in lime groves and their potential role in suppressing the citrus leafminer population. P. 72 *in* M. A. Hoy (ed.). Proceedings, International Meeting: managing the citrus leafminer, 22-25 April 1996, Orlando, Florida, University of Florida, Gainesville, Florida.

AMALIN, D. M., J. REISKIND, R. MCSORLEY, AND J. PEÑA. 1999. Survival of the hunting spider, *Hibana velox* (Becker), raised on different artificial diets. J. Arachnol. 27(2): 692-696.

BEATTIE, G. A. C. 1992. The use of petroleum spray oils in citrus and other horticultural crops. Proc. 1st Nat. Conf. Aust. Soc. Hortic. Sci., Sydney, 1991. Pp. 351-362.

BEATTIE, G. A. C., AND D. SMITH. 1993. Citrus leafminer. Agfact H2.AE.4, second Ed. NSW Agriculture, Orange, Australia 6 pp.

BEATTIE, G. A. C., Z. M. LIU, D. M. WATSON, A. D. CLIFT, AND L. JIANG. 1995. Evaluation of petroleum spray oils and polysaccharides for control of *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae). J. Aust. Entomol. Soc. 34: 349-353.

BROWNING, H. W. 1994. Early classical biological control on citrus. Pp. 27-46 *in* D. Rosen, F. D. Bennet, J. L. Capinera (eds.), Pest Management in the Subtropics, Biological Control—A Florida Perspective. Intercept, Andover, UK.

ERKILIC, L. B., AND N. UYGUN. 1997. Studies on the effects of some pesticides on white peach scale, *Pseudaulacaspis pentagona* (Targ. Tozz.) (Homoptera: Diaspididae) and its side-effects on two common scale insect predators. Crop Protection 16: 69-72.

HEPPNER, J. B. 1993. Citrus leafminer, *Phyllocnistis citrella*, in Florida (Lepidoptera: Gracillariidae: Phyllocnistinae). Trop. Lepidoptera 4: 49-64.

HUANG, M. AND S. LI. 1989. The damage and economic threshold of citrus leafminer (Stainton) in citrus. Pp. 84-89 *in* Studies on the Integrated Management of Citrus Insect Pests. Academic Book and Periodical Press. Beijing (in Chin., Eng. abs.).

KNAPP, J. L. 1996. 1996 Florida Citrus Pest Management Guide. Fla. Coop. Ext. Serv., Institute of Food and Agricultural Sciences. University of Florida, Gainesville, FL.

MANSOUR, F. 1987. Effect of pesticides on spiders occurring on apple and citrus in Israel. Phytoparasitica. 15: 43-50.

PEÑA, J. E., AND R. DUNCAN. 1993. Control of the citrus leafminer in south Florida. Proc. Fla. State. Hort. Soc. 106: 47-51.

SAXENA, R. C., H. D. JUSTO JR., AND P. B. EPINO. 1984. Evaluation and utilization of neem cake against the rice brown planthopper, *Nilaparvata lugens*, J. Econ. Entomol. 77: 502-507.

STARK, J. D., P. C. JEPSON, AND C. F. GEORGE THOMAS. 1995. The effects of pesticides on spiders from the lab to the landscape. Rev. Pestic. Toxic. 3: 83-110.

TAN, B. AND M. HUANG. 1996. Managing the citrus leafminer in China. Pp. 49-52 *in* M. A. Hoy (ed.). Proceedings, International Meeting: Managing the Citrus Leafminer, 22-25 April 1996. Orlando, Florida. University of Florida, Gainesville, FL.

VILLANUEVA-JIMENEZ, J. A. 1998. Development of an integrated pest management program for the citrus leafminer, (Lepidoptera: Gracillariidae) in Florida Nurseries. Ph.D. Dissertation. University of Florida, Gainesville, FL. 133 pp.

VILLANUEVA-JIMENEZ, J. A., AND M. A. HOY. 1997. Current practices in Florida nurseries for managing the citrus leafminer. Citrus Industry 78: 80-85.