Relative Attractiveness of Oranges and Grapefruits to Mexican Fruit Flies (Diptera: Tephritidae) in a Wind Tunnel[1]

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J. Entomol. Sci. 38(4): 566-575 (October 2003)

Abstract Grapefruits and sweet oranges were equally attractive to, and elicited comparable oviposition behavior from, naïve laboratory-strain female Mexican fruit flies, *Anastrepha ludens* (Loew), in wind-tunnel experiments. Neither fruit attracted nor elicited oviposition behavior from naïve wild females. For laboratory females, experience with either grapefruits or oranges enhanced attraction to both fruits and enhanced attraction to the experienced fruit more so than to the other, but did not affect oviposition propensity. For wild females, experience with either fruit enhanced attraction to both fruits, enhanced attraction to the experienced fruit more so than to the other, and increased oviposition propensity on both fruits. Also, wild females experienced with grapefruits oviposited more readily in grapefruits than did those experienced with oranges. Both laboratory and wild females experienced with either fruit directed less oviposition behavior toward wind-tunnel walls than did naïve females. Laboratory males were attracted to both fruits, but wild males were attracted to neither. Overall, experience with fruit had smaller effects on responses of males compared with effects on females.

Key Words *Anastrepha ludens,* fruit fly, oranges, grapefruit, attraction, oviposition

The highly polyphagous Mexican fruit fly, *Anastrepha ludens* (Loew), is a pest of citrus in Mexico, Central America and Texas and is a threat in other citrus producing regions of the United States. Throughout its range, it is common knowledge that the fly infests grapefruit, *Citrus paradisi* (MacFadyen), preferentially over other commercial citrus. This was previously reported by Baker et al. (1944), although some workers at the time considered sour oranges to be the most attractive of cultivated citrus. Norrbom and Kim (1988) list both sour orange, *C. aurantium* (L.), and sweet orange, *C. sinensis* ((L.) Osbeck), as field hosts of the Mexican fruit fly. Baker et al. (1944) indicated that sweet oranges generally were lightly infested compared with grapefruit and sour oranges. I (DCR) observed during numerous collecting trips to Mexico over the past several years that infestations are usually easier to find in grapefruit orchards than sour orange orchards, and are less commonly found in sweet orange than sour orange orchards. This suggests that preferences of the Mexican fruit fly for these commercial hosts decrease in the order grapefruit, sour orange, and sweet orange.

In previous research we showed that mature, well fed, wild (from field-collected fruit in Mexico), female Mexican fruit flies with no previous experience with fruit (naïve) were not significantly attracted to grapefruit in wind-tunnel experiments (Ro-

[1]Received 13 December 2002; accepted for publication 15 February 2003.

backer and Fraser 2002). Attraction of naïve laboratory-strain females to grapefruit was significant but not strong in that study. Food deprivation for one day enhanced attraction of naïve laboratory females (Robacker and Fraser 2001) and experience with grapefruit enhanced attraction of both laboratory and wild females to grapefruit (Robacker and Fraser 2002). Our interpretation was that wild naïve females searching for general fruit stimuli were not specifically attracted to grapefruits but were able to accept them as hosts after encountering them, and subsequently would learn to search for cues specific to grapefruit. Because grapefruit is not native to the natural range of this fly, it is not surprising that flies did not respond to it instinctively. We hypothesized that Mexican fruit flies would encounter oranges, also not native hosts, through the same process of searching for general fruit stimuli and subsequently would learn to recognize oranges as hosts, but that oranges would be less acceptable than grapefruits for oviposition, based on observed lower infestation rates in the field.

The purpose of the present work was to test the hypotheses that oranges (1) are not attractive to naïve Mexican fruit flies, (2) would be less acceptable for oviposition than grapefruits, and (3) would be more attractive to flies that previously were exposed to oranges. We evaluated attractiveness of sweet oranges relative to grapefruit and yellow spheres in no-choice bioassays using both naïve flies and flies experienced with either grapefruits or oranges. Bioassays were conducted in a wind tunnel, testing laboratory-strain and wild flies in separate experiments.

Materials and Methods

Insects and handling methods. Laboratory stock of *A. ludens* was started in 1997 from 2,000 pupae collected from yellow chapote, *Sargentia greggii* S. Wats. (Rutaceae), a native host, from the Montemorelos area of Nuevo Leon in northeastern Mexico. Flies were reared in artificial medium for approximately 55 generations. No fruit or fruit extract is used in rearing of the laboratory culture. Wild flies were obtained from grapefruits, sour oranges, and yellow chapote collected in the Montemorelos area. Adults of both strains were held in Plexiglas cages (20.5 × 20.5 × 20.5 cm) with screened tops containing a diet mixture of sugar and yeast hydrolysate, with water supplied separately. Beginning when flies were one or two days old, one-third of the cages was provisioned with a Rio Red grapefruit and one-third with a Valencia (sweet) orange. Fruit were obtained from local orchards. All fruits used in cages and in bioassays were full grown and ripe. One-third of the cages was not provisioned with fruit. Laboratory flies and wild flies were used in bioassays when 13 to 23 and 19 to 31 days old, respectively. Bioassays were conducted between 1000 and 1600 h. These ages and test times were based on results of previous experiments (Robacker and Fraser 2002). Laboratory conditions where flies were housed and bioassayed were 22 ± 2°C, 50 ± 20% relative humidity, and photophase from 0630 to 1930 h provided by fluorescent lights.

Wind-tunnel experiments. Bioassays were conducted in a Plexiglas wind tunnel with the dimensions of 0.3 × 0.3 × 1.2 m. Each end of the wind tunnel was screened to allow airflow. The downwind end contained a baffle system to create a uniform airflow through the chamber. Air was pulled through the chamber at 0.4 m/sec by an exhaust fan connected to the downwind end. Air exiting the chamber was directed into an exhaust hose and removed to the outdoors. The top of the chamber had two circular openings (12.8 cm diam) with Plexiglas covers, located at each end of the chamber, to allow easy access to the chamber's interior. A 75 W "soft white" light bulb

(General Electric Co., Cleveland, OH) in a reflecting lamp was positioned 17 cm above the downwind end of the chamber. The purpose of this light was to minimize random flying into the upwind end of the chamber by using the flies' positive phototaxis. Bioassays were conducted in the same laboratory where adult flies were held. In addition to the direct exhaust from the wind tunnel, this room contains inlet and outlet vents to bring new air into the room from outdoors and remove air from the room to the outdoors. Complete air replacement occurs eight times per hour.

Flies to be used in bioassays were transferred into cylindrical paper cartons (473 mLs), approximately 12 of each sex per carton, 24 h prior to testing. Cartons were not provisioned with food. Previous research demonstrated that 24 h of food deprivation enhanced attraction of Mexican fruit flies to grapefruits and did not affect oviposition propensity compared with non-starved flies (Robacker and Fraser 2001). Cartons were sprayed with water several hours before trials were conducted.

Grapefruits (Rio Red) and sweet oranges (Valencia) used in bioassays were picked fresh each day from local orchards. A circular piece of the rind and pulp measuring 2.5 cm diam was removed from fruits so that volatiles from both the peel and pulp were present in the aroma. Previous work showed that grapefruits damaged in this way were more attractive to Mexican fruit flies than were undamaged fruits (Robacker and Fraser 2002). Fruits were washed with water before each trial to remove any chemicals left by flies in the previous trial. Yellow plastic balls (8 cm diam), approximately the size of oranges, were used as fruit-model controls in some trials. These balls were described previously (Robacker 1992).

Wild flies and laboratory flies were tested in separate experiments. Each replication of each experiment was conducted as a series of nine trials, each testing one of three fly types (naïve, grapefruit-experienced, orange-experienced) with one of three fruit types (grapefruit, orange, yellow plastic ball), in random order. To conduct a trial, a grapefruit, orange, or yellow ball was placed into a chicken-wire basket suspended from the opening in the upwind end of the chamber, and one carton of flies was placed under the downwind opening. Flies were allowed 5 min to leave the carton and respond to the fruit, then were removed from the chamber. We recorded upwind movement if flies passed a point 2/3 of the distance from the release carton to the fruit, landing if flies either landed on or walked onto the fruit, oviposition into fruits or onto the yellow ball, and attempts to oviposit onto the Plexiglas walls of the bioassay chamber. Twenty-five replications were conducted with laboratory flies and 22 with wild flies.

Oviposition propensity experiments. Two additional experiments were conducted following completion of wind-tunnel experiments. These were performed to clarify apparently contradictory results of the main experiments in which fruit experience affected oviposition propensity on the two fruits differently for wild vs laboratory females. The first experiment tested oviposition propensity on oranges by laboratory females experienced with oranges vs grapefruits. The second experiment tested oviposition propensity on grapefruits by wild females experienced with oranges vs grapefruits. In preparation for trials, females from holding cages containing grapefruits or oranges were put into separate cylindrical paper cartons (473 mLs) with no food 24 h prior to testing. Cartons were sprayed with water as in the previous experiments. To conduct trials, individual flies were transferred into 30.5 × 30.5 × 30.5 cm aluminum-framed, aluminum-screened cages containing a ripe grapefruit or orange. Fruit were washed with water before each bioassay. Oviposition behavior was observed for 0.5 h. The two experience treatments were tested in pairs; 40 replications of each experience treatment for laboratory flies on oranges and 68 replications for wild flies on grapefruits.

Statistical analyses. For wind-tunnel tests, all behaviors except oviposition propensity were tested by analysis of variance (ANOVA) using SuperANOVA (Abacus Concepts 1989). For each trial, the proportions of flies that moved upwind, landed on the fruit, or attempted oviposition on fruit or the walls of the wind tunnel, were transformed by arcsin of the square root (Snedecor and Cochran 1967) before statistical analyses. Proportions of 0 were replaced with 1/4n before transformation (n = number of flies in the trial). Effects of fruit type, experience, and their interactions were calculated for each fly behavior using a factorial ANOVA. An ANOVA was also calculated to determine the overall treatment effect for the nine "fruit type by experience" treatments. Additional analyses were performed using reduced models such as removing data for yellow balls or for naïve flies. Means separations were conducted using Fisher's protected least significant difference (LSD) method (Snedecor and Cochran 1967). Separate analyses were conducted for males and females. Oviposition propensity (percentage of females that attempted oviposition after landing on a fruit) was analyzed by Chi-square tests of single classifications with equal expectations (Snedecor and Cochran 1967), with the null hypothesis that oviposition propensity of every treatment was equal to the overall oviposition propensity.

For flies that landed on a fruit in the oviposition propensity experiments, the percentages that attempted oviposition for each experience treatment were compared by Chi-square tests of single classifications with equal expectations and the numbers of oviposition bouts by flies of each experience treatment were compared by *t*-tests. For flies that oviposited on fruit, the time elapsed from landing on a fruit until the first oviposition bout (latency), the total time spent ovipositing, and the time spent ovipositing per bout, also were analyzed by *t*-tests.

Results

Wind-tunnel experiments with laboratory flies - females. Results are shown in Table 1. Statistics for LSD comparisons in Table 1 for responses to fruits/balls are: upwind movement ($F = 10.1$, df = 8,192, $P < 0.0001$); landings ($F = 24.8$, df = 8,192, $P < 0.0001$); and oviposition attempts ($F = 14.1$, df = 8,192, $P < 0.0001$). With regard to upwind movements, landings, and oviposition attempts, laboratory females responded more to both fruits than to yellow balls. Females with experience with either grapefruits or oranges responded more to grapefruits than did naïve females. Females with experience with oranges responded more to oranges than did naïve females or females with grapefruit experience. In general, responses to each fruit were enhanced more by experience with that fruit compared with experience with the other fruit. This effect was demonstrated by significant test-fruit by experience-fruit interactions for two of the behaviors, using a reduced model in which data for naïve females and yellow balls were removed: upwind movement ($F = 6.2$, df = 1,72, $P < 0.05$); and oviposition attempts ($F = 12.6$, df = 1,72, $P < 0.001$).

Oviposition propensity was greater on fruits than on yellow balls ($\chi^2 = 5.36$, df = 1, $P < 0.05$) and was greater on grapefruits than on oranges ($\chi^2 = 5.37$, df = 1, $P < 0.05$) (Table 1). Oviposition propensity on oranges by females experienced with oranges was greater than by females with grapefruit experience ($\chi^2 = 8.91$, df = 1, $P < 0.01$). More naïve females than females with fruit experience attempted to oviposit on the wind tunnel, regardless of the test fruit ($F = 5.5$, df = 8,192, $P < 0.0001$).

Table 1. Percentages of laboratory-strain female Mexican fruit flies, with or without fruit experience, attracted to a grapefruit, orange, or yellow ball and exhibiting oviposition behavior in wind-tunnel bioassays

Test fruit: Experience	Moved upwind*	Landed on fruit/ball*	Attempted to oviposit on fruit/ball*	Oviposition propensity on fruit/ball**	Attempted to oviposit on wind tunnel*
Grapefruit:					
Naive	29.2bc	18.3b	7.7cd	42.6 (54)	4.4b
Exp grapefruit	45.6de	30.8d	10.7d	34.8 (89)	1.0a
Exp orange	38.4de	27.3cd	9.9de	36.7 (79)	1.1a
Orange:					
Naive	37.5cd	20.0b	4.1bc	20.7 (58)	3.7b
Exp grapefruit	39.1cd	24.8bc	3.0ab	12.9 (70)	0.0a
Exp orange	48.1d	30.3cd	11.3d	37.5 (88)	0.3a
Yellow ball:					
Naive	19.6a	3.1a	0.3a	11.1 (9)	5.2b
Exp grapefruit	19.8a	4.2a	0.7a	16.7 (12)	0.7a
Exp orange	26.7ab	6.2a	0.3a	5.6 (18)	1.0a

* Values are mean percentages of females responding out of the total females in the trial. n = 25 trials each test fruit/experience group; 11.6 females/trial. Means followed by different letters in the same column are significantly different at the 5% level by Fisher's protected LSD.

** Values are percentages of females attempting oviposition out of the number (n) of females that landed on the fruit/ball.

Wind-tunnel experiments with wild flies - females. Results are shown in Table 2. Statistics for LSD comparisons in Table 2 for responses to fruits/balls are: upwind movement ($F = 4.0$, df = 8,168, $P < 0.001$); landings ($F = 5.8$, df = 8,168, $P < 0.0001$); and oviposition attempts ($F = 7.2$, df = 8,168, $P < 0.0001$). Means comparisons in Table 2 show that naïve females did not respond more to either fruit than to yellow balls. Generally, however, responses to fruit were greater than responses to yellow balls. The trend was examined further in analyses of test-fruit effects, summed over experience effects. Statistics for two of these test-fruit effects were significant: landings ($F = 9.6$, df = 2,168, $P < 0.0001$); and oviposition attempts ($F = 7.5$, df = 2,168, $P < 0.001$). Fisher's protected LSD (not shown) indicated that wild females landed and oviposited more on fruit than on yellow balls. Oviposition propensity on fruit was also greater than on yellow balls ($\chi^2 = 4.21$, df = 1, $P < 0.05$). Females responded about the same to grapefruits and oranges, summed over experience treatments.

Wild females with fruit experience responded more to fruit than did naïve females according to some LSD comparisons in Table 2 for upwind movements and landings. The trend was examined further by analyses of experience effects, summed over test-fruit effects. Statistics for these experience effects are: upwind movement ($F = 9.9$, df = 2,168, $P < 0.0001$); landings ($F = 9.5$, df = 2,168, $P < 0.0001$); and oviposition

Table 2. Percentages of wild-strain female Mexican fruit flies, with or without fruit experience, attracted to a grapefruit, orange, or yellow ball and exhibiting oviposition behavior in wind-tunnel bioassays

Test fruit: Experience	Moved upwind*	Landed on fruit/ball*	Attempted to oviposit on fruit/ball*	Oviposition propensity on fruit/ball**	Attempted to oviposit on wind tunnel*
Grapefruit:					
Naive	16.0a	3.8abc	0.0a	0.0 (10)	4.9b
Exp grapefruit	27.7bc	12.1e	4.2c	34.4 (32)	0.0a
Exp orange	20.6ab	7.3cd	0.8a	11.1 (18)	1.6ab
Orange:					
Naive	17.0a	2.7ab	0.0a	0.0 (7)	3.8b
Exp grapefruit	22.1abc	7.8cde	1.5ab	20.0 (20)	0.4a
Exp orange	28.9c	8.1de	2.3b	28.6 (21)	0.0a
Yellow ball:					
Naive	17.2a	0.8a	0.0a	0.0 (2)	3.9b
Exp grapefruit	18.9a	2.3ab	0.0a	0.0 (6)	0.0a
Exp orange	25.9bc	4.8bcd	0.0a	0.0 (12)	0.0a

* Values are mean percentages of females responding out of the total females in the trial. n = 22 trials each test fruit/experience group; 11.7 females/trial. Means followed by different letters in the same column are significantly different at the 5% level by Fisher's protected LSD.

** Values are percentages of females attempting oviposition out of the number (n) of females that landed on the fruit/ball.

attempts ($F = 8.7$, df = 2,168, $P < 0.001$). Fisher's protected LSD's (not shown) for these effects indicates that females with fruit experience moved upwind toward, landed on, and attempted oviposition in fruit more than did naïve females. Further, females experienced with fruit had higher oviposition propensity on fruit compared with naïve females ($\chi^2 = 4.30$, df = 1, $P < 0.05$). As with laboratory-strain females, wild females experienced with one of the two fruits responded more to the fruit they had experienced than to the other. This effect was demonstrated by significant test-fruit by experience-fruit interactions for two of the behaviors, using a reduced model in which data for naïve females and yellow balls were removed: upwind movement ($F = 8.9$, df = 1,63, $P < 0.01$); and oviposition attempts ($F = 7.1$, df = 1,63, $P < 0.01$). Oviposition propensity follows the same trend but Chi-square tests were not significant. Finally, more females experienced with oranges than naïve females moved upwind toward and landed on yellow balls (LSD in Table 2). This was not true for females experienced with grapefruits.

Also, as with laboratory females, experience with fruit affected the tendency of wild-strain females to attempt oviposition on the wind tunnel (LSD in Table 2). More naïve females than females with fruit experience attempted to oviposit on the wind tunnel, regardless of the test fruit ($F = 7.3$, df = 8,168, $P < 0.0001$).

Oviposition propensity experiments. Results are shown in Table 3. For both laboratory females on oranges and wild females on grapefruits, experience with one fruit vs the other did not significantly affect either oviposition propensity (percentage to oviposit after landing) or oviposition latency (time from landing until first oviposition). Wild females with grapefruit experience vs experience with oranges had significantly more oviposition bouts on grapefruit ($t = 3.2$, df = 82, $P < 0.01$). Wild females spent more time ovipositing on grapefruit if they had experience with grapefruit than if they had experience with oranges ($t = 2.6$, df = 61, $P < 0.05$). Laboratory females experienced with oranges spent more time per oviposition bout on oranges than did females with grapefruit experience ($t = 2.0$, df = 56, $P < 0.05$).

Wind-tunnel experiments with laboratory flies - males. Results are shown in Table 4. Statistics for LSD comparisons for laboratory males in Table 4 are: upwind movement ($F = 4.7$, df = 8,192, $P < 0.0001$); and landings ($F = 8.4$, df = 8,192, $P < 0.0001$). Generally, laboratory males moved upwind toward and landed on fruit more than yellow balls. Laboratory males responded about the same to grapefruit and oranges. Experience with fruit had no significant effects on behavior of laboratory males.

Wind-tunnel experiments with wild flies - males. Results are shown in Table 4. Fruit type did not affect behavior of wild-strain males as is evident by examination of means in Table 4. Effects of fruit experience also were not evident based on the LSD analysis in the table. However, the effect of experience on upwind movements, summed over test-fruit type, was significant ($F = 3.7$, df = 2,168, $P < 0.05$). LSD means separation (not shown) indicated that more males experienced with grapefruit,

Table 3. Effects of experience with grapefruits or oranges on oviposition behavior of female Mexican fruit flies on oranges or grapefruits during 30 min tests in small cages

	Laboratory strain on oranges		Wild strain on grapefruits	
	Grapefruit experience	Orange experience	Grapefruit experience	Orange experience
Percentage to oviposit out of (n) females on fruit	96.6 (29)	96.8 (31)	84.6 (39)	69.8 (43)
Oviposition latency (min) for (n) landings with oviposition	2.3 (28)	2.4 (30)	3.1 (33)	4.9 (30)
Oviposition bouts per female for (n) females on fruit	4.2 (29)	4.4 (31)	2.9* (39)	1.7 (43)
Time (min) spent ovipositing per female that oviposited (n)	11.6 (28)	14.4 (30)	11.8* (33)	8.7 (30)
Time (min) spent ovipositing per bout for (n) bouts	2.8* (122)	3.6 (137)	3.8 (112)	4.1 (73)

Percentages to oviposit are not significantly different at the 5% level by the Chi-square test of binomial proportions. Means within a fly strain significantly different at the 5% level by t-tests are indicated by *.

Table 4. Percentages of male Mexican fruit flies, with or without fruit experience, attracted to a grapefruit, orange, or yellow ball in wind-tunnel bioassays*

Test fruit: Experience	Laboratory strain: Moved upwind	Laboratory strain: Landed on fruit/ball	Wild strain: Moved upwind	Wild strain: Landed on fruit/ball
Grapefruit:				
Naive	24.3cd	11.2b	5.2a	1.2a
Exp grapefruit	22.3bcd	15.5b	9.0a	0.8a
Exp orange	18.8abc	9.9b	7.0a	0.4a
Orange:				
Naive	26.0d	13.3b	6.1a	0.8a
Exp grapefruit	25.5cd	14.8b	8.2a	1.1a
Exp orange	26.4d	15.3b	4.6a	1.2a
Yellow ball:				
Naive	12.8a	2.2a	5.8a	0.0a
Exp grapefruit	11.8a	2.7a	10.8a	1.5a
Exp orange	17.7ab	2.0a	5.5a	0.0a

* Values are mean percentages of males responding out of the total males in the trial. n = 25 trials each test fruit/experience group of lab males, 22 of wild males; 11.6 lab males/trial, 11.7 wild males/trial. Means followed by different letters in the same column are significantly different at the 5% level by Fisher's protected LSD.

compared with naïve or orange-experienced males, moved upwind toward fruits and yellow balls.

Discussion

Many results obtained in these experiments were similar to those in our previous work with grapefruits and yellow chapote fruits (Robacker and Fraser 2001, 2002) and in literature discussed in our previous work. These include: (1) laboratory flies responded at higher rates than wild flies; (2) naïve laboratory females were attracted to hosts but wild females were not; (3) experience with fruit increased attraction of both strains to fruit; (4) experience with fruit decreased oviposition on the wind-tunnel walls; and (5) laboratory males were more attracted to fruits than to yellow balls. Results support our previous findings indicating that the Mexican fruit fly is a generalist that does not instinctively seek specific hosts but learns about its hosts after encountering them during general foraging in its habitat.

Results of the wind-tunnel experiment with laboratory flies suggest that experience with oranges, compared with grapefruit experience, greatly enhances oviposition propensity of laboratory females on oranges (Table 1). Results of the oviposition propensity experiments in small cages (Table 3) do not support this effect. Overall, our evidence indicates that experience with either grapefruits or oranges has little effect on oviposition propensity of laboratory females on these two fruits.

Results of the wind-tunnel experiment with wild flies suggest that experience with grapefruits, compared with experience with oranges, greatly enhances oviposition propensity of wild females on grapefruits (Table 2). Results of the oviposition propensity experiments in small-cages (Table 3) support these findings in that grapefruit-experienced wild females had significantly more oviposition bouts and consequently spent more time ovipositing than did orange-experienced females (Table 3). Also, there were indications (not statistically significant) that grapefruit-experienced females accepted grapefruits at higher rates and more quickly than did females experienced with oranges. However, the magnitudes of the effects in the oviposition propensity experiment were much smaller than the threefold difference (34.4 vs 11.1%) in oviposition propensities in the wind-tunnel experiment for grapefruit- vs orange-experienced females on grapefruits. We conclude that effects of experience with grapefruit vs oranges on oviposition propensity of wild females on grapefruits are probably smaller than suggested by data from the wind-tunnel experiment.

Although female Mexican fruit flies responded similarly to grapefruits and oranges, both wild and laboratory flies were able to distinguish the two fruits after exposure to one of them (Tables 1, 2). Typically, experience with one increased response to both fruits but more so to the fruit that flies experienced. These results indicate that cross induction (Jaenike 1983) occurred in that experience with one fruit altered responses to the other. Similarly, Prokopy and Papaj (1988) demonstrated that apple maggot females could learn to distinguish different varieties of apples, all of which had basic red, green and yellow patterns. They suggested that chemical cues were used to distinguish the varieties, as chemical volatiles produced by the different varieties were known to be different. In our experiments, we could not determine which fruit characteristics flies had learned and then recognized in the other fruit type.

Cross induction also occurred in responses to the yellow ball. Yellow balls attracted more wild-strain females experienced with oranges than naïve females or those experienced with grapefruits (Table 2). Data for laboratory females followed a similar trend but the effect was not significant (Table 1). Because yellow balls and grapefruits were similar in color but yellow balls and oranges were similar in size, these data suggest that flies were learning size rather than color in these experiments. Papaj et al. (1989) obtained similar results with Mediterranean fruit flies. They found that female Medflies accepted small fruit less if previously exposed to large fruit, and large fruit less if previously exposed to small fruit. Although color and odor are important in attraction to hosts, learning of fruit color and odor seem relatively unimportant compared with learning of fruit size in these kinds of experiments (Fletcher and Prokopy 1991).

Grapefruits and oranges elicited similar attraction and oviposition behavior from wild female Mexican fruit flies. To summarize similarities: (1) neither grapefruits nor sweet oranges were attractive to naïve females; (2) neither elicited oviposition from naïve females (in 5-min wind-tunnel tests); (3) experience with either fruit increased attraction to both, especially to the experienced one; and (4) experience with either fruit increased oviposition on both. One difference, that experience with grapefruits increased oviposition on grapefruits somewhat more than did experience with oranges, probably would have minor effects in the field where most flies in one type of orchard probably would never experience the other type of fruit. These results, i.e., that grapefruits and oranges elicited equivalent attraction and oviposition behavior from wild flies, suggest that infestations of wild Mexican fruit flies should be similar in grapefruit and orange orchards. Field observations that grapefruit orchards usually have higher infestations than orange orchards [Baker et al. 1944, personal observation (DCR)] contradict our laboratory results and suggest that host preference in this case cannot be explained by attractiveness and oviposition preferences in laboratory environments. Baker et al. (1944) stated that infestation levels reflect factors other than just fruit preferences. They suggested tree size, shade, access to water, planting formation, length of time fruit remain on trees, acceptance for oviposition, and larval survival as possible factors.

Acknowledgments

We thank Don Thomas (USDA-ARS, Weslaco) for assistance in obtaining wild flies; Celestino Cervantes, Francisco Daniel, and Ronay Riley Rodas (USDA-APHIS-IS, Mexico City) for collection of wild fly pupae; and Bob Heath (USDA-ARS, Miami, Florida) and Peter Landolt (USDA-ARS, Wapato, Washington) for use of the wind tunnel. Use of a product brand in this work does not constitute an endorsement by the USDA.

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