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Authors: Martinez, A. J., Salinas, E. J., and Rendon, P.

Source: Florida Entomologist, 90(1) : 258-263

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/0015-4040(2007)90[258:COASDT]2.0.CO;2
CAPTURE OF ANASTREPHA SPECIES (DIPTERA: TEPHRITIDAE) WITH MULTILURE TRAPS AND BIOLURE ATTRACTANTS IN GUATEMALA

A. J. MARTINEZ 1, E. J. SALINAS 1 AND P. RENDON 2

1USDA-APHIS-PPQ-CPHST, 22675 N. Moorefield Rd, Edinburg, TX 78541-5033
2USDA-APHIS-PPQ-CPHST, 4ª Avenida 12-62, Zona 10, Guatemala City, Guatemala

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 época lluviosa de Mayo a Diciembre, 2001. Combinaciones de trampa/atrayente que consistieron de trampas de plastico con bases verdes o amarillos y con atrayentes sintéticos (acetate de amonio y putrecina) fueron comparadas con el sistema de trampeo tradicional McPhail de vidrio cebado 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 especies adicionales de Anastrepha asi como Toxotrypana curvicuda Gerstaecker con el cebo sintético. El cebo sintético fue efectivo por diez semanas sin recesar. Las trampas de plastico capturaron mas moscas del genero Anastrepha que la trampa de cristal McPhail. Las excepciones fueron A. distincta en donde no hubo diferencias en la captura con la trampa de plastico con base amarillo y la trampa McPhail de cristal asi como A. fraterculus en donde no hubo diferencias comparando la captura de moscas con ambos sistemas. La proporción sexual de las moscas capturadas con los dos sistemas fue al favor de las hembras. La captura de otros tipos de insectos fue significativamente 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 capturadas.

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 Palín (Palín), Palín, 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. reticulata Blanco), mango (Mangifera indica L.), guava (Psidium guajava L.), and zapote (Diospyros digyna 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 aurantiun 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 Palín; 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. aleverata Stone, A. ampliata Hernandez-Ortiz, A. pas- tranai 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 Palín (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).

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 re-capture 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. 1. Total captured fruit fly adults with the Multi-lure/BioLure/antifreeze and the glass McPhail/torula yeast/borax/water systems at the Silmar, Palín, Peña Plata, and San José sites, Guatemala, 2001.
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 (chrysoptas) 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
to dry out (Thomas et al. 2001; Martinez et al.; Sali-
nas 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 con-
trast, 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 sub-
strate. 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 am-
monium acetate) is a long-lasting lure used pri-
marily for Anastrepha spp. In a Florida study, the
lure was used from 3 to 12 weeks without re-
newal, depending on fly activity (Thomas et al.
2001). In our LRGV study, we ground-released ir-
radiated 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 Guate-
mala 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

| 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 |

*Means within each row followed by the same letter are not different (α = 0.05).

| Species          | n    | Multilure Yellow | Multilure Green | Glass McPhail |
|------------------|------|-----------------|----------------|---------------|
| C. capitata      | 116  | 4.8 ± 1.2       | 9.0 ± 2.1      | 1.6 ± 0.4     | 2.90 ± 0.6 |
| A. ludens        | 116  | 35.0 ± 6.0      | 62.6 ± 7.9     | 20.5 ± 3.4    | 29.80 ± 4.8 |
| A. obliqua       | 116  | 25.8 ± 4.5      | 47.3 ± 7.8     | 14.3 ± 2.9    | 21.00 ± 4.2 |
| A. serpentina    | 116  | 1.2 ± 0.3       | 2.5 ± 0.5      | 0.8 ± 0.2     | 0.66 ± 0.2 |
| A. striata       | 116  | 2.8 ± 0.6       | 3.0 ± 0.6      | 0.7 ± 0.1     | 0.53 ± 0.1 |
| A. distincta     | 116  | 7.1 ± 1.5       | 8.7 ± 1.8      | 6.2 ± 1.0     | 7.80 ± 1.8 |
| A. fraterculus  | 116  | 1.5 ± 0.3       | 3.0 ± 0.5      | 1.5 ± 0.5     | 2.20 ± 0.5 |

| 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  |

*Means within rows followed by same letter are not different (α = 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.

ACKNOWLEDGMENTS

The authors thank the Guatemalan technical help: Felix Acabajon, Marvin Xinic, and Jose M. Gudiel for dedication to the trapping study; Jorge Lopez, Taxonomist, MoscaMed, Guatemala for primary identification of trapped flies and Dr. Alan Norrbonn, Taxonomist, Smithsonian Institute, Washington, D. C., USA for confirmation of identified flies. We thank Don Thomas, USDA ARS, Weslaco, TX, Hugh Conway and Bacilio Salas USDA APHIS PPQ CPHST for the critical review of the manuscript. We thank Aracely De Galan, USDA APHIS PPQ CPHST, Guatemala and Elena Ibanez, USDA APHIS PPQ CPHST, Edinburg, TX for administrative assistance.

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