Interactions of Ants (Hymenoptera: Formicidae) and Mealybugs (Homoptera: Pseudococcidae) on Pineapple

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Abstract. Ant and mealybug interactions were studied in a pineapple field near Honolua on the island of Maui, Hawaii. Big-headed ants (*Pheidole megacephala* (F.)) were found to have a positive association with gray pineapple mealybugs (*Dysmicoccus neobrevipes* Beardsley) but no association with pink pineapple mealybugs (*D. brevipes* (Cockerell)). Sticky trap collections revealed that *D. neobrevipes* and *D. brevipes* are dispersed by the wind. Field experiments indicated that both species of mealybugs could establish on pineapple plants, even in the absence of ants. The positive association between *P. megacephala* and *D. neobrevipes* was not due to ants transporting mealybugs, but could have resulted from ants deterring natural enemies or removing honeydew.

Keywords: ant, mealybug, pineapple, symbiosis

Introduction

There is evidence that the gray pineapple mealybug, *Dysmicoccus neobrevipes* Beardsley, and the pink pineapple mealybug, *Dysmicoccus brevipes* (Cockerell), transmit wilt disease of pineapple (Carter 1963, Illingworth 1931, Ito 1959, 1962, Ullman et al. 1989). These mealybugs have a worldwide distribution and are found in most areas where pineapples are grown, including: Jamaica, most of South and Central America, East Africa, West Africa, South Africa, the Philippines, Thailand, and Hawaii (Beardsley 1993; Carter 1935, 1942; Jahn 1992; Petty 1990; Réal 1959; Serrano 1934). In pineapple fields *D. brevipes* and *D. neobrevipes* are generally associated with ants (Jahn and Beardsley 1998). At least 29 ant species have been found in Hawaiian pineapple fields (Carter 1967; Huddleston et al. 1967). In Hawaii, where *D. brevipes* is often subterranean, fire ants, *Solenopsis geminata* F., are reported to build nests around colonies of pink pineapple mealybugs (Carter 1962). Gray pineapple mealybugs in Hawaii are found on the surface of pineapple fruits and leaves, as well as inside closed blossom cups (Jahn 1995). Gray pineapple mealybugs have a symbiotic relationship with the big-headed ant, *Pheidole megacephala* (F.) (Carter 1932). Big-headed ants are distributed throughout the major Hawaiian islands (i.e., Hawaii, Kauai, Lanai, Maui, Molokai, and Oahu) (Reimer et al. 1990).

When ants are eradicated from a pineapple field, the mealybug population declines (Beardsley et al. 1982; Carter 1933; Jahn 1990; Phillips 1934). Thus, control of ants is considered essential for the control of pineapple wilt disease in Hawaii. Why are ants necessary for mealybugs to infest pineapple? The major hypotheses are that: 1) ants are the primary or sole means of mealybug dispersal in pineapple, 2) ants deter the natural enemies of mealybugs, and 3) ants prevent the accumulation of honeydew by consuming it (Jahn and Beardsley 1994; Phillips 1934; Rohrbach et al. 1988). Honeydew accumulation, and the sooty mold that can grow on honeydew, may be detrimental to mealybugs. These hypotheses are consistent with well-documented cases of mutualism between ants and Homoptera (Way 1963; Hölldobler and Wilson 1990).

Laboratory experiments by Jahn and Beardsley (1996) suggest (1) that big-headed ants do not have a positive effect on gray pineapple mealybug population growth in the absence of natural enemies or adverse weather; (2) that big-headed ants do not transfer gray pineapple mealybugs from one pineapple fruit to another; and (3) that honeydew removal by ants in the absence of sooty molds does not lower gray pineapple mealybug mortality. To determine if big-headed ants are essential to the establishment of mealybugs on pineapple and if mealybugs are dispersed by the wind we conducted a field experiment.

Materials and Methods

Twenty potted pineapple plants and ten sticky traps were placed in a 2.5 ha pineapple field near Honolua, on the island of Maui in Hawaii, to test for ant and mealybug interactions, as well as the wind dispersal of mealybugs. Each experimental unit consisted of 2 potted pineapple crowns. Before planting, crowns were treated with diazinon [O,O-diethyl O-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphorothioate] and held indoors in a mealybug-free area for 4 weeks. Each pot was placed on an inverted styrofoam plate, on top of an inverted pot. One pineapple plant of each pair had Tack Trap (Animal Repellents, Inc., Griffin, GA) applied to the outer surface of the top and bottom pots, to the inner surface of the bottom pot, and to the underside of the plate. Tack Trap was re-applied every 2–3 weeks to prevent ants and mealybugs from walking up the pots and infesting the plants. The other pineapple plant of each experimental unit was not treated with Tack Trap. A pineapple fruit with at least 25% of its surface area covered with *D. neobrevipes* was placed on the ground between the 2 plants to assure a source of gray pineapple mealybugs.

Experimental units and sticky traps were placed in the field in September 1989. After 2 weeks, we found that the pineapple leaves in 2 of the pots with Tack Trap were touched by the leaves of nearby pineapples growing in the field. Thus the barrier to crawling insects was no longer effective in these 2 cases. The experiment therefore consisted of 8 plants with barriers to crawling insects, and 12 plants without such barriers.

A blue sticky trap was placed less than 1 meter from each experimental unit to monitor wind-borne mealybugs. Yellow sticky traps were first tried, but flies (Tephritidae, Sciaridae, and Muscidae) and souring beetles (Nitidulidae: *Carpophilus humeralis* (F.) and *Carpophilus hemipterus* (L.)) covered the traps within hours, making it difficult to find mealybugs. Sticky traps were constructed by coating blue plastic cups with Tack Trap and attaching them to the top of 1 m high wooden stakes. A 5 cm strip of Tack Trap was applied to the lower portion of each stake to prevent insects from climbing up the stake. After 13 days, all the sticky traps were collected and examined with a dissecting microscope for mealybug presence. Insects were removed from cups using xylene to dissolve the Tack Trap.

Each potted plant was placed in an individual plastic bag and taken to the laboratory in April 1990. Pineapple plants were removed from their pots in the laboratory and dissected to check for the presence of mealybugs and ants.

Statistics

Two-way contingency tables were constructed for each mealybug species versus ants. Because the marginal totals of these contingency tables were not fixed (i.e., under the control of the investigators), the *G* statistic was used to test for the independence of each mealybug species from ants (Sokal and Rohlf 1981). *G* was compared to $\chi^2_{.05[1]} = 3.841$ (i.e., the critical value of χ^2 for one degree of freedom) to test the null hypothesis that mealybugs are independent of ants (Rohlf and Sokal 1981). For $G > \chi^2_{.05[1]}$, we calculated the Dice Index to determine the direction of the association, since Ludwig and Reynolds (1988) report that this index performs well at N = 20.

Results and Discussion

If mealybugs were wind-borne and did not rely on ants to transport them, we expected that some of the potted pineapples which had never been invaded by ants, would nevertheless have mealybugs. In one instance a pineapple crown without ants was infested with *D. neobrevipes* (Table 1). The pot had been treated with Tack Trap, and in this case the glue successfully prevented ants and mealybugs from climbing up the pot. In four instances *D. brevipes* were found in pots lacking *P. megacephala*. Three of these pots had functional Tack Trap barriers. How did *D. brevipes* and *D. neobrevipes* enter the pots painted with adhesive? All sticky traps had several hundred first instar mealybugs, indicating that mealybugs are dispersed by the wind. Since the completion of this investigation we have found that Carter (1967) briefly considered the significance of windborne mealybugs in an out of print in-house publication of the defunct Pineapple Research Institute. Carter (1967) noted that pineapple mealybugs were discovered on sticky traps, but that windborne mealybugs are probably not an important source of pineapple infestation compared to transport by ants.

In our experiment, big-headed ants had a positive association with gray pineapple mealybugs, but no association with pink pineapple mealybugs (Table 2). This is consistent with observations by Carter (1960) that subterranean mealybug colonies can flourish in the absence of ants.

Table 1. Contingency tables showing the association between big-headed ants (BHA) and gray pineapple mealybugs (GPM) or pink pineapple mealybugs (PPM).

	GPM	No GPM	Total
BHA	8	4	12
No BHA	1	7	8
Total	9	11	20
	PPM	No PPM	Total
BHA	5	7	12
No BHA	4	4	8
Total	9	11	20

Table 2. *G*-test of independence and Dice Index for the interspecific association between big-headed ants (BHA) and gray pineapple mealybugs (GPM) or pink pineapple mealybugs (PPM) in potted pineapple crowns.

Species pair	*G*[z]	Dice index[y]	Association[x]
BHA x GPM	6.22089	0.76	+
BHA x PPM	0.13456	—	0

[z] If $G < \chi^2_{.05[1]}$, then accept the null hypothesis that mealybugs are independent of ants; if $G > \chi^2_{.05[1]}$, then reject the null hypothesis. $\chi^2_{.05[1]} = 3.841$.
[y] Values above 0.5 indicate a positive association.
[x] "+" indicates that two species are found together more frequently than probable by chance. "0" indicates that two species are probably found together or apart by chance.

This investigation provided evidence 1) that *D. brevipes* and *D. neobrevipes* are dispersed by the wind and do not require ant-mediated transport to establish on pineapple; and 2) that *P. megacephala* have a positive association with *D. neobrevipes,* but no association with *D. brevipes* on pineapple.

The information gathered in this study is potentially useful to the pineapple industry. Mealybug infestations may be slowed or prevented by placing wind barriers around pineapple fields. Mealybug dispersal can be monitored with sticky traps. The industry should continue managing wilt disease by controlling ants. We propose that the positive association of *P. megacephala* with *D. neobrevipes* does not result from ants providing transportation, but from ants deterring natural enemies and/or consuming honeydew.

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