Field Comparison of Chemical Attractants and Traps for Caribbean Fruit Fly (Diptera: Tephritidae) in Florida Citrus

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ABSTRACT Field studies in citrus were conducted to compare the following as attractants for the Caribbean fruit fly, *Anastrepha suspensa* (Loew): torula yeast–borax; propylene glycol (10%); a two-component lure consisting of ammonium acetate and putrescine; a two-component lure consisting of ammonium bicarbonate and putrescine; and a three-component lure consisting of ammonium bicarbonate, methylamine hydrochloride, and putrescine. Various combinations of these attractants in glass McPhail, plastic McPhail-type (Multi-Lure), and sticky panel traps were investigated in two replicated studies. In one study on wild flies, the most effective and least complex trap–lure combination tested was the Multi-Lure with propylene glycol baited with ammonium acetate and putrescine. This trap–lure combination captured significantly more female and male flies than the standard glass McPhail baited with torula yeast–borax in water. All of the trap–lure combinations were female biased, with an overall average of 80.8% (SEM 1.4) flies captured being female. A second study on laboratory-reared, irradiated flies indicated no significant differences among these trap–lure combinations with respect to number of flies recaptured, although rankings based on mean number of flies recovered per trap per day supported results of the first study. The percentage of flies recaptured that were female (83.0%, SEM 0.9) was statistically the same as in the first study. Weekly percentage recovery of flies during the second study was low, possibly due to our fly release strategy. Future release/recovery studies with laboratory-reared flies would benefit from some basic research on release strategies by using different trap densities and on relating recapture rates of laboratory-reared flies (nonsterile and sterile) to capture rates of wild flies.

KEY WORDS grapefruit, lures, McPhail, Multi-Lure, sterile release

THE CARIBBEAN FRUIT FLY, *Anastrepha suspensa* (Loew), is an important quarantine pest of Florida grapefruit, *Citrus paradise* Macfady, exported to Japan (Greany and Riherd 1993, Riherd and Jenkins 1996). This invasive pest is permanently established and widespread in Florida where it commonly develops on host plants such as Calamondin (× *Citrofortunella mitis* J. Ingram & H. E. Moore), common guava (*Psidium guajava* Lindl.), Cattley guava (*Psidium cattleianum* Sabine), loquat (*Eriobotrya japonica* Lindl.), rose apple (*Syzygium jambos* Alston), Surinam cherry (*Eugenia uniflora* L.), and occasionally commercial citrus (*Citrus* spp.) (Nguyen et al. 1992). Although infestations of the fly in grapefruit occur infrequently, fruit for the fresh export market must either be grown under a fly-free certification protocol or subjected to expensive postharvest treatments (Nigg et al. 1994, Riherd and Jenkins 1996). The fly-free program includes removing preferred host plants of the fly from the vicinity of citrus, seasonal trapping, and, when flies are detected, broadcast applications of poisoned bait within and around a grove being certified as fly free (Riherd and Jenkins 1996).

Tephritid traps vary in effectiveness depending on a number of factors, including their size and color (Moericke 1976, Prokopy and Economopoulos 1976, Prokopy 1977, Robacker et al. 1990), shape (Prokopy 1969, Prokopy and Bush 1973, Aliniazee and Brown 1977, Cytrynowicz et al. 1982, Sivinski 1990) and the particular olfactory attractant used. The open-bottomed McPhail trap design (glass and plastic versions) has proven to be relatively good for capturing *A. suspensa.* Glass McPhail traps baited with torula yeast–borax (the latter added to reduce decomposition of the yeast and trapped flies) in water have been traditionally used to monitor *Anastrepha* fruit flies (Burditt 1982, Thomas et al. 2001), although problems with high variability and low efficiency of these traps have been recognized (Lopez-D. et al. 1971, Calkins et al.

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Table 1. Trap–lure combinations evaluated for *A. suspensa* in citrus

Trap	Fluid[a]	Olfactory lure
	Study 1, natural pop of wild flies	
McPhail	Water	Torula yeast–borax
McPhail	Propylene glycol	Torula yeast–borax
Multi-Lure	Propylene glycol	None
Multi-Lure	Propylene glycol	Torula yeast–borax
Multi-Lure	Propylene glycol	Ammonium acetate and putrescine[b]
Multi-Lure	Propylene glycol	Ammonium bicarbonate and putrescine[c]
Multi-Lure	Propylene glycol	Ammonium bicarbonate, methylamine HCl and putrescine[d]
Multi-Lure	Propylene glycol	Torula yeast–borax, ammonium bicarbonate, and putrescine[c]
Yellow panel		Ammonium bicarbonate and putrescine[c]
	Study 2, releases of laboratory-reared irradiated flies	
McPhail	Water	None
McPhail	Water	Torula yeast–borax
McPhail	Propylene glycol	Torula yeast–borax
Multi-Lure	Propylene glycol	None
Multi-Lure	Propylene glycol	Torula yeast–borax
Multi-Lure	Propylene glycol	Ammonium acetate and putrescine[b]
Multi-Lure	Propylene glycol	Ammonium bicarbonate and putrescine[c]
Multi-Lure	Propylene glycol	Ammonium bicarbonate, methylamine HCl, and putrescine[d]
Multi-Lure	Propylene glycol	Torula yeast–borax, ammonium bicarbonate, and putrescine[c]
Yellow panel		Ammonium bicarbonate and putrescine[c]

[a] 400 ml in the reservoir of each trap.
[b] BioLure, components in vented packs suspended above fluid inside trap.
[c] Two-component *Anastrepha* Fruit Fly Lure, components in vented packs suspended above fluid inside trap.
[d] Three-component *Anastrepha* Fruit Fly Lure, components in vented packs suspended above fluid inside trap.

1984, Plant and Cunningham 1991, Malo 1992, Thomas et al. 1999). Traps baited with torula yeast–borax capture more female than male flies because females are more strongly attracted to torula yeast and other proteinaceous baits than males (Malo 1992). Previous studies in Florida on monitoring *A. suspensa* in loquat trees and Surinam cherry hedges by using different trap–lure combinations indicated that plastic McPhail traps baited with a two-component synthetic lure (ammonium acetate and putrescine, BioLure from Suterra LLC, Bend, OR) captured as many and sometimes more flies than McPhail traps baited with torula yeast–borax in water, and the two-component lure was effective for at least 10 wk (Thomas et al. 2001). This two-component lure was similar to the yeast–borax attractant with respect to sex ratios of flies attracted based on trap counts, both being female biased (Thomas et al. 2001). Propylene glycol has shown to increase captures of *A. suspensa* in liquid traps and to improve preservation of captured flies (Thomas et al. 2001). Three-component lures (ammonium bicarbonate or ammonium carbonate, methylamine hydrochloride, and putrescine) have been shown to be as or more attractive than torula yeast to the Mexican fruit fly, *Anastrepha ludens* (Loew) (Robacker and Warfield 1993, Robacker 1995), but these have not been tested as attractants for *A. suspensa.*

The purpose of this research was to compare in Florida citrus different chemical attractants and traps for detecting and monitoring *A. suspensa.* Two studies were conducted to compare different trap–lure combinations, one in which captures of wild flies were used to make comparisons and one in which recaptures of irradiated, laboratory-reared flies were used to make comparisons.

Materials and Methods

Two studies were conducted to evaluate the following as attractants for *A. suspensa:* torula yeast–borax pellets (5-g pellets, 2% borax) (ERA International, Ltd., Freeport, NY); a two-component lure consisting of ammonium acetate and putrescine (BioLure, Suterra LLC, Bend, OR); another two-component lure consisting of ammonium bicarbonate and putrescine (two component *Anastrepha* Fruit Fly Lure, Advanced Pheromone Technologies, Inc., formerly Integrated Pest Management Tech, Inc., Portland, OR); and a three-component lure consisting of ammonium bicarbonate, methylamine hydrochloride and putrescine (three component *Anastrepha* Fruit Fly Lure, also from Advanced Pheromone Technologies, Inc.). The attractants were evaluated as lures in glass McPhail traps (e.g., Carlos Mora, Baja California, Mexico), a plastic version of the McPhail (Multi-Lure trap, Better World Manufacturing, Inc., Fresno, CA), and sticky yellow panel traps (two 14 by 23-cm panels per trap, Scentry Biologicals, Inc., Billings, MT).

In the first study, a field test was conducted to compare capture of wild *A. suspensa* by using nine different trap–lure combinations (Table 1). This study was conducted west of the city of Fort Pierce in Saint Lucie County in a large grove of 2.7–3.3 m-tall 'Ruby Red' grapefruit trees interplanted with slightly smaller pineapple orange trees. Rows ran north-south with 7.6 m between rows and 3.7 m between trees. Traps were placed in the center of the grove in a block of trees 335 by 80 m (2.7 ha). This block of trees was completely surrounded by citrus, with the narrowest buffer being 230 m of citrus trees planted to the north. The study was initiated 19 April 2004 and concluded

17 June 2004. A few Cattley guava plants were observed outside the boundary of the citrus grove, but no host species other than citrus were observed within the grove itself. Trapping before the study indicated a population of wild flies was present.

In the second study, releases of laboratory-reared, irradiated flies were made and the performance of 10 trap–lure combinations (Table 1) compared based on numbers of flies recovered. Irradiation was conducted to sterilize the flies to guard against promoting an infestation, an approach that has been used by other fruit fly researchers (Calkins et al. 1984, Robacker 1995, Robacker and Heath 2001). This study was conducted west of the city of Fort Pierce in Saint Lucie County but in a different commercial citrus grove consisting of 3-m-tall 'Marsh' grapefruit trees. Rows ran north south with 7.6 m between rows and 4.9 m between trees. Traps were placed in the center of the grove in a block of trees 373 by 117 m (4.4 ha) completely surrounded by citrus. The second study was initiated 22 June 2004 and concluded 14 July 2004. No host species other than citrus were observed within the grove. Trapping before the study indicated the area was void of wild flies. Weekly releases of laboratory-reared, irradiated flies (obtained from a colony of flies [five to six generations removed from wild stock] maintained by the Florida Department of Agriculture, Division of Plant Industries, Gainesville, FL) were initiated on 22 June 2004 at each of 54 release locations uniformly situated throughout a central area of 6.2 ha at a spacing of 96 by 175 m (3.5 release sites/0.4 ha). The release area completely encompassed the area where traps were located and exceeded it with a buffer area of 48–88 m on all sides. This layout rendered four release points associated with each tree with a trap (one release point 29 m to the northwest, southwest, southeast, and northeast of each trap). These release points were between rows. On the morning of each release, a plastic bucket (26-cm-diameter top, 25-cm.-diameter bottom, 21.5 cm in height with screened lid and screen side ports for ventilation) containing 2,400 adult flies (3–7 d old, supplied with a carbohydrate diet before release) that emerged from mature irradiated pupae (50:50 sex ratio based on international standard quality control tests [FAO/IAEA/USDA 2003] conducted on each cohort of flies) per bucket was placed on the ground at each release location. This release rate was equivalent to ≈8,300 total flies per 0.4 ha. The flies were marked with fluorescent dye by using procedures described previously (Calkins et al. 1984).

All fly traps were hung in grapefruit trees 1.7–2.3 m aboveground inside the northeastern area of the tree canopy in a relatively open space. No canopy touched the trap. Glass McPhail and plastic Multi-Lure traps were charged with 400 ml of either tap water or 10% propylene glycol (Prestone Low-Tox antifreeze). Three tablets of torula yeast–borax were added to the fluid. For the traps containing fluids in combination with two- or three-component lures, the lures were in packs suspended inside the trap above the fluid. For the sticky card traps, packs with the lures were hung so that the lower edge of the lure was ≈5 cm above the top edge of the card.

Each experiment followed a randomized complete block design with four replications, with one trap–lure combination per replication. For each study, traps were randomly assigned to specific locations within each replication at the start of the test using uniform spacing with 30 m between any two trees with traps. In the first study, traps were checked and flies removed and counted on Mondays and Thursdays over the course of 9 wk. On each day they were checked, the traps were sequentially rotated among locations with each replication. The traps were rotated to reduce possible location effects due to possible uneven distribution of flies. For the traps with fluids, enough fresh fluid was prepared to completely recharge all traps on Mondays leaving enough to replenish evaporated fluid the following Thursday. When liquid traps were recharged with fresh fluid on Mondays, old fluid remaining in each liquid trap was collected and removed from the test site. Lures were replaced every 2 wk (shorter than necessary based on recommendations by the lure companies). In the second study, traps were checked to remove and count flies and to recharge with fresh fluid weekly on Wednesdays over the course of 3 wk. When liquid traps were recharged with fresh fluid, old fluid remaining in each liquid trap was collected and removed from the test site. The traps were not rotated among locations in the second study because flies were uniformly released. Lures were not replaced during the 3-wk period.

The following data were recorded during each study: numbers of female, male, and total flies collected per trap per sample date. For statistical analyses, numbers of flies captured per trap per sample date were converted to number of flies captured per trap per day to accommodate for minor deviations during the study with respect to planned and actual sample dates. The data ($\log_{10}$ transformed) were analyzed using a multiobservation (measurements over time) analysis of variance (ANOVA) (PROC GLM, SAS Institute 2002), and Tukey's studentized range (honestly significant difference) (SAS Institute 2002) was used to determine significant differences ($P = 0.05$) among trap–lure combinations. For each trap–lure combination in each study, the percentage of captured flies that were female was computed (obtained from the average per trap per replication over the whole time period of each study), and for each study the percentages were analyzed by one-way ANOVA by using PROC GLM (SAS Institute 2002) (Epsky et al. 1999). For the second study, the percentage of flies recaptured per trap was calculated based on the total number of flies released around each trap (four release sites associated with each trap, 2,400 flies per site, 9,600 flies per trap, an estimated 4,800 flies of each sex per trap) and evaluated using the same statistical analyses but on square-root-transformed data. Weather data (air temperature at 60 cm aboveground, wind speed at 10 m aboveground, and rainfall) during each study was obtained from a University of Florida weather station at Fort Pierce through the Florida

Table 2. Mean (SEM) numbers of wild *A. suspensa* fruit flies captured using different types of traps and lures in citrus (April–June 2004)

Trap	Fluid	Lure	Male flies/d[a]	Female flies/d[b]	Total flies/d[c]
McPhail	Water	Torula yeast–borax	0.3 (0.10)bc	1.1 (0.26)b	1.4 (0.34)b
McPhail	Propylene glycol	Torula yeast–borax	0.1 (0.04)cd	0.5 (0.11)c	0.6 (0.12)c
Multi-Lure	Propylene glycol	None	0.0 (0.00)c	0.0 (0.00)d	0.0 (0.01)d
Multi-Lure	Propylene glycol	Torula yeast–borax	0.2 (0.04)cd	0.6 (0.11)bc	0.7 (0.01)bc
Multi-Lure	Propylene glycol	Ammonium acetate and putrescine[d]	0.7 (0.16)a	2.0 (0.45)a	2.7 (0.60)a
Multi-Lure	Propylene glycol	Ammonium bicarbonate and putrescine[e]	0.1 (03)cd	0.6 (0.11)bc	0.7 (0.13)bc
Multi-Lure	Propylene glycol	Ammonium bicarbonate, methylamine HCl and putrescine[f]	0.2 (04)cd	0.5 (0.14)c	0.7 (0.16)c
Multi-Lure	Propylene glycol	Torula yeast–borax, ammonium bicarbonate, and putrescine[e]	0.5 (0.12)ab	1.5 (0.24)a	2.0 (0.35)a
Yellow panel	None	Ammonium bicarbonate and putrescine[e]	0.2 (0.04)cd	0.7 (0.13)bc	0.9 (0.16)bc

Means in the same column followed by the same letter are not significantly different ($P = 0.05$), Tukey's multiple comparison test (analyses on log data, but mean and SEM numbers shown are nontransformed data).

[a] $F = 3.15$; $Pr > F = 0.0001$; df = 67 model; df = 544 error (analyses on log data).

[b] $F = 6.35$; $Pr > F = 0.0001$; df = 67 model; df = 544 error (analyses on log data).

[c] $F = 6.33$; $Pr > F = 0.0001$; df = 67 model; df = 544 error (analyses on log data).

[d] BioLure.

[e] Two-component *Anastrepha* Fruit Fly Lure.

[f] Three-component *Anastrepha* Fruit Fly Lure.

Automated Weather Network (http://fawn.ifas.ufl.edu). This weather station was ≈6 km east of the first study site and 19 km northeast of the second study site.

Results and Discussion

Wild Fly Study. During the first study, air temperatures averaged 24.4°C (SEM 0.1, minimum 12.1°C, maximum 35.5°C) and winds averaged 11.5 kph (SEM 0.2, maximum 71.0 kph). In total, 6.4 cm of rainfall was recorded 6 km east of the study with notable rain events occurring on 27 April (1.0 cm), 19 May (0.5 cm), 5 June (0.7 cm), eight (0.7 cm) and 11 (2.5 cm). Weather data directly at the study site were not available. Over all trap–lure combinations, numbers of flies captured per trap per day averaged 0.8 (SEM 0.1, maximum 24.5) female flies, 0.2 (SEM 0.03, maximum 6.7) male flies, and 1.1 (SEM 0.1, maximum 30.5) females and males combined. These numbers were lower than those reported by Thomas et al. (2001) in trap–lure comparisons conducted in loquats and Surinam cherry.

The greatest numbers of wild *A. suspensa* (female, male, and total of both) were collected at Multi-Lure traps containing propylene glycol that were baited with ammonium acetate and putrescine and at Multi-Lure traps containing torula yeast in propylene glycol that were baited with ammonium bicarbonate and putrescine (Table 2). There were no significant differences between these two traps with respect to number of female, male, or total flies captured. These two trap–lure combinations captured significantly more flies (females and total of both sexes) than the standard glass McPhail with torula yeast–borax in water. Multi-Lure traps containing propylene glycol that were baited with ammonium acetate and putrescine captured significantly more male flies than the standard glass McPhail with torula yeast–borax in water. Yellow panel traps with packs of ammonium bicarbonate and putrescine captured statistically the same number of female and male flies as a standard McPhail baited with torula yeast–borax in water. Noted was that the yellow panel traps were difficult to work with due to factors such as adherence of debris to the panel surface and hand contamination with the trap adhesive.

Multi-Lure traps charged with torula yeast–borax in propylene glycol and baited with ammonium bicarbonate and putrescine captured significantly more female and male flies than the same traps without the two-component lure and significantly more flies than the same traps without torula yeast–borax (Table 2). These results indicated there was a synergistic effect between torula yeast–borax and the two-component lure in their attraction to *A. suspensa.* Glass McPhail traps captured more flies when they contained torula yeast–borax in water than when they contained torula yeast–borax in propylene glycol. Based on fly capture data using Multi-Lure traps, propylene glycol by itself lacked attractiveness to female and male *A. suspensa.* Statistically the same numbers of flies (female, male, and total of both sexes) were captured in Multi-Lure and glass McPhail traps baited with torula yeast–borax in propylene glycol, indicating these trap designs were equally effective in capturing flies. This agreed with observations by Thomas et al. (2001) that plastic versions of the glass McPhail are as effective. Overall, the most effective and least complex trap-lure combination tested was the Multi-Lure with propylene glycol baited with ammonium acetate and putrescine. There were no significant differences between any of the lure and trap combinations tested with respect to percentage of captured flies that were female ($F = 0.79$; $Pr > F = 0.6425$; df = 10 model; df = 21 error; analyses on square-root-transformed data; Multi-Lure trap charged with propylene glycol excluded from the analysis) (overall mean 80.8% female, SEM 1.4).

Table 3. Mean (SEM) numbers of laboratory-reared irradiated *A. suspensa* fruit flies recaptured using different types of traps and lures in citrus (June–July 2004)

Trap	Fluid	Lure	Males/d[a]	Females/d[b]	Total flies/d[c]
McPhail	Water	None	0.0 (0.0)c	0.2 (0.1)b	0.2 (0.1)b
McPhail	Water	Torula yeast–borax	14.9 (2.9)a	63.0 (9.0)a	78.0 (10.9)a
McPhail	Propylene glycol	Torula yeast–borax	12.1 (3.8)a	49.8 (11.2)a	61.9 (14.7)a
Multi-Lure	Propylene glycol	None	0.6 (0.2)bc	1.6 (0.5)b	2.2 (0.7)b
Multi-Lure	Propylene glycol	Torula yeast–borax	5.3 (1.4)ab	25.5 (5.3)a	30.8 (6.6)a
Multi-Lure	Propylene glycol	Ammonium acetate and putrescine[d]	15.9 (2.5)a	67.8 (8.1)a	83.7 (9.7)a
Multi-Lure	Propylene glycol	Ammonium bicarbonate and putrescine[e]	12.2 (2.9)a	58.5 (11.8)a	70.7 (14.0)a
Multi-Lure	Propylene glycol	Ammonium bicarbonate, methylamine HCl and putrescine[f]	9.2 (2.1)a	53.9 (9.8)a	63.1 (11.5)a
Multi-Lure	Propylene glycol	Torula yeast–borax, ammonium bicarbonate, and putrescine[e]	17.9 (6.2)a	75.4 (19.3)a	93.3 (24.9)a
Yellow panel	None	Ammonium bicarbonate and putrescine[e]	4.8 (1.1)ab	27.1 (3.0)a	31.9 (3.6)a

Means in the same column followed by the same letter are not significantly different ($P = 0.05$), Tukey's multiple comparison test (analyses on log data, but mean and SEM numbers shown are nontransformed data).
[a] $F = 5.32$; $Pr > F = 0.0001$; df = 119 (analysis on log data).
[b] $F = 13.97$; $Pr > F = 0.0001$; df = 119 (analysis on log data).
[c] $F = 13.69$; $Pr > F = 0.0001$; df = 119 (analysis on log data).
[d] BioLure.
[e] Two-component *Anastrepha* Fruit Fly Lure.
[f] Three-component *Anastrepha* Fruit Fly Lure.

Sterile Laboratory-Reared Fly Study. During the second study, air temperatures averaged 27.0°C (SEM 0.1, minimum 19.8°C, maximum 35.7°C) and winds averaged 7.4 kph (SEM 0.1, maximum 25.4 kph). In total, 3.7 cm of rainfall was recorded 19 km northeast of the study with notable rain events occurring on 26 June (1.6 cm) and 1 July (1.7 cm). Weather data directly at the study site were not available. So many released flies were recovered at some of the traps during our second study that the tasks of counting and sexing flies were so laborious and time-consuming that we elected not to verify that every fly was marked with florescent dye. Because pretest trapping indicated the study site was free of wild flies, it was probable that most if not all of the flies captured had been released. Over all trap–lure combinations, numbers of flies captured per trap per day averaged 42.3 (SEM 3.7, maximum 217.4) female flies, 9.3 (SEM 1.0, maximum 68.3) male flies, and 51.6 (SEM 4.6, maximum 285.7) females and males combined.

Mean numbers of released flies recaptured per trap during this study varied to the extent that few significant differences were found among the trap–lure combinations. Over both sexes, significantly fewer flies were captured in glass McPhail traps with water (no lure) and in Multi-Lure traps with propylene glycol (no lure) than in any of the other trap–lure combinations (Table 3). There were no significant differences among any of the other trap–lure combinations with respect to number of females or total number of flies recaptured. Regarding the magnitude rankings of recaptures, the greatest mean number of *A. suspensa* (females, males, and both sexes combined) was recaptured at Multi-Lure traps containing torula yeast–borax in propylene glycol baited with ammonium bicarbonate and putrescine. The second greatest mean number of flies (females, males, and both sexes combined) was recaptured at Multi-Lure traps containing propylene glycol baited with ammonium acetate and putrescine (the latter numerically captured the greatest numbers based on $\log_{10}$-transformed counts). These data rankings supported results of the first study that indicated these two were the most effective trap–lure combinations for *A. suspensa.* Although not significantly different, numbers of flies captured at Multi-Lure traps charged with propylene glycol and baited with ammonium bicarbonate and putrescine tended to be greater than numbers captured at yellow panel traps baited with the same lure. Because propylene glycol by itself was relatively unattractive to *A. suspensa* in each study, it was therefore possible that the yellow panel was a less effective trap design than the Multi-Lure trap for capturing the sterilized laboratory-reared flies.

Over all trap–lure combinations and sample dates in the second study, an average of 83% (SEM 0.9) flies recovered was female. Standard errors indicated this percentage was statistically the same as that observed during the first study (80.8%), suggesting a similarity between wild and laboratory-reared, irradiated flies with respect to percentage attraction to the traps–lures by females and males. Definite conclusions could not be made because the sex ratio of the population of wild flies at the first study site was not known. In two previous tests with sterilized flies released in citrus groves (999 flies per 0.4 ha, 4.5 release sites per 0.4 ha), the percentages of females recovered at glass McPhail traps (18.2 traps per 4 ha) charged with torula yeast–borax in water (two tablets per 300 ml of water) were 76.4 and 63.3% (Calkins et al. 1984), numerically lower than observed in our study. There were no significant differences between any of the trap–lure combinations we tested with respect to percentage of recaptured flies that were female ($F = 0.53$; $Pr > F = 0.8665$; df = 11 model; df = 24 error; analyses on square-root-transformed data; McPhail traps charged with water excluded from the analysis).

With respect to weekly recovery of the flies released in the vicinity of each trap in the second study, over all traps and sample dates averages of 1.4% (SEM 0.2) and 6.2% (SEM 0.5) male and female flies, respectively, were recovered weekly with an overall average recovery rate of 3.8% (SEM 0.3) per trap per week. Significantly lower recovery rates were observed at McPhail traps charged with water (no lure) (0.0% total flies recovered) and at Multi-Lure traps charged with propylene glycol (no lure) (0.2% total flies recovered), but no significant differences were found among the other trap–lure combinations (range, 2.2–6.8% total flies recovered) ($F = 7.34$; $\Pr > F = 0.0001$; df = 39 model; df = 119 error). These recovery rates were lower than observed in studies by Calkins et al. (1984) (some of their test details presented above), in which recapture rates of 12.8–14.4% occurred. With respect to traps charged with torula yeast–borax, the differences in recapture rates between our study and the ones by these researchers might not be attributed to differences in torula yeast–borax rates, because research by Burditt (1982) indicated rates of two to six pellets of yeast–borax were equally effective for capturing wild *A. suspensa.* Due to procedural differences between our study and studies by Calkins et al. (1984), recovery rate comparisons may be dubious. To what extent capture rates of our laboratory-reared irradiated flies may apply to wild flies is not known. Biological differences between wild and laboratory-reared flies have been noted (Sharp and Webb 1977, Sharp 1980, Nigg et al. 1994), and these differences may affect their attraction and movement to traps and lures. Regardless of biological differences between wild and laboratory-reared flies, capture rates of flies in general may vary with the environment, age structure of a population of flies, habitat, and other factors (Thomas et al. 2001). In our study, over all trap–lure combinations, the percentage of flies recovered per week was 3.5 (SEM 0.5), 5.1 (SEM 0.7), and 2.7 (SEM 0.4) during weeks 1, 2, and 3, respectively.

In summary, our data indicated that, among liquid traps charged with 10% propylene glycol without torula yeast–borax, plastic Multi-Lure traps baited with ammonium acetate and putrescine captured the greatest numbers of flies in citrus, significantly so in the study with wild flies and rankwise in the study with laboratory-reared flies. This supports the data of Thomas et al. (2001) that indicated the combination of ammonium acetate and putrescine was a relatively good attractant for *A. suspensa* in other habitats. Statistically the same numbers of flies were captured when Multi-Lure traps charged with 10% propylene glycol were baited with torula yeast–borax in combination with ammonium bicarbonate and putrescine but not when torula yeast–borax was excluded. Propylene glycol (10%) by itself was not attractive. With respect to significant differences being observed among trap–lure combinations in the first study and not in the second study, we speculated this may have been a consequence of biological differences between wild and laboratory-reared irradiated flies or of our release rate strategy. Future studies with laboratory-reared fly releases would benefit from some basic research on release rates and strategies by using different trap densities and on relating recapture rates of laboratory-reared flies (nonsterile and sterile) to capture rates of wild flies. Such research could be conducted using the ammonium acetate and putrescine lure in Multi-Lure traps charged with 10% propylene glycol.

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