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PEST MANAGEMENT OF *Annona* spp. IN FLORIDA AND SOUTH AMERICA

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ABSTRACT

The *Annona* seed borer *Bephratelloides* spp., (Hymenoptera: Eurytomidae) and the fruit borer *Cerconota anonella* Sepp., are the key pests of *Annona* crops in the Caribbean region and tropical America. Summary information is given on the biology, chemical and biological control of both pest species.

INTRODUCTION

Fruit species within the plant family Annonaceae are considered to have great potential for utilization and export in the Caribbean countries (Pinchinat et al., 1981). Despite the primitive nature of cultural practices (Wilson, 1981) the soursop, *Annona muricata*, and the sugar apple, *Annona squamosa*, are currently exported as frozen commodities (Maynard, 1981) or as fresh fruits to Europe and the United States. Exports of these crops from the Caribbean have increased substantially during the past 10 years, surpassing traditional crops such as guava (Maynard, 1981; García, 1981; Marte, 1981). Annonas are also cultivated in southern Florida, where demand exceeds current production (Knight et al., 1984).

Annona pests in tropical America and the Caribbean consist of two key insect species, and numerous problems of pathological and secondary nature. The *Annona* seed borers, *Bephratelloides cubensis* and *B. maculicollis*, and the fruit borer *Cerconota anonella* Sepp., are recognized as the major constraints of production (Knight et al., 1984). Although these constraints are recognized, there is little actual documentation on systems to control these pests. Losses due to the seed borer have been reported to exceed 60% in Florida (Pena et al., 1984) and more than 50% in the Caribbean Region (Brussell and Wiedijk, 1975).

The present paper summarizes results from studies conducted in Florida, U.S.A., and Medellín, Colombia, to determine the biology of these insects, and cultural, chemical and biological control methods.

Annona Seed Borer (ASB)

The first key pest is the complex of different species of Bephratelloides spp., which are oligophagous, multivoltine Annona-seed feeders and commonly occur in damaging numbers in South and Central America, the Caribbean and Southern Florida (Pena et al., 1984; Brunner and Acuna, 1967; Brussel and Weidjik, 1975). Hosts recorded for the Annona seed borers include Annona muricata, A. squamosa, A. squamosa x A. cherimola, A. reticulata, A. cherimola, A. montana, and A. glabra.

Biology

The biology of B. cubensis was studied in Cuba by Brunner and Acuna (1967). They concluded that ASB has approximately 4-5 generations per year, egg stage lasts 12-14 days, larval stage 6-8 weeks, and pupal stage 12-18 days.

The wasp prefers fruit sizes in the range of 1.5-5.0 cm diameter. Although fruits larger than 5 cm are attacked, usually when ASB populations are high, most of these attacks probably do not result in infestation. Preferred fruit sizes correspond with those stages in which the seeds are presumably still very soft and easy to penetrate with the ovipositor; the seeds of larger, older fruits are probably too hard to penetrate. Larger fruits may be less preferred also because the distance from the fruit surface to the seed may exceed the length of the ovipositor.

Nadel and Pena (1990) concluded that ASB populations develop during the winter months in Florida, mainly in the bullock's heart (A. reticulata). Because this fruit is not grown extensively, populations of adult ASB, which emerge from February to the end of the fruiting season in late May, are relatively low. Atemoyas, which begin setting fruit in April, become infested early in the season because they tend to set fruit after the majority of the ASBs have emerged from bullock's heart and died. This lower initial infestation in sugar apple orchards is later reflected in a lower overall infestation compared with atemoya. This trend holds even when the two crops are adjacent, which suggests that adult ASB will stay near the area of emergence if fruits are available for them to infest. After a development time of about 9 weeks, ASBs emerge from early atemoyas and proceed to infest younger atemoya and some sugar apple fruits. Emergence, and therefore new infestations, occurs for several weeks, and may not abate until the end of the fruiting season.

Sampling

Pena et al. (1984) observed that peaks of adult activity are observed at 15:00 hr when the average temperature fluctuates around 31-33^{o}C. Oviposition (Nadel and Pena, 1990) is more frequent at 15:00 and 16:00 hr than at other times. Nadel and Pena observed ASBs in the middle stratum of the outer tree canopy; thus future monitoring of ASBs populations should concentrate on the middle canopy of the tree and should be conducted between 9:00 and 16:00 hr.

Cultural Control

Bagging prevented infestation by ASB (Table 1). The materials of bags used were brown paper, glassine, and polyethylene. Brown paper and glassine were inadequate because the seams quickly became unglued in the wet spring weather. Polyethylene bags held up for the duration of fruit growth. Small fruits (ca. 1-1.5 cm in diameter) were bagged before they reached the vulnerable size. Early in the season, however, the grower can bag fruits without regard to size, since infestation is usually very low. Ideally, fruits should be bagged just before they reach vulnerable size; very small fruits have a high probability of aborting. Bagging includes not only applying the bag (20-30 sec.) but also searching for the unbagged fruit, which takes much longer.

Table 1. Effectiveness of bagging Annona fruits against infestation by Bephratelloides cubensis.

	Grove 1	Grove 2	Grove 3
No. fruits bagged	100	100	100
No. fruits matured	58	76	58
No.(%) fruits infested	0(0)	0(0)	0(0)
No. control fruits	88	50	100
No.(%) controls infested	34(38.6)	8(16.0)	11(11.0)

Grove 1: Atemoya, pesticide free.
Grove 2: Atemoya, pesticides applied
Grove 3: Sugar apple, pesticide free.

Chemical Control

Under laboratory conditions malathion and permethrin were highly toxic to ASB adults (Table 2). At 24 hr after treatment malathion at 0.57 g ai/l killed all ASB adults, while permethrin at 0.256 g ai/l produced 98% mortality. Mean LD 50 was 0.039 g ai/l for malathion and 0.034 g ai/l for permethrin. Under field conditions malathion toxicity to ASB adults was significantly greater than the control, but not to the other insecticides used (Table 3).

Table 2. Mortality of Annona seed borer in the laboratory.

Treatment	Dose g ai/l	% Mortality at 24 h	48 h		
Permethrin	0.256	98	98		
	0.0256	54	62		
	0.00256	10	26		
	0.000256	4	16		
	0.0	8	20		
				LD 50	0.039
Malathion	0.57	100	100		
	0.057	53	68		
	0.0057	10	25		
	0.0	3	10		
				LD 50	0.034

Table 3. Chemical control of the Annona seed borer adults under field conditions.

Treatment	Dose lb ai/A	No. adults dead/plot
Fenvalerate	0.10	0.875ab
Permethrin	0.21	0.375ab
Malathion	0.24	1.370a
Acephate	0.75	1.125ab
Control		0.125 b

Numbers followed by a different letter are significantly different (Duncan's 1955 multiple range test).

Biological Control

The fungus *Beauveria bassiana* was collected from an ASB adult. To our knowledge, this pathogen is the only biological control agent identified from ASB. The fungus was applied to ASB adults under laboratory conditions, providing 90% adult mortality 8 days post treatment.

Annona Fruit Borer (AFB)

The Annona fruit borer (AFB), Cerconota anonella Sepp. (Lepidoptera: Stenomiidae) is the second key pest of Annona spp. This species, recorded in northern South America, Ecuador, Brazil, Central America and the Caribbean (Fennah, 1937; Martínez and Godoy, 1983; Lawrence, 1974; Zenner and Saldarriaga, 1969; Gutierrez y Trochez, 1977), damages the fruit epidermis, pulp and seeds during larval feeding (Fennah, 1937).

Biology

The AFB life cycle, investigated by Bustillo and Pena (Unpublished data), averages 36.4 days, undergoes five instars and larval life span is 18.56 days at room temperature (21°C). Preliminary observations show that males are attracted to virgin females when placed in cardboard traps. Attraction to black light traps was also observed, which could be useful in monitoring populations of C. anonella.

Biological Control

Sampling for parasites of C. anonella consisted of collections of fruits of A. muricata, A. reticulata, A. montana, and A. cherimola in Colombia and Ecuador, where two braconid species were identified as natural enemies of C. anonella: Apanteles spp., and an unknown genus of the subfamily Rogadinae. Parasitism by Apanteles ranged from 2-5% in Colombia and 2% in Ecuador. The Rogadinae species was recorded for the first time from Palmira, Colombia. The results contrast with high parasitism levels from other braconid species observed in Venezuela by Martínez and Godoy (1983).

Chemical and Cultural Control

The effect of different types of protective bags and insecticides were tested in 3-5-year-old A. muricata trees. Treatments were (1) fruits covered by plastic bags treated with chlorpyriphos (1.0%), (2) fruits covered by nylon bags closed at both ends, (3) carbaryl (80% WP) and Mancozeb (Dithane M45) applied to fruits, and (4) untreated fruits. Results are shown in Table 4. Fruits with chlorpyriphos treated bags were attacked at significantly lower rates than fruits with plastic bags or direct chemical treatment. All treated fruit was less damaged than untreated ones. Thus, only chlorpyriphos treated bags appeared to be efficacious in protecting fruits from C. anonella attack. Our studies suggest that fruit bagging may be a useful addition to control programs for C. anonella, and the use of pesticide treated bags may enhance its efficacy. Pesticide treated bags also have reduced infestation of B. cubensis in Costa Rica (Villalobos, 1987) and may therefore give an adequate control of both insect species.

Table 4. Effect of cultural and chemical control on Cerconota anonella in soursop fruits.

Treatment	Fruit Infested %	Undamaged fruit %
Chlorpyriphos bag	5.4	91.9a*
Nylon bag	14.3	65.7b
Carbaryl+ Dithane M45	44.4	55.5b
Control	72.7	22.7c

*Means followed by the same letter within a column are not significantly different (Duncan's multiple range test, p=0.01).

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