POTENTIAL FOR BIOLOGICAL CONTROL OF CROP PESTS IN THE CARIBBEAN

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ABSTRACT

The potential for biological control of important insect pests of crops of economic importance in the Caribbean is evaluated. Crops include sugarcane, coffee, bananas, plantains, sweet potatoes, yams, cassava, tomato, peppers, cabbage, curcubits, some fruits, pigeon pea and beans. Suggestions are made for biological control of major insect pests such as *Diatraea saccharalis*, *Diaprepes abbreviatus*, *Cosmopolites sordidus*, *Cylas formicarius*, *Hypothenemus hampei*, *Leucoptera coffeella*, *Plutella xylostella*, *Heliothis zea* and *Diaphania* spp. Recommendations are made for the proper evaluation and selection of candidate pests.

RESUMEN

Se informa aqui sobre la evaluacion del potencial de control biologico de insectos plagas de los principales cultivos del Caribe. Los cultivos considerados importantes incluyen caña, cafe, platanos, guineos, batata, ñame, yuca, tomate, pimiento, repollo, cucurbitaceas, algunas frutas, gandul y habichuelas. Se hacen sugerencias sobre el control biologico de algunos insectos importantes tales como *Diatraea saccharalis*, *Diaprepes abbreviatus*, *Cosmopolites sordidus*, *Cylas formicarius*, *Hypothenemus hampei*, *Leucoptera coffeella*, *Heliothis zea* y *Diaphania* spp. Se hacen recomendaciones para evaluar las posibles plagas y establecer prioridades para el control biologico en el Caribe.

Biocontrol of plant pests in the Caribbean was almost completely neglected with the advent of pesticides which appeared to be the solution to all pest problems. However, due to the development of resistance in some major pests, as well as to public awareness of hazards posed to human health and the environment searches are being made for seemingly old alternatives.

The tropical environment in the Caribbean facilitates a year round growing season and supports continuous generations of both pests and beneficial organisms. Agriculture is characterized by small subsistence farms, multiple crops and pests, pesticide problems and other problems common to production and marketing.

Biocontrol is now being acknowledged as a major area for further research and is a component of a USDA initiative in sustainable agriculture. The ARS, the Entomology Department Administrators (1988) in U.S. Universities and the Experiment Stations have proposed working groups to prepare national biocontrol research programs. This has evolved as an effective alternative to the pesticide dilemma.

Biocontrol is one of the most thoroughly studied methods against insects, nematodes, diseases and weeds. Scientists are now increasing efforts and emphasis on pest control methods not aimed at wholesale eradication, but rather at maintaining pest populations below economic thresholds.

This has already started in the Caribbean, where efforts of national and international institutions have begun to emphasize and implement biocontrol programs. These efforts

are directed at identification of research priorities and possible areas for cooperation within the region. At present, there are several institutions conducting individual research with little or no regional coordination. Biocontrol efforts and findings remain little known even between neighboring countries. This is due in large measure to inadequate communication between research and development organizations in the region. There are limited means to disseminate and exchange findings (scientific congresses, journals, meetings, seminars, etc.). Lack of funds for research and for attending local or international meetings is by far the greatest constraint to the development of biocontrol in the region. A workshop should serve to identify research needs and to promote interchange of knowledge within the Caribbean community.

There is evidence of the effective biocontrol successes worldwide and in the Caribbean (Cock 1985). Bennet (1990) and Alam et al. (1990) summarized the most important cases of successful biocontrol in the Caribbean. The recent introduction of the citrus blackfly *Aleurocanthus woglumi* in Puerto Rico and its outstanding effective control with the subsequent introduction of the parasitoids *Encarsia opulenta* and *Amitus hesperidum* are a pertinent example (Medina et al. 1991). Chemical control of this pest has been impossible in most places; only biocontrol has been effective.

In Puerto Rico, as in many other Caribbean countries, biocontrol has been used for decades. Table 1 presents information regarding the introduction of parasites and predators into Puerto Rico in the 1900's. Most introductions were made during the 1930's, up to 1940, just before the pesticide era. As often occurs, data on many of these introductions are not available since relevant studies were never conducted.

TABLE 1. PARASITES AND PREDATORS OF INTRODUCED PESTS IN THE 1900'S.

Species	Natural Enemy	Success Level
Scapteriscus spp.	*Larra bicolor*	Partial
Selenothrips rubrocinctus	*Dasyscapsus parvipennis*	Partial
Dysdercus amdreae	*Hyalomya chilensis*	Unknown
	Acauloma peruviana	Unknown
Aleurocanthus woglumi	*Encarsia opulenta*	Successful
	Amitus hesperidum	Successful
Sipha flava	*Coleophora inaequalis*	Unknown
	Scymnodes lividigaster	Unknown
Asterolecanium bambusae	*Cladis nitdula*	Successful
and *A. pustulans*	*Chilocorus cacti*	Successful
Clastoptera undulata	*Carabunia myeresi*	Successful
Pulvinaria psidii	*Cryptolaemus montrouziere*	Partial
Saissetia oleae	*Scutellista cyanea*	Partial
Coccus viridis	*Coccophagus caridei*	Unknown
	Coccophagus fallax	Unknown
	Azya sp.	Unknown
Aspidiotus destructor	*Cryptognatha nodiceps*	Partial
	Cryptognatha simillisima	Unknown
	Azya trinitatis	Partial
	Scymmus aeneipennis	Unknown
	Pentilia castenea	Unknown
	Aphytis lignamensis	Partial
Pseudaulacaspis pentagona	*Encarsia berlesei*	Failure
	Chilocorus cacti	Partial

TABLE 1. (CONTINUED)

Species	Natural Enemy	Success Level
Icerya purchasi	*Rodolia cardinalis*	Successful
Dysmicoccus bonimsis	*Aphycus terryi*	Unknown
	Pseudaphycus mundus	Unknown
Dysmicoccus brevipes	*Hambletonia pseusococcina*	Successful
	Anagyrus coccidivorus	Unknown
Nipaecoccus nipae	*Cryptolaemus montrouzieri*	Partial
Diatraea saccharalis	*Metagonistylum minense*	Unknown
	Paratheresia claripalpis	Failure
	Lixophaga diatreae	Partial
	Apanteles flavipes	Unknown
Pectinophora gossypiella	*Bracon kirpatricki*	Unknown
	Chelomus blackburni	Unknown
	Exeristes robator	Unknown
Leucoptera coffeella	*Mirax insularis*	Partial
Etiella zinckenella	*Macrocentrus ancylovorus*	Failure
	Bracon piger	Failure
	Apanteles beaussetensis	Failure
	Bracon pectoralis	Failure
	Phanerotoma planifrons	Failure
	Cyrtotyx lichtensteini	Failure
	Bracon cajani	Unknown
	Icomella etiellae	Partial
Cosmopolites sordidus	*Plaesius javanus*	Unknown
Phyllophaga spp.	*Bufo marinus*	Partial
Anastrepha suspensa	*Parachasma crawfordi*	Failure
Anastrepha obliqua	*Dirhinus giffardii*	Failure
	Opius tryoni	Failure
	Tetrastichus giffardianus	Failure
	Pachycrepoideus vindemia	Unknown
Mosquitoes	*Gambusia affinis*	Partial
	Poecilia reticulata	Unknown
Haematobia irritans	*Canthon pilualaris*	Unknown
	Phanaeus triangularis	Unknown
	Copris prociduus	Unknown
	Onthophagus incensus	Unknown
	Spalangia endius	Unknown

Some exotic natural enemies have been recently introduced for the control of certain insect pests, such as the citrus black fly, the lima bean pod-borer, and the sugarcane borer and others such as nematodes, diseases and weeds (Cruz & Segarra 1990). Also, several species of entomophilic nematodes for the control of root weevils were introduced and tested.

Some recent biocontrol attempts have been successful in Caribbean countries, i.e. the sugarcane borer, the citrus blackfly, the diamondback moth (to a certain level). On-going projects are devoted to control of the coffee berry borer, *Hipothenemus hampei* (Baker 1990). Two potential parasitoid candidates have been identified: *Prorops*

nasuta, and *Cephalonomia stephanoderes*. These parasitoids will be reared and increased for distribution in the areas where the pest has been identified: Colombia, Jamaica, Mexico, etc. Very positive results are expected from this initiative.

Important Crops and Insect Pests in the Caribbean

Several lists of important pests in the Caribbean have been compiled elsewhere. However, a partial lists of crops and pests which are considered important in the Caribbean are presented in Table 2 and potential biocontrol agents are presented in Table 3. These are based mostly on experience and the literature. Among the most important crops grown in the Caribbean are coffee, sugarcane, bananas, plantains, root crops (sweet potato, yams, taniers, cassava), tomato, peppers, cabbage, cucurbits, citrus, pineapple, avocado, mango, pigeon pea and beans. There are important insect pests attacking these crops, some of them with a high potential for biocontrol (Table 3).

The Sugarcane Borer

The sugarcane borer, *Diatraea saccharalis*, is under effective biocontrol in some countries, but it remains an important limiting factor in several others. Different natural agents have been successful on some countries, probably indicating the influence of varying habitats. This pest offers a good opportunity for classical biocontrol. Several natural enemies have been reported by Bennet (1990) and others. Currently, *Cotesia flavipes*, *Lixophaga diatraeae*, *Metagonistylum minense* and *Trichogramma* spp. are

TABLE 2. Some important crops and their main insect pests in the Caribbean.

Crops	Main Insect Pests
Sugarcane	*Diatraea, Diaprepes, Phyllophaga*
Coffee	*Hypothenemus hampei, Leucoptera coffeella*
Banana and plantains	*Cosmopolites sordidus*
Sweet potato	*Cylas formicarius, Euscepes postfasciatus*
Yams	*Diaprepes*
Cassava	*Silva* spp. (Stem shoot fly), mites
Citrus	*Aleurocanthus woglumi, Diaprepes*, scales
Pineapple	*Batrachedra comosae* (gomosis) *Dysmiococcus brevipes*
Beans	Leafhoppers, whiteflies, pod borers
Pigeonpea	Pod borers, leafhoppers
Tomato	*Heliothis, Liriomyza, Keiferia lycopersicella*
Pepper	*Anthonomus eugenii, Myzus persicae, Thrips palmi*, mites, etc.
Cabbage	*Plutella xylostella*
Cucurbits	*Diaphania* spp.

TABLE 3. SOME IMPORTANT INSECT PESTS AND THEIR POTENTIAL FOR BIOLOGICAL CONTROL IN THE CARIBBEAN.

Insect pests	Biocontrol potential
Root weevils: *Diaprepes abbreviatus*, *Cylas formicarius*, *Cosmopolites sordidus*	Entomopathogenic nematodes, Ants, Entomopathogenic fungi, others
The coffee berry borer *Hypothenemus hampei*	*Prorops nasuta*, *Sephanoderes cephalonomia*
Whiteflies: *Aleurocanthus woglumi*, *Bemisia tabaci*	*Encarsia* spp., *Amitus* sp., *Eretmocerus serius*
Lepidopterous pests: *Diatraea* spp.	*Cotesia flavipes*, *Lixophaga diatraeae*, *Metagonistylum minense*, *Paratheresia claripalpis*, *Trichogramma* spp., Microbial control
Plutella xylostella	*Cotesia plutellae*, *Diadegma insularis*, *Diadegma* sp.
Leucoptera coffeella	*Mirax insularis* - augmentation Others - Conservation, foreign exploration
Diaphania spp.	Several: Conservation and augmentation
Heliothis spp.	Many: Conservation and augmentation
Others: *Liriomyza* spp.	Many: Conservation and augmentation
Thrips palmi	Some: Foreign exploration, conservation and augmentation

the most successful biocontrol agents. Research is needed to continue the improvement of the existing biocontrol agents.

Root Weevils

Historically, the sugarcane rootstalk weevil, *Diaprepes abbreviatus*, has been among the most difficult pest to control in the Caribbean. One contributing factor is the high reproductive potential (5,000 eggs/female) in a situation where very low egg suvivorship is enough for it to be a pest (Armstrong 1987). Several biological control attempts have failed except for entomopathogenic nematodes. However, the search for other biocontrol agents continues. Castro (1986) studied the ants species feeding on neonate larvae. She found seven feeding on the larvae. Of these, *Pheidole subarmata borinquensis* and *Pheidole fallax* demonstrated the greatest efficiency. In Cuba, Castineiras et al. (1990a, 1990b), reported *P. megacephala* controlling *Cosmopolites sordidus* and *Cylas formicarius*. Richman et al. (1983) reported the ants *Monomorium floricola* and *Crematogaster ashmeadi* preying on the egg masses of *D. abbreviatus* in Puerto Rico and Florida, respectively. Colón (1986) found 17 species of fungi associated with the larvae of *D. abbreviatus*. Pathogenicity tests demonstrated that half of them were able to kill the larvae. *Gliocadium* sp. and *Fusarium* sp. caused the highest mortality. Armstrong (1981, 1987) studied the efficiency of the egg parasitoid *Tetrastichus haitiensis* on *D.*

abbreviatus eggs oviposited on sugarcane. He found a low efficiency of the parasitoid and concluded it was probably due to the difficulty of oviposition through the sugarcane leaves as compared to other hosts.

Several species of entomopathogenic nematodes have been tested for the control of the most important root weevils in Puerto Rico. Román & Figueroa (1985) reported effective control of the larvae of *D. abbreviatus* with *Steinernema feltiae* (=*Neoaplectana carpocapsae*). Figueroa & Román (1990) reported tests with *S. glaseri, S. bibioni* and *Heterorhabditis heliothidis* against *D. abbreviatus*. González (1986) observed some control using *H. bacteriophora* and *H. heliothidis*. Figueroa (1990) obtained excellent results with *S. feltiae* and *S. bibioni* against *C. sordidus*. A graduate student is currently evaluating *S. feltiae* and *H. heliothidis* against *C. formicarius*. Several local strains or species of entomopathogenic nematodes recently found in Puerto Rico are being evaluated. Natural enemies against other curculionid pests such as *Exophthalmus* spp. and *Pachnaeus* spp. are being sought in some Caribbean countries.

The Coffee Berry Borer

The coffee berry borer, *H. hampei*, is threatening coffee production in the Caribbean. Biocontrol research has produced encouraging finding. Besides the two parasitoids mentioned in the introduction, other potentially effective parasitoids are under study. An example is *Heterospilus coffeicola*, which has been classified as effective but difficult to rear in the laboratory. Other potential candidates include *Phymasticus coffea, Aphanognus dictynnu* (apparently a hyperparasite of *Prorops nasuta*), and some microbial agents such as *Beauveria bassiana, Metarhizium anisopliae* and *Paecilomyces* spp. These are under study at various research centers worldwide (CENICAFE, Colombia).

The Coffee Leafminer

Another pest of coffee with a high potential for biological control is the coffee leafminer, *Leucoptera coffeella*. Gallardo (1988) and Wolcott (1947) have reported 15 parasitoids from Puerto Rico. Gallardo has proposed a biocontrol program utilizing the augmentation method using the parasitoid *Mirax insularis*. This idea has extraordinary merit and should be pursued vigorously. There are many other natural enemies reported that could be considered when their efficacy and mass rearing techniques are determined. Foreign exploration is another potential alternative which has not been attempted for this pest, which supposedly originated in Reunion (Green 1984).

The Diamondback Moth

The diamondback moth (DBM) *Plutella xylostella* is a lepidopteran pest of importance to the Caribbean with a significant number of natural enemies. It has outstanding potential for a successful biocontrol program. In Puerto Rico several parasitoids are particularly effective. *Diadegma insularis* may have rates of parasitism up to 90% when protected from pesticides. One limitation is the very low economic injury level of the pest. However, the selection of planting dates, use of selective pesticides and the introduction (where not available) of the most effective parasitoids will undoubtedly improve the level of biocontrol.

Alam (1986) reported complete biocontrol with *Trichogramma* spp. and *Cotesia* spp. Bennett & Yasseen (1972) reported effectiveness of *C. plutellae* against DBM in Barbados, Montserrat, St. Vincent and Trinidad.

The Corn Earworm

The corn earworm (CEW) *Heliothis zea* is the limiting factor for sweet corn and other vegetable crops. Chemical control is very difficult, even with an effective insecticide. However, many natural enemies have been observed attacking the eggs and larval stages of this insect (King & Coleman 1989). The wasp *Trichogramma* sp. and the predator *Orius pumilio* are considered by Figueroa (1983) to be the most important natural enemies in Puerto Rico. In the US, CEW infestations are considered more severe in dry than in wet summers because moist conditions favor the development of several fungal and bacterial diseases. Also several species of predators and parasitic wasps attack it. Populations of these natural enemies can significantly reduce or almost eliminate CEW infestations early in the season. Therefore, early season sprays should be delayed in order to allow populations of natural enemies to develop. Frequent sampling and control measures are necessary in vegetables because even minimal damage by this and other pests can render produce unmarketable.

The Melonworm

Usually the melonworm *Diaphania hyalinata* (L.) is the most important insect pest of cucurbits in the Caribbean. Medina et al. (1989) observed several parasitoids and predators in Puerto Rico. No natural enemies have been studied in detail. In Barbados, Alam (1986) reported melonworm eggs parasitized by *Trichogramma pretiosum*, the larvae by *Eiphosoma dentator* and by *Cotesia* sp., and the pupae by *Brachymeria* sp. There is a great potential for the biocontrol of this pest, particularly with microbial insecticides, which are already being used in some countries like Guatemala (Agrícola El Sol, 30 Calle 11-42, Zona 12, Guatemala).

Scale Insects, Whiteflies, Aphids and Thrips

The potential for biocontrol of small insects is well known. Since the introduction of *Rodolia cardinalis* in California in 1892 for control of the cottony cushion scale or the biocontrol of the citrus blackfly in the Caribbean, many outstanding examples have occurred. In Florida, a biocontrol project is seeking natural enemies for whiteflies. As a result, several natural enemies have been recorded from Florida, California, the Caribbean, and Central and South America.

Some Criteria for Biocontrol Target Selection

Because there are many biocontrol success stories and the many introduced pests in the Caribbean, primary emphasis (or first step) should be given to classical biocontrol. The main task is to identify biocontrol agents (Fry 1989) and introduce them where the target species are present. There are many known effective biocontrol agents that still have not been established in countries where target pests are causing crop losses. It is only recently that many species of important pests have been introduced into Puerto Rico and several other islands; e.g., the citrus blackfly, *A. woglumi;* the pepper weevil, *Anthonomus eugenii*; the beet armyworm, *Spodoptera exigua*; the tomato pinworm, *Keiferia lycopersicella*; the imported fire ant, *Solenopsis invicta*; *Thrips palmi*; the sugarcane thrips, *Fulmekiola serrata*; and the avocado lace wing bug, *Pseudacysta persea*. Most recently an apparently new race of the whitefly, *Bemicia tabaci* has invaded the Caribbean, being more destructive and with a wider range of plant hosts than the common whitefly.

Designating priority to pests should be an important goal of local and regional efforts to establish biocontrol programs. Pests, needs, and goals will vary among Caribbean countries. Therefore, a system to evaluate candidate pests should be developed based primarily on three components: 1) an assessment of current or potential impact of the pest to the regional economy; 2) a thorough appraisal of institutional policy and logistic capabilities; and 3) an evaluation of prior biocontrol achievements against the pest. When applied within the context of local conditions, these criteria should insure that the initial phases of a biocontrol initiative in the Caribbean will be as risk free as possible.

Pests should be targeted according to crop importance, impact on the crop, and finally a cost and benefit analysis. Those pests which attack a major commodity with highly predictable temporary consistency, where current management methods are no longer effective, and which are not under quarantine regulations are excellent candidates. Similarly, pests with high economic injury levels, that are non-vectors, and which are sole 'key' pests ought to be given preference as targets. Finally, if funds are scarce, priority should be given to pests with natural control agents which have proven effective elsewhere in contrast to projects requiring more expensive operations like mass rearing or foreign exploration.

The depth of biocontrol achievements against a pest should be the final component of its assessment as a target. Pests where natural enemy taxonomy is well known as well as those where the study of natural mortality is available should be considered first. Targets where successful programs exist abroad should be favored initially.

References Cited

ALAM, M. M. 1986. Vegetable pests and their natural enemies in Barbados, West Indies, Proc. 22nd Caribbean Food Crops Society. 25-29 August, 1986. St. Lucia.

ALAM, M. M., J. C. REID, AND G. MULLER. 1990. The present status and future needs of biological control in the Caribbean community. Caribbean meetings on Biological Control, 5-7 November 1990, Guadeloupe, F.W.I.

ARMSTRONG, A. 1981. Distribución de *Diaprepes abbreviatus* L. (Coleoptera:Curculionidae) y *Tetrastichus haitiensis* Gahan (Hymenoptera:Eulophidae) en las áreas cañeras del norte y noroeste de Puerto Rico. M.S. Thesis, RUM-UPR. 83 pp.

ARMSTRONG, A. 1987. Parasitism of *Tetrastichus haitiensis* Gahan on egg masses of *Diaprepes abbreviatus* in Puerto Rico. J. Agric. Univ. P.R. 71(4): 407-409.

BAKER, P. 1990. Biological control of the coffee berry borer. CARAPHIN News, No. 2, IICA, Trinidad and Tobago.

BENNETT, F. D. 1990. An overview of Classical Biological Control in the Caribbean and some examples of the utilization of entomophagous insects. Caribbean Meetings on Biological Control, 5-7 November 1990, Guadeloupe.

BENNETT, F. D. AND, M. YASSEEN. 1972. Parasite introduction for the biological control of three pests in the Lesser Antilles and British Honduras. PANS 18: 468-474.

CASTINEIRAS, A., A. BORGES, AND O. OBREGON. 1990a. Biological control of *Cylas formicarius elegantulus* (Summ.). Caribbean Meetings on Biological Control, 5-7 November 1990, Guadeloupe.

CASTINEIRAS, A., T. CABRERA, A. CALDERÓN, M. LÓPEZ, AND M. LUJÁN. 1990b. Lucha biológica contra *Cosmopolites sordidus*, Caribbean Meetings on Biological Control, 5-7 November 1990, Guadeloupe, F.W.I.

CASTRO, S. 1986. Hormigas depredadoras de larvas neonatas de *Diaprepes abbreviatus* (Coleoptera:Curculionidae). M.S. Thesis, RUM-U.P.R. 72 pp.

COCK, M. J. W. 1985. Review of Biological Control of Pest in the Commonwealth Caribbean and Bermuda up to 1982. Commonwealth Inst. Biol. Cont. Tech. Comm. #9. 244 pp.

COLÓN, I. 1986. Estudio preliminar de generos de hongos aislados de larvas de *Diaprepes abbreviatus* en el área oeste de Puerto Rico y su evaluación como control biológico. M.S. Thesis, R.U.M.-U.P.R. 30 pp.

COUNCIL OF ENTOMOLOGY DEPARTMENT ADMINISTRATORS. 1988. Research Initiatives, A Research Agenda for Entomology, Prepared by the Subcommittee on Research Initiatives, T. Don Canerday, Chairman, Univ. of Georgia, Ga.

CRUZ, C., AND A. SEGARRA. 1990. Recent biological control experiences in Puerto Rico. Caribbean Meetings on Biological Control, 5-7 November 1990, Guadeloupe, F.W.I.

FIGUEROA, W. 1990. Biocontrol of the banana root borer weevil, *Cosmopolites sordidus* (Germar), with steinernematid nematodes. J. Agric. Univ. P.R. 74(1): 15-20.

FIGUEROA, W., AND J. ROMÁN. 1990. Parasitism of entomophilic nematodes on the sugarcane rootstalk borer, *Diaprepes abbreviatus* L. (Coleoptera:Curculionidae), larvae. J. Agric. Univ. P.R. 74(2): 197-202.

FIGUEROA, E. 1983. Ciclo vital y enemigos naturales de *Heliothis zea* en maíz. M.S. Thesis, R.U.M.-U.P.R. 110 pp.

FRY, J. M. 1987. Natural enemy data bank. CAB International Institute of Biological Control, United Kingdom, 185 pp.

GALLARDO, F. 1988. Faunal survey of the coffee leafminer (*Leucoptera coffeella*) parasitoids in Puerto Rico. J. Agric. Univ. P.R. 72(2): 255-62.

GONZÁLEZ, N. 1986. Evaluación de dos nematodos entomófagos *Heterorhabditis heliothidis* y *H. bacteriophora* (Rhabditoidea:Heterorhabditidae) en el control de la larva de *Diaprepes abbreviatus* (L.) (Coleoptera:Curculionidae). M.S. Thesis, R.U.M.-U.P.R. 36 pp.

GREEN, S. D. 1984. A proposed origin of the coffee leafminer *Leucoptera coffeella* (Guérin-Méneville) (Lepidoptera:Lyonetidae). Bull. Entomol. Soc. Am. 30: 30-31.

KING, E. G., AND R. J. COLEMAN. 1989. Potential for biological control of *Heliothis* species. Annu. Rev. Entomol. 34: 53-75.

MEDINA, S., E. ABREU, F. GALLARDO, AND R. FRANQUI. 1989. Natural enemies of the melonworm, *Diaphania hyalinata* L. (Lepidoptera:Pyralidae), in Puerto Rico. J. Agric. Univ. P.R. 73(4): 313-320.

MEDINA, S., A. SEGARRA, AND R. FRANQUI. (in press). La mosca negra ed los cítricos, *Aleurocanthus woglumi* Ashby (Homoptera:Aleyrodidae) en Puerto Rico. J. Agric. Univ. P.R.

RICHMAN, D. B., W. F. BUREN, AND W. H. WHITCOMB. 1983. Predatory arthropods attacking the eggs of *Diaprepes abbreviatus* (L.) (Coleoptera:Curculionidae) in Puerto Rico and Florida. J. Georgia Entomol. Soc. 18: 335-342.

ROMÁN, J., AND W. FIGUEROA. 1985. Control of the larva of the sugarcane rootstalk borer, *Diaprepes abbreviatus* (L.) with the entomogenous nematode *Neoaplectana carpocapsae* Weiser. J. Agric. Univ. P.R. 69(2): 153-158.

WOLCOTT, G. 1947. A quintessence of sensitivity: The coffee leaf miner. J. Agric. Univ. P.R. 31: 215-219.