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Pheidole ants as potential biological control agents of the boll weevil, *Anthonomus grandis* (Col., Curculionidae), in Southeast Brazil

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Abstract

This study evaluates the potential of ants as natural biological control agents of the boll weevil (*Anthonomus grandis*), during the between-season period, in South-east Brazil. Active adults of *Anthonomus* were experimentally distributed on the ground of the cotton field. Results show that 20 % of the adult *Anthonomus* are attacked and removed by foraging ants. The native ant *Pheidole oliveirai* was by far the most efficient predator, accounting for 94 % of the predation on *Anthonomus*. Recruited workers of *P. oliveirai* were usually very fast at transporting the weevils to their nests. The potential benefit of suppressing overwintering adult *Anthonomus* during the between-season period is mainly that of reducing the risk of high level infestations during the next cropping cycle.

1 Introduction

The boll weevil, *Anthonomus grandis* Boh., has been of increasing concern in Brazil since 1983, when it was first detected in cotton fields in the State of São Paulo (HABIB and FERNANDES 1983). *Anthonomus grandis* is now considered one of the most important pests of cotton in Brazil, and its increasing abundance has stimulated studies aiming to suppress its populations in the cotton agroecosystem. Much work has been done concerning the use of chemical control (HABIB et al. 1984a; BLEICHER and ALMEIDA 1988a, b), pheromones (HABIB et al. 1984b; FERNANDES et al. 1991a), natural enemies (PIEROZZI 1985, 1989; CARVALHO et al. 1991), as well as feeding and oviposition behavior of the boll weevil (PIEROZZI 1985, 1989; FERNANDES et al. 1991b).

Ants (Formicidae) possess many characteristics that are associated with the potential to act as biological control agents, especially in tropical agroecosystems (see RISCH and CARROLL 1982a, b). Due to their abundance and ecological dominance, their stability as populations, diversity of feeding habits, and eusocial mode of life, ants play a major role in many habitats and therefore can be very useful in Insect Pest Management Programs (HÖLLDOBLER and WILSON 1990; WAY and KHOO 1992).

Ants have been considered the most important predators of *Anthonomus grandis*, and those in the myrmicine genus *Solenopsis* ('fire ants') were shown to have the greatest impact on boll weevil populations in North America (STERLING 1978; JONES and STERLING 1979; AGNEW and STERLING 1981; STURM and STERLING 1990). Some species in the cosmopolitan ant genus *Pheidole* (Myrmicinae) are known to prey on eggs of pest insects from different cropping species (GASOGO 1982; RISCH 1981; JAFFÉ et al. 1986; GODFRET et al. 1989; WAY and KHOO 1992). GRAVENA and PAZETTO (1987) have recently shown that *Pheidole* ants

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are much more important than *Solenopsis* at preying on eggs of the cotton leafworm *Alabama argillacea* (Hbn.) in a cotton field in Jaboticabal, São Paulo.

The act of predation is usually very hard to be observed in nature, and predators constitute the less studied category of natural enemies of the boll weevil. Ants are major components of the insect fauna in the Neotropical region (FITTKAU and KLINGE 1973), but surprisingly very little is known about their importance as predators of insect pests, including the boll weevil in Brazil. The present study evaluates the potential of ants as natural biological control agents of *Anthonomus grandis* during the between-season period. During such a period most of the adult population of the weevil is found either on alternative host plants or on the ground (FERNANDES et al. 1991a); there is also a possibility that part of the population enters diapause (CROSS 1973; CAMPANHOLA et al. 1986; HENNEBERRY et al. 1990).

2 Methods

Field work was carried out from May to October 1991, in an area of 7000 m^2 in Santo Antonio de Posse (22°35'S, 46°55'W), State of São Paulo, South-east Brazil. Cotton was previously cultivated in the area, and no chemical insecticides have been utilized for pest control. At the end of the cropping cycle the cotton was harvested and the field was cleared from the remainder of the crop. The area was not re-used for cultivation during the study period.

An experiment using active adults of *Anthonomus grandis* was conducted in the field in order to investigate whether ground ants could act as biological control agents of the boll weevil. Active adults *of Anthonomus* were collected in neighboring cotton fields which had been cultivated late in the season, or on alternative host plants. In the laboratory, the weevils were kept in plastic boxes until their utilization for the field experiments. Groups of five active adults *of Anthonomus* were each distributed on the ground of 82 plots (4 m^2 each) which were randomly selected in the study area. In 20 other similar-sized plots, groups of five larvae *of Anagasta kuehniella* (Zell.) (Lep., Pyralidae) were also distributed to provide comparative standard data on predation by ants. Ant attacks on *Anthonomus* and *Anagasta* were monitored each minute during a 20 min period.

All ants observed attacking either *Anthonomus* or *Anagasta* were collected for taxonomic identification. The ant genus *Pheidole* is currently under a taxonomic revision by E. O. WILSON (Harvard University) and W. L. BROWN Jr. (Cornell University), and the description of *Pheidole oliveirai* Wilson & Brown as a new species is in progress. Therefore our usage of the name *Pheidole oliveirai* in the present paper is not intended to serve as an original taxonomic description.

3 Results and discussion

The results from the field experiment indicate that 20% of the adult *Anthonomus*, and 61% of the *Anagasta* larvae, were attacked and removed by foraging ants on the ground of the cotton field (table). The far greater proportion *of Anagasta* caterpillars being preyed and removed by ants is probably due their lower mobility on the ground, and much softer integument when compared to the adult boll weevils. The rigid structure of the weevils' exoskeleton and their intense mobility (including flight capability) enabled 9.5 % of the beetles (39 out of 410) to break free after ant attacks. Some adult weevils also exhibited thanatosis when confronting the ants. *Angasta* larvae, on the other hand, were never able to escape from ant attacks (table).

Ant predation on active adults of *Anthonomus grandis* and on larvae of *Anagasta kuehniella* at a cotton field in Southeast Brazil. *Anagasta* caterpillars were attacked and removed by ants at a significantly higher proportion than *Anthonomus* ($P < 0.001$, X^2 test)

Type of prey	Percentage of prey attacked and removed by ants	Percentage of prey escaping after attacks by ants
Anthonomus grandis (n = 410)	20.0% (82)	9.5% (39)
Anagasta kuehniella (n = 100)	61.0% (61)	0.0% (0)

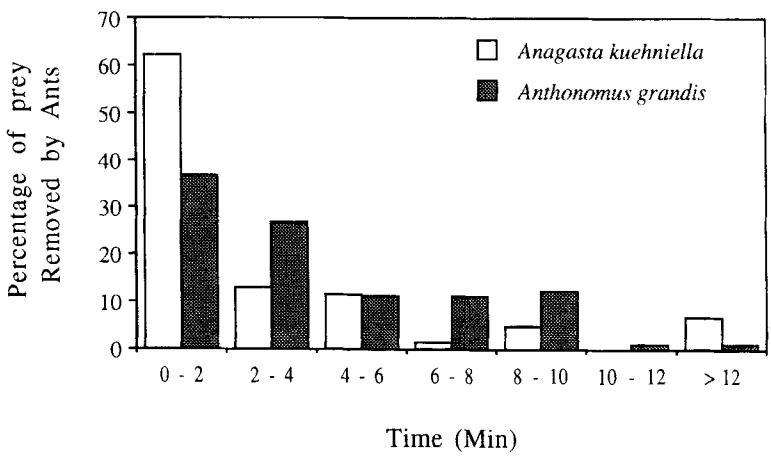
The rate of predation by foraging ants indicate that the vast majority of both *Anthonomus* and *Anagasta* are intensively attacked and removed during the first minutes of the experiment (fig.). *Anagasta* caterpillars, however, are preyed at a much faster rate than adult weevils ($P < 0.05$, see fig.). Weevils which were not immediately attacked by the ants usually walked and/or flew away from the experimental plot.

One species in each of four ant genera were observed in the field: *Pheidole, Solenopsis, Conomyrma, Tapinoma*. The ant *Pheidole oliveirai* was by far the most efficient predator during the field experiment, accounting for 94 % of the predation events on *Anthonomus* and 79 % on *Anagasta*. Nests of *P. oliveirai* were dispersed fairly uniformly across the study area, and groups of recruited workers (including soldiers) were usually very fast at transporting either type of prey to their nests.

The present field experiment indicates that adult beetles occurring on the ground of the cotton field (either active or quiescent) must face the risk of ant predation. The fact that the experiment was conducted using only active adult weevils (i.e. able to escape) suggests that natural predation by foraging ants may be even higher in the cotton agroecosystem. STERLING (1978) showed that *Solenopsis invicta* Buren can be very efficient at suppressing larval stages of *Anthonomus*, consuming up to 85 % of the weevils in a cotton field in Texas (USA). Moreover, AGNEW and STERLING (1981) have provided evidence that *S. invicta* can kill large numbers of pupae and adult of the weevil when infested mature bolls open and expose the insects. The benefit of such weevil suppression by ants late in the season is the reduction of the weevil population that will enter diapause and survive the winter.

In cotton fields of São Paulo, PIERROZZI (1985) observed the ant *Camponotus sericeiventris* (Guerin) consuming adult *Anthonomus* in traps during the between-season period, as well as *Solenopsis* sp. preying on immature (larvae and pupae) and adult weevils on the cotton plants. FERNANDES (1993) has also observed adult *Anthonomus* being killed on the ground and on the cotton foliage by *Pheidole oliveirai*, and on cotton bolls by *Ectatomma quadridens* (Fab.). The presence of extrafloral nectaries on cotton (cf. KOPTUR 1992) certainly promotes ant visitation to the plants and probably increases the benefit afforded by ants through predation on *Anthonomus* (see also AGNEW and STERLING 1981; OLIVEIRA et al. 1987; OLIVEIRA and BRANDÃO 1991; COSTA et al. 1992).

According to WILSON (1976) *Pheidole* is one of the most prevalent ant genera in the world. Such dominant status of *Pheidole* is achieved by several atributes, the most important



Attack and removal rates of active adult *Anthonomus grandis* (N = 410) and larvae of *Anagasta kuehniella* (N = 100) by foraging ants in a cotton field, during the inter-cropping season. *Anagasta* larvae are removed at a much faster rate than adult *Anthonomus* ($D = 0.2571$, $P < 0.05$, Kolmogorov–Smirnov test)

of which include: large numbers of species in most zoogeographical regions, high local abundance, and a wide diversity of adaptations. In Brazil *Pheidole* is widespread and well represented in most regions; at least 27 species are currently known for the State of São Paulo (KEMPF 1972). Most of the ant fauna in this region is now confined to scattered forest and cerradõ (savannah-like vegetation) remnants that occur near large cultivated areas. Such natural areas may therefore represent reservoirs of many ant species that could act as biological control agents of the boll weevil or other insect pests. *Pheidole oliveirai*, for example, is very frequent in forest edges in the region of Campinas (São Paulo), occurring at a density of approximately one nest per every 20 m^2 (P. S. OLIVEIRA, unpubl. observ.).

Although reaching only one-third of the predatory capacity observed for standard *Anagasta* (see table), suppression of adult *Anthonomus* by ants can be considered as highly satisfactory in view of the weevils' defensive traits (high mobility, structural rigidity of the exoskeleton, and thanatosis). Moreover, prey density at the experimental plots (1.25 prey per m^2) was close to what is expected in a cotton field.

The potential benefit of ants removing overwintering adult *Anthonomus* on the ground during the inter-cropping season is mainly that of reducing the risk of high level infestations during the next cropping cycle. More experimental field studies with native ant species are needed before an efficient management strategy is established for boll weevil populations in cotton fields.

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