PREDATORY ANTS OF *DIAPREPES ABBREVIATUS* (COLEOPTERA: CURCULIONIDAE) IN CITRUS GROVES IN MARTINIQUE AND GUADELOUPE, F.W.I.

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Although ants were used as biocontrol agents by different ancient cultures, few works on the possible use of ants as natural enemies of agricultural pests are known. The role of ants in protecting forests against hervibores in the northern hemisphere is well documented (Pavan 1961, Gosswald et al. 1968). Several studies, evaluating ants as possible predators of pests, have been carried out on cocoa plantations in Africa (Leston 1972, 1973, Majer 1972, Room 1971) and in South America (Jaffe et al. 1987). Also, ants may interfere with control agents for tuliptree aphids (Dreistadt et al. 1986). Tryon (1986) and Fowler (1988) showed that ants have an untrapped potential in biological control, including citrus grove pests.

Among the 23 species of 5 genera of Curculionidae known to attack citrus in Martinique and Guadeloupe, *Diaprepes abbreviatus* (L.), *D. famelicus* (Oliver), *D. marginatus* (Fabrcius) and *Litostylus pudens* (Boheman) are common pests since 1973, though *D. marginatus* is absent in Martinique (Mauleon & Marival 1986). Although it is not the primary problem affecting production, they remain an important insect pest on citrus. Whitcomb et al. (1982) reported two *Pheidole* species, *Tetramorium simillum* and *Paratrechina bournonica* as possible control agents for *D. abbreviatus* in Florida, though different live stages of these curculionids may be affected by various predators (Whitcomb et al. 1982, Mauleon & Marival 1986, Tryon 1986). *Diaprepes spp* deposit their eggs between leaves that are glued together with a genital secretion. Once the larvae emerge, they drop to the ground and penetrate into the soil where they spend all their larval stages. The insect pupates in the soil. Life stages that might be succeptible to ant predation are, the eggs, first instar (before burying), and recently emerged adults. To evaluate the possibility of using ants for biological control of *Diaprepes* pests in the French Antilles, a search was made for the most promissing autoctonous ant species.

Ant species in citrus groves were collected from October 1986 to April 1987 on trees and on the ground, during a minimum of 4 h at each site following the hand collecting method described elsewhere (Romero & Jaffe 1989). Collections were made only during the day. Sites visited were: Guadeloupe: Vieux-Habitants (1), Capesterre (2) and Duportail (3); and Martinique: Riviere Lezarde-Saint Joseph (1), Habitation Moulin a Eau-Le Robert (2), Hab. Belle Vue-Marigot (3), Hab. Concorde-Sainte Marie (4), Hab. Grand Case-Le Precheur (5) and Morne Rouge (6). In Table 1, only species that were collected in more than two trees at each location were reported.

Groups of at least 10 eggs, first or last *D. abbreviatus* instars or 1 adult were offered to workers of at least 3 different colonies on the ground around citrus trees, in Riviere Lezarde, Martinique, in Vieux Habitantes and in Capesterre, Guadeloupe. Ant species collecting all eggs or larvae 10 min after a scout ant discovered the food, or attacking

TABLE 1. ANT SPECIES FOUND IN DIFFERENT CITRUS GROVES IN FRENCH WEST INDIES, THEIR ABILITY OF PREYING ON DIFFERENT LIVE STAGES OF *D. ABBREVIATUS*, AND THEIR NESTING AND FORAGING HABITS.[1]

Ant species	Site number: Martinique 1	2	3	4	5	6	Guadelupe 1	2	3	Predation on life stage: a	b	c	d	e	Habits: Nest	Foraging
PONERINAE																
Ectatomma ruidum Roger	–	–	–	–	–	–	x	x	x	–	+	+	+	–	T	TA
Odontomachus bauri Emery	–	–	–	–	–	x	–	x	–	–	–	–	–	?	T	T
Odontomachus haematodus (L.)	x	–	x	–	–	–	x	–	–	?	?	?	?	?	T	T
FORMICIANE																
Nylanderia steinhelli (Forel)	–	x	–	–	x	x	–	x	–	?	?	?	–	–	A	A
Nylanderia sp.	x	D	D	D	x	x	D	x	D	–	–	–	–	–	TA	TA
Brachymyrmex sp.	D	D	x	D	x	x	–	x	–	?	?	?	–	–	A	TA
Paratrechina longicornis (Latr.)	x	–	x	–	–	–	x	x	x	–	–	–	+	–	T	TA
Camponotus sexguttatus (Fabr.)	x	x	x	–	x	–	–	–	–	–	?	+	+	–	T	TA
Camponotus sp.	x	–	–	–	–	–	–	x	–	?	?	+	+	?	T	TA
DOLICHODERINAE																
Azteca delpini Emery	–	–	–	–	–	–	x	D	x	+	+	+	+	+	A	TA
Tapinoma littorale Wheeler	–	–	–	–	–	–	x	–	–	–	–	+	–	–	TA	TA
MYRMICINAE																
Pheidole fallax Mayr	D	D	D	x	x	x	x	x	x	?	+	+	+	+	T	TA
Solenopsis geminata (Fabr.)	x	x	x	x	D	x	x	x	x	?	+	+	+	+	T	TA
Crematogaster sp.	–	–	–	–	–	–	x	D	–	–	+	+	–	–	A	A
Wasmania auropunctata (Roger)	–	x	x	x	x	D	x	x	x	–	+	+	–	–	TA	TA
Leptothorax sp.	x	–	x	x	x	–	x	–	–	–	–	–	–	–	TA	TA
Monomorium destructor (Jerdon)	x	x	x	x	x	x	–	–	–	+	?	?	?	?	TA	TA
Monomorium floricola (Jerdon)	x	–	x	–	–	x	x	x	–	+	+	?	–	–	TA	TA
Solenopsis sp.	–	x	–	–	–	–	x	x	–	+	+	+	–	–	TA	Ta
Cyphomyrmex rimosus (Spinola)	–	x	x	x	x	x	x	x	–	–	–	–	–	–	T	T
Mycocepurus smithi Forel	–	–	x	–	–	x	x	x	–	–	–	–	–	–	T	T

a: eggs protected with leaves; b: exposed eggs; c: first instar; d: last instar; e: adult *D. abbreviatus*.
x: species collected at that site; D: species is dominan in that site.
+: 100% of samples taken by workers; ? sample partially taken.
T: terretrial; A: arboreal.

the adults were recorded. Eggs were offered on paper (exposed) or inside two citrus leaves sealed by adult *D. abbreviatus* females (protected). Exposed eggs were observed for 2 h whereas protected eggs were left on the trees for up to 48 h and the ant species collecting them were noted.

The ant species found on citrus groves in Martinique and Guadeloupe are listed in Table 1. The citrus ant fauna of the two islands is similar and many species are common to all groves in both islands.

Not all species found in citrus groves preyed on *D. abbreviatus* (Table 1). *Monomorium floricola*, *M. destructor* and *Solenopsis spp* only preyed on eggs, whereas *Camponotus sp* and *Ectatomma ruidum* preyed on adults or late instar. *Azteca delpini*, *Pheidole fallax* and *Solenopsis geminata* preyed on all live stages of *D. abbreviatus*.

First *D. abbreviatus* instars, though preyed upon, appeared to repell ants (with the possible exception of *P. fallax*). Workers collecting larvae dropped them, and carried them to the nest only after many attempts. *Paratrechina longicornis* did not collect them, although they did transport the much larger last instar. Freshly laid *D. abbreviatus* eggs (less than 48 h old) were mostly ignored by the ants, even if they were presented without the protecting leaf-shield. Older eggs (more than 4 days old) were normally collected without problems by the species listed as egg-predators in Table 1. The ants most promissing as biological control agents are:

Azteca delpini forms huge colonies which may involve over a dozen trees. Transport of nests is not easy but colonies may be introduced and left to establish themselves. The colonies effectively hinder curculionid access to trees. Trees with *A. delpini* are greener and healthier in appearance, although this may also be due to the ants preference for trees with a closer and denser canopy. Site 2 in Guadeloupe (Table 1), where *A. delpini* was dominant, is also the site with the fewest *Diaprepes* pest problems.

Pheidole fallax, which nests on the ground is a very effective predator of first instars on the ground. In mean it finds them in less than 3 min, if larvae are placed not farther than 1 m from their nest (n = 8). Thus, *P. fallax* might be able to find first instars before they bury themselves, or might collect the practically immobile recently emerged adults. *P. fallax* is rarely seen on trees, and its colonies do not survive floodings. Cultural practices that leave dry strips of earth between the trees favor the establishment of these ants.

Solenopsis geminata, also nests on the ground and is an effective predator of the weevil pest. *S. geminata* could be managed as described for *P. fallax*.

Monomorium floricola and *M. destructor*, nests on trees in hollow twigs and branches. Their nesting habits make it easy to transfer colonies. These ants might be the most efficient egg predator if sufficient large colonies could be maintained in all citrus trees.

A. delpini is very territorial and will exclude all other species from the trees they inhabit. Thus, two main possibilities for biological control should be tested. *A. delpini*, used alone as a control agent; or, a combination of *P. fallax* and/or *S. geminata* in the soil, plus *Monomorium spp* and/or *Solenopsis sp* on the trees

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QUEENS OF THE SOUTHERN YELLOWJACKET, *VESPULA SQUAMOSA*, PRODUCE SEX ATTRACTANT (HYMENOPTERA: VESPIDAE)

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Sex pheromones have been implicated in the mate-finding and courtship behavior of vespine wasps, including species of *Vespula* and *Dolichovespula*, commonly referred to as yellowjackets. Queen-produced sex pheromones that elicit copulatory responses in males have been demonstrated for *Vespula maculifrons* (Buysson) (Ross 1983) and for the hornets *Vespa mandarinia* Smith (Ono et al. 1985), *Vespa analis* F., *Vespa tropica* L., *Vespa simillima xanthoptera* (Cameron), and *Vespa crabro* L. (Ono and Sasaki 1987, Batra 1980). Observations of queens and males of *V. maculifrons* (Post and Jeanne 1983, Ross 1983), *Vespula germanica* F. (Thomas 1960), *Vespula atropilosa* (Sladen) (MacDonald et al. 1974), and *Dolichovespula sylvestris* (Scopuli) (Sandeman 1938) suggest that female pheromones function as male sex attractants. However, there have been no experimental demonstrations of sexual attraction of either sex in any of the Vespinae. In *V. mandarinia*, Ono et al. (1985) showed that males are attracted to workers, males, and queens in what appeared to be an aggregation, rather than sex attraction, response. We report here the demonstration of upwind oriented flight by male *Vespula squamosa* (Drury) in a flight tunnel in response to new queens and to extracts of new queens. This is the first evidence of a sex pheromone in this species and the first experimental demonstration of a sex attractant in the Vespinae.