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# CAPTURE OF *ANASTREPHA* SPECIES (DIPTERA: TEPHRITIDAE) WITH MULTILURE TRAPS AND BIOLURE ATTRACTANTS IN GUATEMALA

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ABSTRACT

Two trapping systems were compared in a study in Guatemala during the wet season, May through Dec 2001. Trap/lure combinations consisting of green or yellow-based plastic McPhail-like traps baited with a synthetic 2-component lure (putrescine and ammonium acetate) and 300 mL of propylene glycol antifreeze as a preservative were compared to the traditional glass McPhail baited with torula yeast/borax and 300 mL of water. Both systems captured several key *Anastrepha* species including *Anastrepha ludens* Loew, *A. obliqua*, Macquart, *A. serpentina* Weidemann, *A. striata* Schiner, *A. distincta* Greene, *A. fraterculus* Weidemann as well as *Ceratitis capitata* Weidemann. Additionally, 13 other *Anastrepha* spp. were captured with the synthetic lure. The plastic traps captured more key flies than the McPhail trap except for *A. distincta* where there were no significant differences between the yellow-based plastic trap and the McPhail trap and no significant differences between any trap and lure for trapping *A. fraterculus*. The synthetic lure lasted 10 weeks. The sex ratio was female-biased for almost all captured key species in both systems. Moreover, there were significant numbers of captured nontarget insects in all traps; however, the captured flies in those traps with the synthetic lure were not adversely affected by these insects. Propylene glycol-based antifreeze was a superior preservative when compared to borax/water.

RESUMEN

En Guatemala, se compararon dos sistemas de trampeo durante la epoca lluviosa de Mayo a Deciembre, 2001. Combinaciones de trampa/atrayente que consistieron de trampas de plastico con bases verdes o amarillos y con atrayentes sintéticos (acetate de amoniaco y putrecina) fueron comparadas con el sistema de trampeo tradicionál McPhail de vídrio cebada con torula y borax en agua. Los dos sistemas capturaron moscas del genero *Anastrepha* incluyendo *Anastrepha ludens* Loew, *A. obliqua*, Macquart, *A. serpentina* Weidemann, *A. striata* Schiner, *A. distincta* Greene, *A. fraterculus* Weidemann y *Ceratitis capitata* Weidemann. Además, se capturaron 13 especias adicionales de *Anastrepha* asi como *Toxotrypana curvicauda* Gerstaecker con el cebo sintético. El cebo sintético fue efectivo por diez semanas sin recebar. Las trampas de plastico capturaron más moscas del genero *Anastrepha* que la trampa de cristal McPhail. Las excepciónes fueron *A. distincta* en donde no hubo differencias el la captura con la trampa de plastico con base amarillo y la trampa McPhail de cristal asi como *A. fraterculus* en donde no hubo differencias comparando la captura de moscas con ambos sistemas. La proporción sexuál de las moscas capturadas con los dos sistemas fue al favor de las hembras. La captura de otros tipos de insectos fue significantemente elevado, sin embargo, las moscas capturadas con los cebos sintéticos no fueron afectados adversamente por estos insectos. El 10% del anticongelante, glicol propilico, fue superior al borax/agua como conservador de las moscas capturardas.

Translation provided by the authors.

Fruit flies of the genus *Anastrepha* cause significant damage to fruit cultivars throughout the Western Hemisphere. In the United States, there have been sporadic outbreaks of these species in Texas, California (*Anastrepha ludens* Loew and other *Anastrepha* spp.) and Florida (*A. suspensa* Loew). The citrus industry as well as federal and state agricultural agencies in California, Texas, and Florida has been searching for new attractants and traps to monitor existing and exotic fruit fly populations that may migrate to citrus growing areas. In the Lower Rio Grande Valley of Texas (LRGV), besides trapping *A. ludens*, there have been recent detections of *A. serpentina* Macquart in citrus and a confirmed outbreak of *A. obliqua* Weidemann adults in guava in 2001 (Thomas, personal communication). There continues to be sporadic capture of *A. serpentina* in northern Mexico (Thomas, personal communication).

The McPhail trap (McPhail 1939), baited with torula yeast/borax tablets in water (Lopez et al. 1967), has been the method of choice for trapping

*Anastrepha* spp. as well as other tephritid adults for many years. Recent advances in trap/lure technology have produced several versions of plastic McPhail—like traps and ammonium—based synthetic lures (Heath et al. 1995; Heath et al. 1997; Robacker et al. 1993, 1995; Epsky 1995). Within the last ten years, a new synthetic lure (BioLure®, Suterra LLC, Bend, OR) for *A. ludens* and *Ceratitis capitata* Weidemann has become commercially available.

Thomas et al. (2001) as well as studies in Florida and Mexico demonstrated that a McPhail-like plastic trap, Multilure® (Better World Manufacturing, Inc, Fresno, CA) baited with BioLure® (Suterra LLC, Bend, OR) attractants (MB) was able to compete with the standard McPhail trap (STD) baited with torula yeast/borax tablets in water. Results indicated that the MB system was equal to or better than the STD system. Martinez et al. (unpublished data) also showed that the MB was as good as or better than the STD in a study in the LRGV of Texas. Additionally, the preservation of captured flies is another trapping component that was studied. According to Thomas et al. (2001), a 20% propylene glycol antifreeze solution preserved the captured *Anastrepha* spp. and also significantly enhanced the attraction of the flies to the traps. In our LRGV study, we successfully used 10% propylene glycol as Low Tox Prestone® antifreeze as a preservative to trap sterile *A. ludens* (Martinez et al.; Salinas et al. unpublished data).

The ability of the MB system to attract other *Anastrepha* spp. was still in question. The study herein is the first phase of a 22-month study conducted in Guatemala to ascertain the capability of the MB system (a) to successfully trap other *Anastrepha* spp., (b) to determine whether the Multilure trap base color augments the attraction of flies to the trap, and (c) to verify that a 10% Low Tox Prestone® antifreeze (LTA) is an effective preservative for the captured flies.

## Material and Methods

### Study Sites

The first phase of the study was conducted for 29 weeks during the rainy season of 2001, usually the time of year when there is a high fly population. Trapping began in late May and continued through the middle of Dec. There were 4 agricultural sites used in the study that were identified by property, municipality, and department: Finca Silmar (Silmar), Palin, Escuintla (600 m elevation); Finca San José Buena Vista (San José), Guanagazapa, Esquintla (200 m elevation); Finca Peña Plata (Peña Plata), Yepocapa, Chimaltenango (598 m elevation) and Finca Palin (Palin), Palin, Esquintla located ~1000 m above sea level.

The sites contained a variety of host material and other vegetation that was not in any given host pattern. The Silmar site had sweet oranges (*Citrus aurantium* (Linn) *var. dulcis*), mandarin (*C. reticulate* Blanco), mango (*Mangifera indica* L.), guava (*Psidium guajava* L.), and zapote (*Diospyros digyn*a Jacq). In the Palin site, there were sweet oranges, mango, guava, zapote, mamey (*Pouteria sapota* (Jacq), mandarin, caimito (*Chrysophyllum caimito* L.), coffee (*Coffea arabica* L.), grapefruit (*Citrus paradisi* Macf), Inga (*Inga* spp. Miller) and sour oranges (*Citrus aurantium* L.). The Peña Plata and San José sites had mostly mango with a scattering of coffee, Inga, zapote, caimito, sour oranges, mandarin, and a small plot of coffee in the Peña Plata site.

### Trapping Protocol

Two trapping systems were compared in this study. The MB system consisted of a 2-piece plastic McPhail-like trap with transparent tops and green or yellow bottoms that attached in the middle. The separate lure envelopes were attached by an adhesive inside the trap on opposite sides of the upper transparent part of the trap. The lure consisted of putrescine and ammonium acetate released from the envelopes. The traps contained 300 mL of a 10% LTA solution as the preservative for the captured flies in these traps. The STD system consisted of the glass McPhail trap with 3 torula yeast/borax tablets (ERA International Limited, Freeport, NY) in 300 mL of tap water.

A 4 × 9 trap grid (12 traps of each type; a total of 36 traps/plot) was set up in each site. Traps were placed on the northeastern side of the host approximately 50 m apart and 50 m between rows in hilly, uneven terrain. The traps were serviced and rotated weekly. Rain gauge collectors measured rainfall; however, temperature and humidity data was not collected until late Jul due to logistic problems getting the equipment to Guatemala. Temperature and humidity from Jul through Dec averaged 25 ± 4°C with a relative humidity of 91 ± 7%.

### Statistical Analysis

Data were analyzed by comparing each of the 7 key *Anastrepha* spp. and *C. capitata* caught in the 2 trapping systems for 29 weeks. Total number of captured flies by month were plotted to compare effectiveness of the different trap types. The overall mean number of captured flies per week by species and trap types was calculated. Results for all significant *Anastrepha* spp. and for *C. capitata* were analyzed by standard analysis of variance (ANOVA), SAS Institute (2001), Cary, NC. Sex ratios by key species were calculated. The total numbers of nontarget flies were calculated and recorded by trap type.

## Results and Discussion

There were 63,838 adults captured in all traps with 33.7% (21,485) captured at the Silmar; 27.5% (17,560) at Palin; 22.7% (14,487) at Peña Plata and 16.1% (10,306) at the San José sites. The majority of flies were trapped from late May through Aug, possibly due to (a) the availability of host material especially in the San José and Peña Plata sites; these sites were almost exclusively mango, harvested by Jul, and (b) the reduced rainfall with a monthly average of 254 mm of precipitation between Jul and Nov (Fig. 1). Trap catches in all sites dropped substantially from Sep through Dec (Fig. 1).

The key *Anastrepha* spp. and *C. capitata* (Fig. 2) captured at the four sites with both systems were: *A. ludens*; *A. obliqua*; *A. serpentina*; *A. striata*, *A. distincta*, and *A. fraterculus*. The MB system also captured 13 other *Anastrepha* spp. They included: *A. canalis* Stone, *A. robusta* Greene, *A. spatulata* Stone, *A. leptozona* Hendel, *A. bezzii* Lima, *A. bahiensis* Lima, *A. crebra* Stone, *A. limae* Stone, *A. minuta* Stone, *A. aleveata* Stone, *A. ampliata* Hernandez-Ortiz, *A. pastranai* Greene, and *A. pickeli* Lima. *Toxotrypana curvicauda* Gerstaecker were also captured in very low numbers with this system.

The abundance of host material, the environment (Cunningham et al. 1978), harvest period, and the possibility of trap placement (Robacker et al. 1990) were factors in the capture of fruit flies in the test sites making trap rotation necessary. In the Silmar (1) and Palin (2) sites, sweet orange was the main host fruit with a distribution of some mango, zapote, coffee and other vegetation. *Anastrepha ludens* was captured most often than any other species in these sites followed by *A. obliqua*, *C. capitata*, and *A. distincta*. *Anastrepha obliqua* and *A. ludens* were the most captured species at the Peña Plata (3) and San José (4) sites (Fig. 2) where mango was the prevalent host followed by mandarin, caimito, and *Inga* (Vainillo). However, mangoes were picked by Jul leading to the reduction of *A. obliqua* in these sites. By the end of the study, most of the fruit at all sites had been picked and a minimal number of flies were trapped. There were significant differences in the mean trap per site for the key flies captured except for *A. serpentina* ($df = 6$; $F = 1.81$, $P = 0.0994$), *A. distincta* ($df = 6$, $F = 1.41$, $P = 0.2118$) and *A. fraterculus* ($df = 6$; $F = 1.00$; $P = 0.4290$).

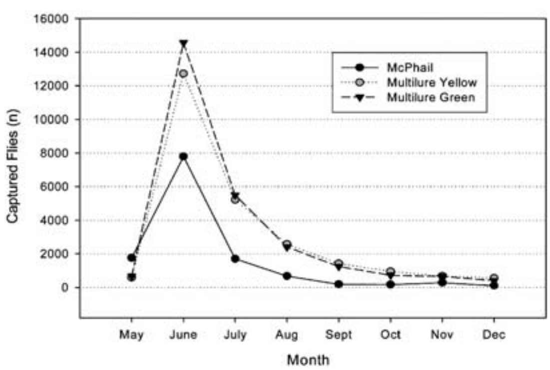


Fig. 1. Total captured fruit fly adults with the Multilure/BioLure/antifreeze and the glass McPhail/torula yeast/borax/water systems at the Silmar, Palin, Peña Plata, and San Jose sites, Guatemala, 2001.

The MB system attracted more flies than the STD system for all sites. There were significant differences in the mean trap catch when comparing the yellow and green-based Multilure traps of the MB system to the glass McPhail used in the STD system with key flies (Table 1). With *A. distincta*, there were significant differences between the green-based trap and the STD but no differences between the yellow-based trap and the STD. However, in the case of *A. fraterculus*, there were no significant differences in trap catches between the two systems. Mean totals for captured flies by all traps indicated that *A. ludens* and *A. obliqua* were the most captured species (Table 1).

A good number of MB traps were lost due to high winds. The fallen trap's substrate would wet the lure, rendering it useless for further trapping. We managed to conduct 10 weeks of trapping before we lost lures to wind damage. It is possible that the lure could have lasted more than 10 weeks. Furthermore, we could not determine if the LTA preservative played a part in enhancing the number of fruit flies that were trapped with the MB system in this phase of the study. However, the LTA did preserve the flies better than the borax used in the STD system.

### Sex Ratio

Food-based attractants are not considered to be as effective in attracting flies to traps when compared to the non-food attractants such as trimedlure. Non-food lures tend to attract only males (Sivinski and Culkins, 1981). Attractants such as the two or three component BioLure have become a new tool for the capture of both male and female fruit flies. According to Thomas et al. (2001), in a field study in Mexico, the McPhail traps baited with torula yeast/borax caught the same number of males and females, while the traps with synthetic lures were more male-biased. Calkins et al. (1984) showed that there was a male: female ratio of 2:1 when traps were baited with protein. In our LRGV study, we found the recapture rate of sterile *A. ludens* was about 1:1 (male: female) ratio with BioLure (putrescine and ammonium acetate). However, in our present study, there was ~1:2 (male: female) ratio (36.6% vs. 63.4%) captured in all traps and sites. The sex

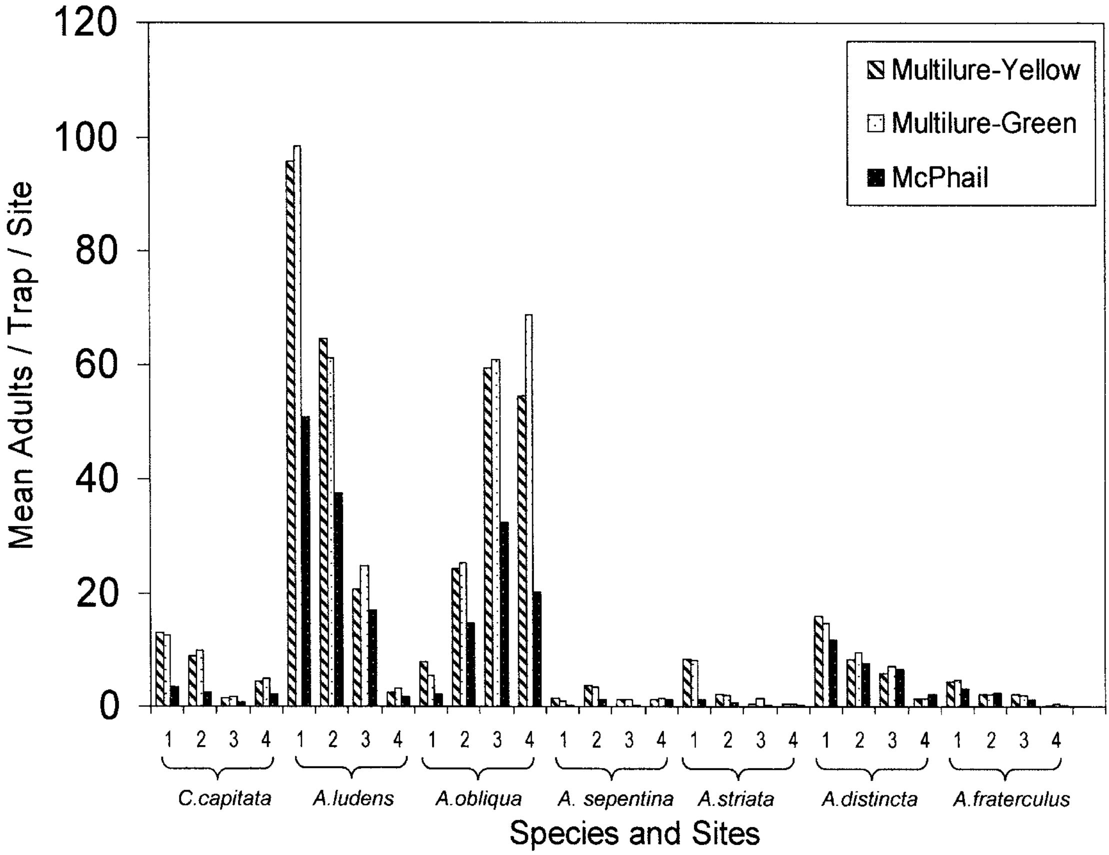


Fig. 2. Means of all *Anastrepha* species and *Ceratitis capitata* captured by trap and site (1) Silmar; (2) Palin; (3) Peña Plata and (4) San José) with the Multilure/BioLure/antifreeze and the glass McPhail/torula yeast/borax/water trapping systems.

ratio was the same for all key species except for *A. serpentina* and *A. striata*, in which there were slightly more males than females in the STD system and with *A. striata*, where there were almost 1:1 male: female ratio in the green-based trap of the MB system (Table 2). Comparison of site and gender indicated significant differences for both sexes for all key species except with *A. serpentina* ($F$ = 3.73, $P$ > 0.0543); *A. striata* ($F$ = 0.00, $P$ = 0.9586) and *A. distincta* ($F$ = 2.00, $P$ = 0.1579).

Nontarget Insects

Nontarget insects trapped by both systems included dipterans (black flies), lepidopterans (moths and butterflies), neuropterans (chrysopas) and hymenopterans (bees and wasps). In all traps, we captured a total of 50,547 nontarget insects of which 27,984 (55.4%) were dipterans, by far, the highest percentage of all nontarget insects captured; 18,822 (37.2%) lepidopterans, 1,825 (3.6%) neuropterans and 1,916 (3.8%) hymenopterans. Thomas (2003) found that dipterans made up about 90.1% of nontarget insects captured in the glass McPhail baited with torula yeast/borax and 79.6% captured with the Multilure/BioLure trapping system. In our study, there were 51.3% vs. 48.7% dipterans captured in the STD and MB systems, respectively. Thomas (2003) also stated that out of a total of 18,091 nontarget specimens captured, 9.4% were beneficial insects compared to 3.8% vs. 3.6% beneficials captured by STD and MB systems, respectively. The differences in the captures rates could be attributed to the differences in the habitat as well as the seasonality of the various crops found in all sites. Mean comparison of all captured nontarget insects by trap indicated that there were significantly more dipterans ($df$ = 2, $F$ = 62.55, $P$ < 0.0001) and hymenopterans ($df$ = 2, $F$ = 17.36, $P$ < 0.0001) trapped by the STD system. In contrast, there were significantly more lepidopterans ($df$ = 2, $F$ = 35.51, $P$ < 0.0001) and neuropterans ($df$ = 2, $F$ = 45.49, $P$ < 0.0001) trapped by the MB system (Table 3).

The glass McPhail used in the STD system is a cumbersome and bulky trap and breakage can be a problem. It is difficult to service and also tends

TABLE 1. MEANS OF KEY FRUIT FLY SPECIES CAPTURED WITH YELLOW AND GREEN BASED COLORED MULTILURE/BIOLURE/ANTIFREEZE AND THE GLASS MCPHAIL TRAPS/TORULA YEAST/BORAX/WATER TRAPPING SYSTEMS IN THE SILMAR, PALIN, BUENA VISTA, AND PEA PLATA SITES, GUATEMALA, 2001.

| Species | *n* | Multilure Yellow | Multilure Green | Glass McPhail |
|---|---|---|---|---|
| *C. capitata* | 116 | 14.32 ± 3.24 a | 14.84 ± 3.45 a | 4.51 ± 0.93 b |
| *A. ludens* | 116 | 98.47 ± 13.4 a | 95.75 ± 12.7 a | 50.84 ± 7.92 b |
| *A. obliqua* | 116 | 72.71 ± 12.3 a | 81.71 ± 13.5 a | 35.54 ± 6.90 b |
| *A. serpentina* | 116 | 3.45 ± 0.75 a | 3.52 ± 0.70 a | 1.34 ± 0.37 b |
| *A. striata* | 116 | 5.70 ± 1.08 a | 5.72 ± 1.06 a | 1.08 ± 0.21 b |
| *A. distincta* | 116 | 16.81 ± 3.51 ab | 17.90 ± 3.33 a | 14.22 ± 3.00 b |
| *A. fraterculus* | 116 | 4.04 ± 0.65 a | 3.90 ± 0.60 a | 2.98 ± 0.70 a |

[a]Means within each row followed by the same letter are not different ($\alpha = 0.05$).

to dry out (Thomas et al. 2001; Martinez et al.; Salinas et al. unpublished data). Moreover, the STD system uses a proteinaceous mixture as a bait that frequently has a high microbial load that can easily cause deterioration of the captured adults, making identification more problematic (Thomas et al. 2001; Martinez et. al. unpublished data). In contrast, with the MB system, there is uniformity in the trap design. Due to its two-piece construction, it is easier to service with virtually no spilled substrate. It can also utilize various lures.

There were no substantial differences in the number of captured adults with either the yellow or green colored trap. However, we preferred the green color base trap for this study because it blended well with the foliage, reducing theft losses and vandalism.

The 2-component BioLure (putrescine and ammonium acetate) is a long-lasting lure used primarily for *Anastrepha* spp. In a Florida study, the lure was used from 3 to 12 weeks without renewal, depending on fly activity (Thomas et al. 2001). In our LRGV study, we ground- released irradiated flies from the summer of 1998 to the summer of 1999 (Martinez et al. unpublished data). During the summer of 1999, Salinas et al. (unpublished data) air-released irradiated flies every week. While we serviced traps weekly, the lure was not changed until the 12th (air released flies) to 16th week (ground released flies) when we noted a drop in captured flies. In the Guatemala study, we lost a good number of MB traps due to high winds; the fallen trap's substrate would wet the lure. We managed to conduct 10

TABLE 2. MEANS (±SE) OF CAPTURED MALES AND FEMALES ($N = 116$) WITH 2 TRAP/LURE SYSTEMS AT THE SILMAR, PALIN, BUENA VISTA, AND PEÑA PLATA SITES, GUATEMALA, 2001.

| | Multilure Yellow | | Multilure Green | | Glass McPhail | |
|---|---|---|---|---|---|---|
| Species | Male | Female | Male | Female | Male | Female |
| *C. capitata* | 4.8 ± 1.2 | 9.0 ± 2.1 | 4.9 ± 1.3 | 9.7 ± 2.2 | 1.6 ± 0.4 | 2.90 ± 0.6 |
| *A. ludens* | 35.0 ± 6.0 | 62.6 ± 7.9 | 35.0 ± 5.3 | 58.8 ± 7.2 | 20.5 ± 3.4 | 29.80 ± 4.8 |
| *A. obliqua* | 25.8 ± 4.5 | 47.3 ± 7.8 | 27.0 ± 4.5 | 52.3 ± 8.7 | 14.3 ± 2.9 | 21.00 ± 4.2 |
| *A. serpentina* | 1.2 ± 0.3 | 2.5 ± 0.5 | 1.5 ± 0.3 | 2.1 ± 0.4 | 0.8 ± 0.2 | 0.66 ± 0.2 |
| *A. striata* | 2.8 ± 0.6 | 3.0 ± 0.6 | 3.1 ± 0.7 | 3.0 ± 0.6 | 0.7 ± 0.1 | 0.53 ± 0.1 |
| *A. distincta* | 7.1 ± 1.5 | 8.7 ± 1.8 | 7.3 ± 1.4 | 9.2 ± 1.7 | 6.2 ± 1.0 | 7.80 ± 1.8 |
| *A. fraterculus* | 1.5 ± 0.3 | 3.0 ± 0.5 | 1.8 ± 0.6 | 2.9 ± 0.7 | 1.5 ± 0.5 | 2.2 0± 0.5 |

TABLE 3. MEANS (±SE) OF NONTARGET INSECTS TRAPPED WITH 2 TRAP/LURE SYSTEMS AT THE SILMAR, PALIN, BUENA VISTA, AND PEÑA PLATA SITES, GUATEMALA, 2001.

| | *n* | Multilure Yellow | Multilure Green | Glass McPhail |
|---|---|---|---|---|
| Diptera | 116 | 57.28 ± 3.4 b | 60.01 ± 3.3 b | 124.10 ± 10.9 a |
| Lepidoptera | 116 | 62.91 ± 5.0 a | 60.66 ± 4.7 a | 46.33 ± 4.3 b |
| Neuroptera | 116 | 7.22 ± 0.8 a | 6.64 ± 0.8 a | 3.98 ± 0.4 b |
| Hymenoptera | 116 | 3.98 ± 0.4 b | 4.55 ± 0.5 b | 8.53 ± 1.1 a |

[a]Means within rows followed by same letter are not different ($\alpha = 0.05$).

weeks of trapping before we lost the lures to wind damage. It is possible that the lure could have lasted more than 10 weeks. The LTA was an excellent preservative that had minimal evaporation in the traps. Moreover, the number of nontarget found in these traps did not impede preservation or identification of the captured flies. Furthermore, based on our results, we believe that the MB system will prove useful as an early warning technique in citrus producing states by attracting exotic *Anastrepha* spp. populations and possibly preventing their establishment.

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