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# ROLE OF ARTHROPODS IN THE TRANSMISSION OF POSTBLOOM FRUIT DROP

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*Abstract.* **Postbloom fruit drop (PFD) is one of the most important problems affecting lime, *Citrus latifolia* Tan. in southern Florida. Preliminary studies were conducted during 1988-1989 to determine the effect of damage caused by mealybugs, *Planococcus citri* Risso, thrips, *Frankliniella* sp, citrus midge, *Prodiplosis longifila* Gagne, and simulated insect injury and their relationship to postbloom fruit drop (PFD) in limes. Damage by these insects and mechanical injury to flowers was not related to post bloom fruit drop severity. Further studies on PFD dissemination determined that 2% of arthropods collected in lime orchards during 1988-1989 carried spores of *Colletotrichum gloeosporioides*. The role of *Drosophila* sp. as a PFD vector is discussed.**

Citrus post bloom fruit drop (PFD) was first observed in Florida in Lee and Dade counties in 1983 on Tahiti lime, *Citrus latifolia* (8). Most studies in Florida indicate that the primary incitant of the problem is *Colletotrichum gloeosporioides* Penz (12, 3). *Colletotrichum* spores are thought to be dispersed within the tree and between nearby trees by rain (5); however, most medium and long distance dispersal of *Colletotrichum* could depend upon vectors such as fruit pickers, birds and possibly insects (6, 5). Although questions relating to the dispersal of fungal pathogens have been investigated, (13, 11, 2, 15) the possible role of insects and other invertebrates in transmission and dispersal of pathogenic microorganisms have received little attention (7, 2). Several fungal diseases of blossoms have been reported to be associated with insect vectors (1). This paper reports observations on (1) the effect of damage caused by mealybugs (*Planococcus citri* Risso), citrus midge (*Prodiplosis longifila* Gagne), and thrips (*Frankliniella* sp.) and their relationship with PFD, (2) the relationship between simulated insect injury and PFD, and (3) the role of insects in dissemination of *C. gleosporioides*.

## Materials and Methods

Mealybugs. The effect of damage to lime flowers by *P. citri* and *C. gloeosporioides* was assessed on 20 potted lime plants grown in a greenhouse (24-27 °C; 75-85% RH). Four sets of 5 plants were selected, and an average of 15 floral clusters per plant were identified with a numbered tag. Flowers from the first two sets of plants were infested with 8-29 *P. citri* crawlers per cluster, and the clusters were scanned for *P. citri* 15 days after infestation. Sets of plants with and without *P. citri* were inoculated with a suspension of *C. gloeosporioides* (23x$10^3$ spores per ml) to run off, using a manual atomizer. A last set of plants was kept as a control. The number of fruits, calyces or 'buttons' left per cluster were evaluated 30 days after treatment.

Citrus Midge. A lime orchard was monitored during the 1988 spring flower period to determine the disease progress in 120 trees. The number of flowers out of 100 that had necrotic lessions on the petals were counted weekly. At the same time, circular (15 cm diam.) orange traps coated with Tanglefoot were hung on trees, and the population density of midges trapped per week was estimated. The relationship between midge infestation and disease progress was recorded during 6 weeks of the study.

Thrips. An exclusion experiment was conducted during the 1989 winter-spring season to determine the effect of thrips infestation on PFD. A set of trees was individually caged. Each caged tree and the surrounding ground was sprayed throughly with Chlorpyrifos (2.5 lb ai/acre) at the beginning of the experiment to remove potential insect infestation. Another set of trees was left uncaged to allow thrips infestation. An average of 40-50 floral clusters per tree were identified with a numbered tag. Thrips population was monitored by use of a circular (15 cm diam.) red trap coated with Tanglefoot and by counting the number of thrips per flower. A suspension of *C. gloeosporiodes* (ca. 30,000 spores/ml) was sprayed on a set of caged trees and on a set of uncaged trees. Numbers of flowers, fruits, calyces and thrips were determined 8 weeks after treatment.

Mechanical Damage. Twigs bearing newly formed flowers were selected and isolated from insect contact by introducing them into a cylindrical screen mesh cage. The cage was then closed. Cages were inspected weekly for flower development. A set of flowers were separated according to their size. A subgroup of flowers was sprayed with a suspension of *C. gloeosporioides* (23x$10^3$ spores/ml). Mechanical damage was induced by inserting a needle to a depth of 1 mm at 1 point on the wall of a petal. Flowers used as controls were unsprayed and uninjured. Numbers of fruits and calyces were counted 25 days after treatment.

Dissemination. Arthropods were collected from lime groves with high, medium and low PFD symptoms. Arthropods visiting or feeding on flowers were placed in sterile vials, brought to the laboratory where tarsi, mouth parts, thorax and abdomen of each species were dissected and placed for 1 min on potato dextrose agar (PDA) media. The presence of *C. gloeosporioides* in each plate was determined by microscopic observation 10 days after collection. To determine if the fungus remained on the exterior of the insect body, *Drosophila melanogaster* adults (n = 100) reared in the laboratory were placed in contact with *C. gloeosporioides* cultures for half an hour. The flies were removed and transferred to a disinfected box provided with water. A set of 26-29 adults were removed up to 48 h after exposure, and placed in petri dishes with PDA media for half an hour. Adults were removed, and *C. gloeosporioides* development monitored during 10 days.

## Results and Discussion

Mealybugs. Feeding of *Planococcus citri* Risso did not result in higher infection of floral parts (Table 1). The

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Table 1. Effect of *Planococcus citri* feeding on lime flowers infected with *C. gloeosporioides*.[z]

| Treatment | Flowers/ Cluster | Fruits/ Cluster | 'Buttons'/ Cluster |
|---|---|---|---|
| Mealybugs | 7.53 c | 1.62 bc | 0.00 b |
| Mealybugs + Inoculum | 11.67 bc | 2.40 b | 0.02 b |
| Inoculum | 16.17 b | 0.00 d | 1.06 a |
| Control | 11.19 bc | 5.00 a | 0.00 b |

[z]Numbers followed by a different letter within a column were significantly different [P > 0.05; Duncan (1955)].

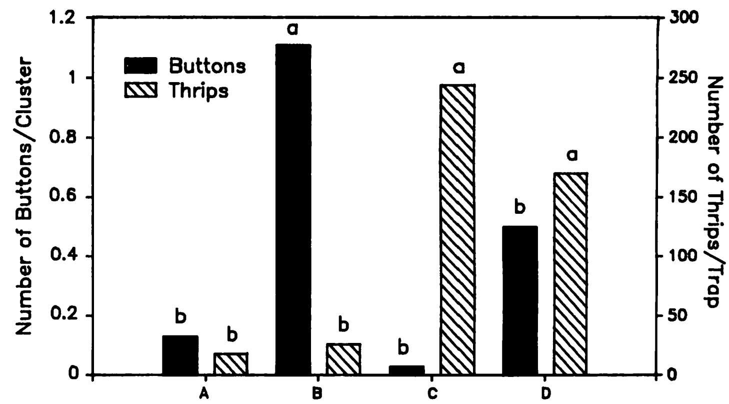


Fig 2. Abundance of thrips and their relationship to number of 'buttons' on lime. (A) total exclusion, (B) partial exclusion with inoculum of *C. gloeosporiodies*, (C) thrips, flowers without inoculum, (D) thrips, flowers with inoculum. a, b: bars with different letters were significantly different at P > 0.05 (Duncan, 1955).

data also indicate that numbers of fruits were reduced significantly as a result of fungal activity but not by injury caused by *P. citri. Planococcus citri* feeds on the calyx and peduncle, but seldom on petals. This suggests that injury to calyx did not enhance PFD infection.

Citrus Midge. *Prodiplosis longifila* Gagne larvae feed on stamens and ovaries of lime flowers (8, 9). Damage caused by this insect results in floral abscision; however, distribution and prevalence of this species did not relate to increased prevalence of the disease (Fig. 1). This result indicates that citrus midge infestation is independent of the severity of the disease.

Thrips. The role of *Frankliniella bispinosa* in PFD was investigated. Although *F. bispinosa* feeds on floral parts, field studies indicated that flowers protected from infestation by *F. bispinosa* were not free from infection by *C. gloeosporioides* (Fig. 2). Moreover, number of buttons was reduced as a result of fungal activity and thrips injury. This result indicate that thrips density may not be correlated with disease severity. Thus, we do not consider the thrips injury significant, as the amount of infection with thrips did not exceed the amount observed in the absence of thrips. Further tests may alter this conclusion.

Mechanical Damage. Mechanical injury to infected petals did not increase disease severity (Fig 3). Numbers of 'buttons' obtained after mechanical injury to infected petals did not differ significantly from those flowers infected without injury. Small flowers were less susceptible to mechanical injury and infection than large or open flowers (Fig. 4). These data indicate that flowers are very susceptible at some stages to the disease, regardless of injury.

Dissemination. Three hundred and fifty-one arthropods were collected from lime orchards with high, medium, and low inoculum. Arthropods from 8 orders and 18 families were found visiting or feeding on flowers. Two percent of the arthropods contained *Colletotrichum* spores. This survey showed that the percentage of arthropods with external fungal contamination was higher in the families Drosophilidae, Apidae and Formicidae. The species *Drosophila melanogaster, Apis melifera,* and an unidentified ant had *C. gloeosporiodes* on their bodies. Infectivity of the organism was measured by infecting host plants. Spores from these insects caused disease symptoms on lime flowers up to 82 h after inoculation. In addition, we observed that the species *Planococcus citri, Toxoptera aurantii* (Fonscolombe), *F. bispinosa, P. longifila* and *Pachneus* sp. which feed on flowers were free from *C. gloeosporioides* contamination. Most of these species were contaminated with *Fusarium* sp. Eighty seven to 97 percent of the *D. melanogaster* flies exposed to cultures of *C. gloeosporioides* retained spores 8 h after exposure to the fungus. Three to 7 percent retained spores 48 h after exposure (Fig. 5). Colonies of

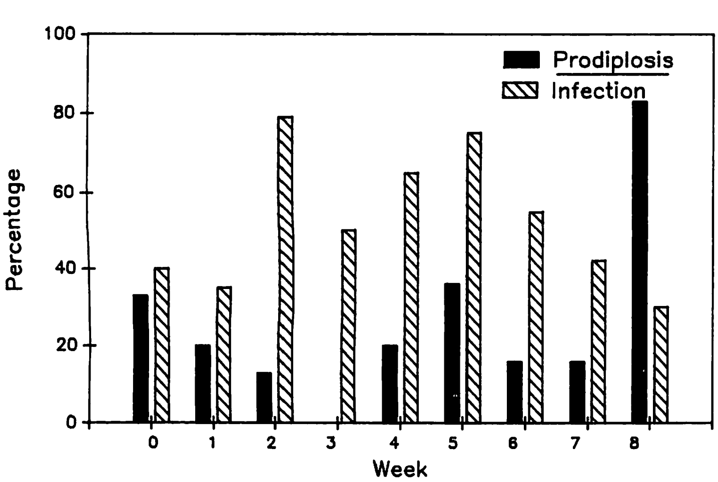


Fig 1. Frequency of *Prodiplosis longifila* adults and percentage of flowers infected with *Colletotrichum gloeosporioides*.

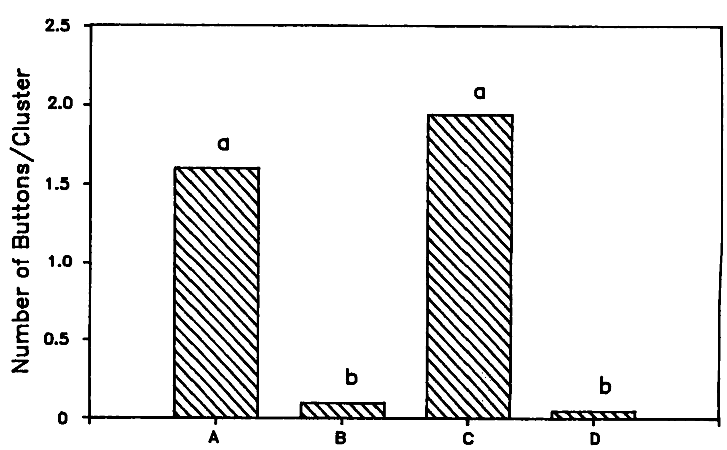


Fig. 3. Mean number of 'buttons' after artificial insect injury and inoculation to lime flowers. (A) flowers injured and inoculated, (B) flowers injured, without inoculum, (C) flowers inoculated without injury (D) control. a, b: bars with different letters were significantly different at P > 0.05 (Duncan, 1955).

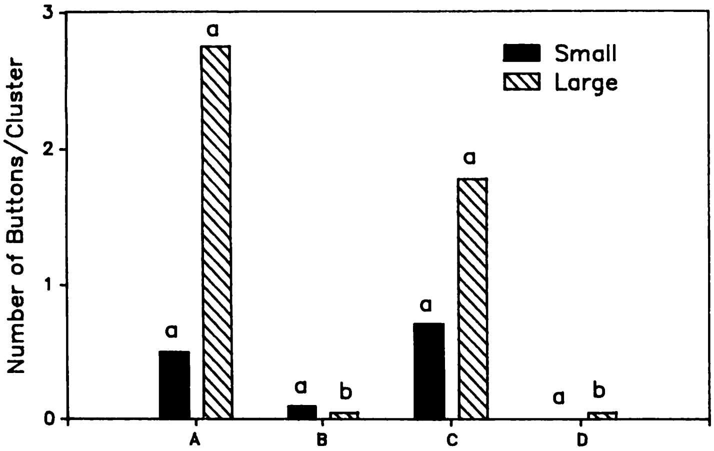


Fig 4. Effect of *C. gloeosporioides* in small and large lime flowers. (A) flowers injured and inoculated, (B) flowers injured without inoculum, (C) flowers inoculated without injury, (D) control. a, b: bars with different letters were significantly different at P > 0.05 (Duncan, 1955).

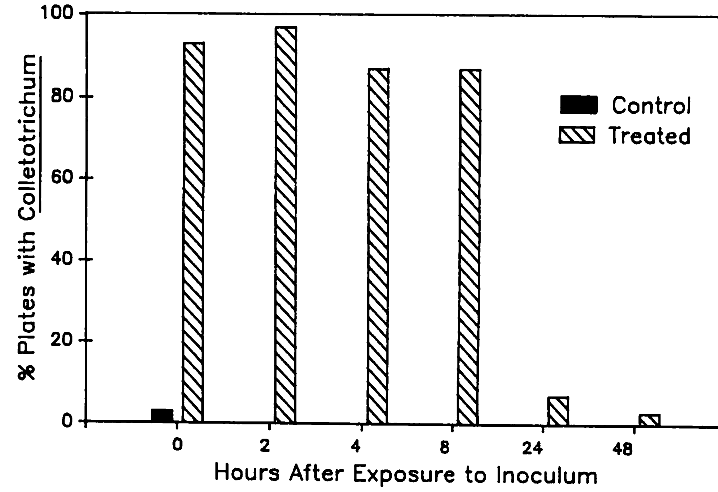


Fig 5. Percentage of *Drosophila* sp. adults with spores of *C. gloeosporiodes* after exposure to the fungus.

the fungus developed in abundance from collections made during the first 8 h. These preliminary observations indicate that *D. melanogaster* flies retain fungal spores on their bodies. Survival of spores in the digestive tract and feces of this species and other species needs to be further investigated. These results show that *D. melanogaster* could carry pathogenic fungi on their body and might transmit postbloom disease from one plant to another. Moreover, this insect depends on yeasts and fungi for its survival and its potential as a disseminator can be higher than expected. Spore dispersal inside groves could be related to rain water; however dispersal over longer distances must depend on biotic vectors such as lime pickers and insects. The role of insects which visit the flowers (*D. melanogaster* or bees) in dissemination should be further studied to reduce future crop losses.

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