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RESPONSE OF *FOPIUS ARISANUS* (HYMENOPTERA: BRACONIDAE) TO FRUIT VOLATILES IN A WIND TUNNEL

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Fopius (*Biosteres*) *arisanus* (Sonan) is a solitary endoparasitoid that oviposits primarily in fruit fly eggs and completes its development within the host. Adults emerge from the host puparium 18-20 d after oviposition (Bess et al. 1961). *Fopius arisanus* was originally collected from *Bactrocera dorsalis* (Hendel), but it is able to parasitize other fruit flies, including *Carpomyia vesuviana* Costa, *Ceratitis capitata* (Weidemann), three species of *Anastrepha*, and 11 other species of *Bactrocera* (Quimio & Walter 2001; Zenil et al. 2004, and references therein). Because of its potential as a biocontrol agent for fruit flies, several aspects of the biology of *F. arisanus* have been studied in detail (e.g., Bautista et al. 1998, 1999; Calvitti et al. 2002; Zenil et al. 2004), although the host location behavior of this parasitoid has been scarcely investigated. Field studies suggest that *F. arisanus* females use visual (Vargas et al. 1991; Liquido 1991) and chemical (Liquido 1991) cues to orient toward eggs of *B. dorsalis*, but the identity of attracting odors is still unknown. Here we conducted a study to determine whether *F. arisanus* are attracted to uninfested fruits in a wind tunnel as a first step to future investigations aimed to identify the compounds responsible for parasitoid attraction.

We used naïve female *F. arisanus*, 10-15 d old obtained from Moscamed facilities in Metapa de Dominguez, Chiapas, Mexico. Parasitoids used for experiments have been reared from eggs of *C. capitata* placed in pieces of papaya at 24 ± 2°C and 60-80% RH, and 12:12 L:D photoperiod as described previously (Zenil et al. 2004). Guavas, *Psidium guava* L. (dessert type), and oranges, *Citrus sinensis* L. (Valencia variety) were obtained from vendors for experiments. These fruits were chosen because they have different chemical and physical characteristics and it has been shown that eggs of *C. capitata* inoculated in common guava were parasitized by *F. arisanus* more heavily than those in citrus fruits (Bautista & Harris 1996).

Two experiments were conducted. In the first one, the response of female parasitoids to uninfested guava fruit was compared to a polystyrene ball (5 cm diameter) painted with vinyl acrylic water-based paints mixed to match (as detected by the human eye) the yellow of guava fruit. In this experiment, treatments were replicated 30 times. In the second experiment, the response of parasitoid females to volatiles of uninfested guava and orange was evaluated. Treatments were replicated 50 times. Both experiments were performed as non-choice tests and treatments were tested in a random order. Observations were carried out in a flight wind tunnel, 120 cm long and 30 cm high and wide. A fan was used to pull air through the tunnel with a velocity of 0.2 m/s and activated charcoal was used to filter intake air. Illumination was provided by two fluorescent bulbs mounted 60 cm above the wind tunnel giving a light intensity of 230 lux. The wasps were individually placed in a 5-cm high plastic container (4 cm internal diameter) (release cylinder) and they were allowed to acclimatize to the wind tunnel room conditions (25 ± 1°C, 70-80% RH) for at least one h before being observed. A fruit or yellow sphere was placed in the center of the wind tunnel, 10 cm from the upwind end. Each observation began by placing the release cylinder on a 15-cm high platform at the downwind end of the tunnel and one insect was released. Individual parasitoids were observed for a maximum time of 5 min. Specific response, including taking off, flight, landing on source, and duration of each response were recorded. Each female had only one flight opportunity within a test and was then discarded. A flight response was considered oriented towards the experimental target when the female flew directly upwind and landed on or not further than 5 cm away from the target. Data of responding *F. arisanus* females were compared between paired treatments by independent samples *t*-test (SPSS version 10.0). In all cases, $P < 0.05$ was used to detect significant differences.

In the first experiment, the number of wasps taking off was not significantly affected by the presence of guava fruit (90%) or yellow sphere (93%) ($t = 0.378$; $df = 4$; $P = 0.362$). The time before flight initiation of the wasp that were exposed to yellow sphere ($n = 30$) and guava fruits ($n = 27$) was of 39.03 ± 8.65 and 51.44 ± 8.89 sec, respectively. Oriented flights only were observed when guava fruit (40%) was present, but not with the yellow sphere. Only 30% of females landed on guava fruits, whereas no females landed on spheres. Landing time of females exposed to guava volatiles was 153.87 ± 29.99 sec ($n = 8$).

In the second experiment, significantly more females left the release cylinder when they were

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exposed to guava than to orange fruits (t = -2.88 df = 6, P = 0.02, Fig. 1). However, the time before taking off between females of both groups was similar (guava = 69.9 ± 46.5 sec, n = 48; orange = 62.5 ± 40.6 sec, n = 43). Significantly more females flew upwind to guava than orange (t = -3.28, df = 8, P = 0.01, Fig. 1). Also, females landed more frequently on guava than orange (t = -5.16, df = 8, P = 0.001, Fig. 1). Landing time of females exposed to guava volatiles was 154.76 ± 51.05 sec (n = 30), while females landing on orange took 237.66 ± 61.04 sec (n = 3).

Even though the yellow sphere did not attract or stimulate female landing under the conditions of the present study, a possible role for visual cues during the host-finding behavior of *F. arisanus* can not be ruled out because a previous study has shown that this species was captured on 4-cm yellow and white spheres in field conditions (Vargas et al. 1991). One possibility is that the light conditions used in the present study could have affected the visual response of *F. arisanus*. Also it is possible that with a bigger sample size some response to the yellow sphere would have been obtained.

The results of the present report agree with those obtained by Liquido (1991), who suggested that *F. arisanus* females may use fruit volatiles during the host location process. The use of fruit volatiles during host location behavior has been demonstrated in other parasitoid species that attack late instars of several species of tephritid flies (Greany et al. 1977; Eben et al. 2000; Jang et al. 2000; Henneman et al. 2002). Females of these species are attracted to odor emanating from healthy and infested fruits, but wasps visited more frequently infested fruits over healthy ones. We have shown that females are attracted to volatiles from uninfested fruits, but still we do not know whether *F. arisanus* females orient to infested fruits and this will be investigated in future studies.

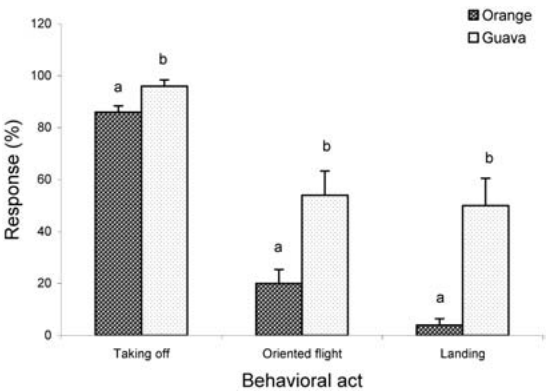


Fig. 1. Mean (±SEM) responses of *F. arisanus* females to orange and guava fruits offered in non-choice situations in a wind tunnel. Significant differences are indicated by different letters over the bars (t-test, $P < 0.05$).

We found that there was a significant difference in take offs with guava vs. orange, but not for guava vs. yellow sphere. Also, the time before flight initiation of females exposed to orange was longer than that of females exposed to guava. These results suggest that volatiles emanating from oranges may affect wasp behavior. Bautista & Harris (1996) suggested that chemicals in citrus peel are toxic to fruit fly eggs and larvae of tephritid fruit flies and this factor may explain low host parasitization by *F. arisanus* in citrus fruits.

We do not know if the strategy of use of fruit volatiles during host location by *F. arisanus* is common to other egg and young larval parasitoids of tephritid fruit flies. Nevertheless, it is well known that three parasitoid species attacking the eggs and young larvae of tephritid fruit flies use the fly's marking pheromone as kairomone for host location by searching longer on pheromone marked than on unmarked fruits (Prokopy & Webster 1978; Roitberg & Lalonde 1991; Hoffmeister & Gienapp 1999). Also, *Halticoptera rosae* Burks, an egg-larval parasitoid of *Rhagoletis basiola* Osten-Sachen, uses the marking pheromone as a guide to the fly's oviposition site and thus the host egg (Hoffmeister et al. 2000). In contrast, a parasitoid attacking late instars of *Rhagoletis pomonella* (Walsh) does not respond to the marking pheromone (Prokopy & Webster 1978). Whether *F. arisanus* females use host marking pheromone during host location behavior remains unknown.

In conclusion, this study confirms that *F. arisanus* females may use fruit volatiles during host location process as previously suggested by Liquido (1991). Also, it shows that females orientate to volatiles emanating from healthy fruits. The chemical identity of the attractants is currently unknown, but the bioassay used here can be useful during the identification of behaviorally active compounds. Semiochemicals offer good prospects as a tool for managing parasitoid behavior, particularly in a view of possible application to enhance the efficacy of parasitoids in biological control programs (Vet & Dicke 1992).

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Summary

The response of *Fopius arisanus* (Sonan) females to fruit volatiles was evaluated in a wind tunnel. In one experiment, the response of female parasitoids to uninfested guava fruit was compared to a yellow sphere. We found that females flew upwind and landed only on guava fruit but

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not on the yellow sphere. In the second experiment, the response of parasitoid females to volatiles from uninfested guava and orange was evaluated. In this experiment, significantly more females flew upwind to guava fruit than orange fruit, and females landed more frequently on guava than orange fruits.

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