Efficacy of New Commercial Traps and the Lure Ceratrap® Against Anastrepha obliqua (Diptera: Tephritidae)

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EFFICACY OF NEW COMMERCIAL TRAPS AND THE LURE CERATRAP® AGAINST *ANASTREPHA OBLIQUA* (DIPTERA: TEPHRITIDAE)

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Abstract

Traps, lures, and trap/lure combinations were tested against the West Indian fruit fly, *Anastrepha obliqua* Macquart (Diptera: Tephritidae). The study aimed to evaluate the efficiency of possible trap/lure substitutes for the traditional McPhail glass trap baited with hydrolyzed protein, which is the trap/lure combination approved for monitoring this pest in Mexico. CeraTrap®, an enzymatically hydrolyzed protein, caught as many or more *A. obliqua* flies as McPhail traps baited with the chemically hydrolyzed protein, Captor®, or with the dry lure, Biolure. When fly densities were high, the average capture was 3 times greater for CeraTrap than for the other lures. Sex ratios were generally female-biased and similar among all lures tested. The CeraTrap lure was not replaced during the course of the experiment and good attraction and preservation of captured specimens were observed after one month of use. CeraTrap attracted more lacewings (Neuroptera: Chrysopidae) than other lures. When commercial traps baited with liquid lures were evaluated under cage conditions, traps with lateral holes, such as Maxitrap and Tephri trap, captured more flies than traps with open bottom access. New commercial traps baited with CeraTrap were significantly more efficient than McPhail traps baited with hydrolyzed protein in hog plum (*Spondias mombin* L.; Sapindales: Anacardiaceae) but similar in mango (*Mangifera indica* L.; Sapindales: Anacardiaceae). We conclude that the CeraTrap lure is an efficient lure when used in combination with other inexpensive simple traps for monitoring this pest, including during periods of low population density.

Key Words: *Anastrepha obliqua*, CeraTrap, McPhail trap, mass trapping, monitoring

Resumen

Trampas, cebos y diferentes combinaciones de trampas y cebos fueron evaluados con la mosca de las Indias Occidentales, *Anastrepha obliqua* Macquart (Diptera: Tephritidae), para determinar un posible sustituto de la tradicional trampa McPhail de vidrio cebada con proteína hidrolizada, la cual está incluida como la combinación trampa/cebo oficial para el monitoreo de esta mosca en México. CeraTrap®, un cebo de proteínas de hidrólisis enzimática, capturó tantas moscas o más moscas de *A. obliqua* que trampas McPhail cebadas con la proteína de hidrólisis química Captor® o el cebo seco Biolure®. Cuando las poblaciones de mosca fueron altas, se observó un promedio de capturas tres veces superior para CeraTrap que con los otros cebos. El ratio de sexos estuvo inclinado generalmente hacia hembras y fue similar entre los cebos evaluados. CeraTrap no fue reemplazado durante el transcurso del experimento y mantuvo buena atracción y preservación de los especímenes después de un mes de uso. CeraTrap atrajo más crisopas (Neuroptera: Chrysopidae) que otros cebos. Cuando trampas comerciales cebadas con cebos líquidos fueron evaluadas en condiciones de jaula, trampas con orificios laterales como la trampa Maxitrap y Tephritrap capturaron más moscas que trampas con acceso invaginado. Nuevas combinaciones de trampas con CeraTrap resultaron ser significativamente más efectivas que la trampa McPhail con proteína hidrolizada en jobo (*Spondias mombin* L.; Sapindales: Anacardiaceae) pero similares en mango (*Mangifera indica* L.; Sapindales: Anacardiaceae). Concluimos que CeraTrap tiene el potencial de uso para el monitoreo de esta plaga, incluso en periodos de bajas densidades poblacionales.

Palabras Clave: *Anastrepha obliqua*, CeraTrap, trampa McPhail, trampeo masivo, monitoreo

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Among *Anastrepha* fruit flies, the West Indian fruit fly, *Anastrepha obliqua* Macquart (Diptera: Tephritidae), is considered one of the most destructive worldwide because it damages crops such as mango (*Mangifera indica* L.; Sapindales: Anacardiaceae), hog plum (*Spondias* spp.; Sapindales: Anacardiaceae), sapodilla (*Manilkara zapota* L.; Ericales: Sapotaceae), and guava (*Psidium* spp.; Myrtales: Myrtaceae) (Hernández-Ortiz & Aluja 1993). Because of its wide host range and broad distribution throughout the New World tropics and subtropics, *A. obliqua* is a potentially serious invasive pest in climatically similar areas where it is not yet established (Birke et al. 2013). Fu et al. (2014) argued that under current climatic conditions, *A. obliqua* has the potential to expand its range throughout much of the tropics and subtropics, including not only Mexico and South America, where it is native, but also Sub-Saharan Africa, southern Asia, and northeastern Australia.

Use of effective traps and lures in susceptible crop areas can detect and help estimate population densities of *A. obliqua* before application of control measures. The most widely used trap for *Anastrepha* surveillance programs around the world has been the McPhail glass trap (Steyskal 1977; Aluja et al. 1989), which was later redesigned as a 2-component plastic device with a yellow base and transparent plastic lid and called the plastic McPhail-like trap or Multilure® trap (Martínez et al. 2007). McPhail traps are recommended for pest monitoring by phytosanitary agencies in several countries, including Mexico (Anonymous 1999), despite the fact that several authors have highlighted their low efficacy (Aluja et al. 1989; Díaz Fleischer et al. 2009).

Torula yeast or hydrolyzed proteins are the most commonly used lures to monitor populations of *A. obliqua* flies. Low capture of adult fruit flies and low longevity of these baits reduce their value for monitoring and increase costs in surveillance programs, making them generally unsuitable for mass trapping programs.

We evaluated, under field conditions, the attraction of *A. obliqua* to a new commercial lure derived from enzymatic hydrolysis of proteins (CeraTrap®) that is commercially available for mass trapping fruit flies. This lure has proven attractive to *Anastrepha ludens* (Loew) and is durable under field conditions (De los Santos et al. 2012; Lasa et al. 2014 a, b). This product was compared under field conditions with the common hydrolyzed protein Captor® and the dry lure Biolure®, 2 of the most commonly used lures for monitoring *Anastrepha* species in Mexico. The capture of lacewings (Neuroptera: Chrysopidae) was also recorded. We also tested the capture efficacy of 12 different commercial trap models under field cage conditions in order to select the most effective one for capture of *A. obliqua*. Finally a field study was performed to compare the efficacy of standardized McPhail + hydrolyzed protein (Captor®) and 2 new trap-lure combinations in mango and hog plum orchards.

Material and Methods

Insects

Wild and semi-wild adults of *A. obliqua* were used for tests. Wild adults were obtained from pupae recovered from infested fruit of *S. mombin* collected near Xalapa, Veracruz, Mexico, and processed in the laboratory of the Red de Manejo Biorracional de Plagas y Vectores in the Instituto de Ecología A. C. Semi-wild adult fruit flies were obtained from pupae recovered in mango fruits (cv 'Manila') that were previously exposed to oviposition under cage conditions by semi-wild fruit flies produced in the laboratory. Newly emerged adults were placed in 30 × 30 × 30 cm acrylic cages covered with organdy and maintained under laboratory conditions at 27 ± 1 °C, 65 ± 10% RH and 12:12 h L:D. Semi-wild flies used in experiments were from generations 1 to 5. Adult flies had *ad libitum* access to hydrolyzed yeast, sugar, and water.

Traps and Lures

Three different commercial odor lures were compared in the field: CeraTrap® (Bioibérica, Barcelona, Spain), Biolure® (Suterra LLC, Bend, Oregon, USA) and the liquid hydrolyzed protein lure commonly used to monitor *Anastrepha* species in Mexico. Hydrolyzed protein (HP) was prepared with 10 mL of hydrolyzed protein Captor 300 (Promotora Agropecuaria Universal, Mexico City, Mexico), 5 g of borax (J. T. Baker, Mexico City) and 235 mL of water as indicated in the Mexican Phytosanitary Authority's standard formula for this kind of fruit fly lure (Anonymous 1999). CeraTrap is a liquid lure consisting of enzymatically hydrolyzed proteins that release a series of volatile compounds, mostly amines and organic acids, that are highly attractive to fruit flies (Marín 2010). Biolure® is a dry lure containing ammonium acetate (AA) and putrescine (Pt). This lure was purchased as individual sachets with adhesive on the back for attachment to the inside of traps.

Two sets of tests, under cage conditions, were performed to evaluate 12 different commercial fruit fly traps. The first set (Fig. 1, a-f) of tests involved the following traps: (Fig. 1a), McPhail-like trap IPS 235 (Great Lakes IPM, Inc. Vestaburg, Michigan), which is an invaginated plastic trap with 2 components; (Fig. 1b), MS2 (Fitozoosanitaria S.A. de C.V., Texcoco, Mexico), which is a 2-component plastic bottle with a yellow base covered by a transparent lid perforated with 3 small (10 mm) holes 5 cm apart; (Fig. 1c), Maxitrap UV (Probodelt, Amposta, Spain), which is a yellow cylindrical fly trap with a funnel base and 3 lateral holes through which transparent cylindrical tubes are placed to decrease the frequency of fly escape from the trap; (Fig. 1d), Maxitrap Plus (Probodelt, Amposta, Spain), which has an orange semi-spherical base with a transparent plastic top with 4 holes with opaque lateral access tubes integrated around the base of the trap. Although developed by Probodelt, this trap is currently distributed with the name Decis® trap

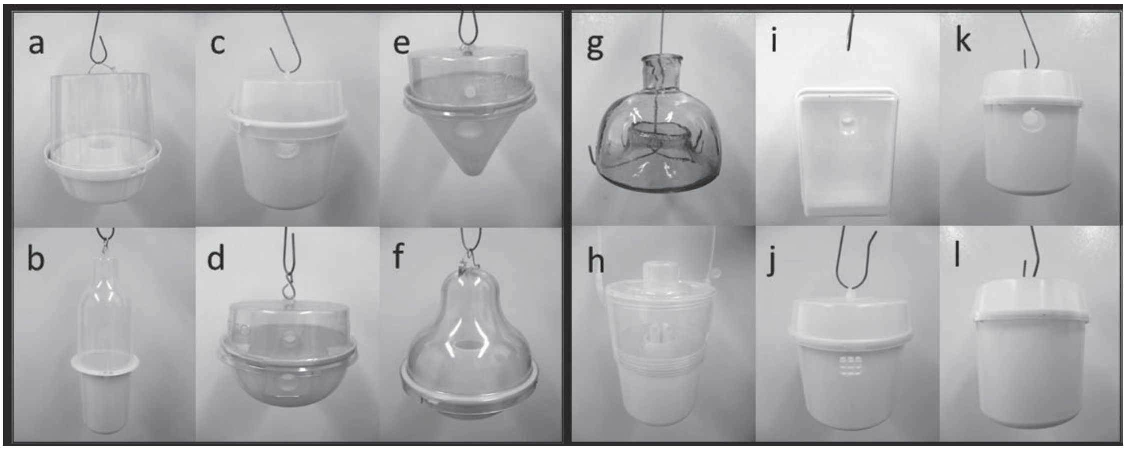

Fig. 1. Trap designs compared in field cage tests (experiment 1: a-f; experiment 2: g-l) to evaluate traps for *Anastrepha obliqua* capture. The traps are named as follows: 1a, McPhail-like trap IPS 235; 1b, MS2; 1c, Maxitrap UV; 1d, Maxitrap Plus (recently sold as Decis® trap by Bayer CropScience); 1e, Conetrap; 1f, Dome trap; 1g), McPhail glass trap; 1h), Bioibérica trap; 1i), Easy trap; 1j), Tephri ecological trap; 1k, Tephri trap; and 1l), McPhail Sorygar trap.

(Bayer CropScience, Valencia, Spain); (Fig. 1e), Conetrap (Probodelt, Amposta, Spain) which is an orange folding conical base trap, without a funnel but with 4 holes with opaque side entrances distributed around the base; and (Fig. 1f), Dome trap (Agrisense BCS Ltd., Pontypridd, UK), which is a bell-shaped invaginated 2 component McPhail-like plastic trap designed for a variety of fruit fly species.

A second set of tests involved traps (Fig. 1, g-l) of the following designs: (Fig. 1g), McPhail glass trap; (Fig. 1h), Bioibérica trap (Bioibérica, Barcelona, Spain), which is a 2-component plastic container with a yellow funnel base covered by a transparent lid perforated with 4 small (10 mm) holes. The upper part of this trap can be attached to the base, which allows traps to be transported with the liquid lure inside; (Fig. 1i), Easy trap (Sorygar, Madrid, Spain), which is an inexpensive rectangular trap with 2 access holes; (Fig. 1j), Tephri ecological trap (Sorygar, Madrid, Spain), which is a yellow cylindrical fly trap with a funnel base and 4 lateral holes where flies enter through a net with 9 holes of 6 × 6 mm; (Fig. 1k), Tephri trap (Sorygar, Madrid, Spain), which is a yellow cylindrical fly trap with a funnel base and four 22 mm lateral holes; and (Fig. 1l), McPhail Sorygar trap (Sorygar, Madrid, Spain), which is similar to the Tephri trap, with a funnel base but without lateral holes.

Evaluation of Lures

Lures were evaluated May-Jul 2013 in a mango orchard in Jalcomulco (N 19° 19' 47.05" W 96° 45' 18.65") in the State of Veracruz, Mexico. The test area was divided in 3 replicate blocks of approximately 2 ha each. Each block contained 3 glass McPhail traps with 3 different lures, i) hydrolyzed protein, ii) Biolure® and iii) CeraTrap®, for a total of 9 traps per area. Traps were baited with 250 mL of liquid lures. For Biolure®, dry sachets were glued in the upper part of the trap and 250 mL of water were used for fly retention. Hydrolyzed protein was replaced every 4 days, whereas Biolure and CeraTrap baits were not replaced during the entire course of the experiment. Additional bait or water (20 to 40 mL), in the case of Biolure, was added to these traps when needed in order to maintain the correct fluid volume (250 mL). Traps were placed one per tree at a height of 3-4 m, within the canopy, spaced 10-12 m between traps. Placement of traps within each block was randomized initially, and traps were checked every 4 days. Captured insects were collected and placed in vials with 70% ethanol. Trap position was rotated clockwise every 4 days during the 36 days of the experiment (3 times per position). Captured insects were counted in the laboratory and identified to species and sex. If some fly bodies had been partially eaten by ants, the number of wings was counted in order to estimate the total number of flies per trap. The percentage of females was calculated with traps that captured at least one fly.

Field Cage Test of Trap Efficacy

Two field cage tests were used to evaluate the efficacy of commercial traps for capture of *A. obliqua*. The first experiment evaluated 6 types of traps (Fig. 1a-1f), testing responses of wild *A. obliqua* flies collected from *S. mombin.* A second experiment evaluated 6 different traps (Fig. 1, traps g to l), testing the response of semi-wild flies. For both of these experiments, 4 to 9-day-old flies were used. These flies were starved overnight before testing. Thirty flies (15 females and 15 males) were released in a field cage (1.80 m × 1 m × 1 m) that contained six 1.4 m high mango plants evenly spaced within the cage. These experiments were done under a 12:12 h L:D, 27 ± 1.5 °C, and 55 ± 10% RH. Five minutes after flies were released inside the cage, the 6 traps were placed randomly at 6 different positions. All traps were previously baited with 150 mL of hydrolyzed protein. Conetrap, a trap designed for dry lures, was used with a small plastic container in the bottom to hold the liquid bait. Trap positions were rotated clockwise daily by one position for each of the 12 daily replicates, in such a way that each trap was placed twice in the same position over the course of the experiment. The total number of captured flies per trap was recorded after 24 h. After each replicate, flies not trapped were recovered and discarded.

Field Evaluation of Trap-lure Combinations

To determine the relative efficiency of new lure-trap combinations under field conditions, 2 experiments were performed; experiment #1 in hog plum trees and experiment #2 in a mango orchard. Experiment #1 used a block design with 3 trap-lure combinations and was set up between Oct and Dec 2012, in an area of *S. mombin*, near Xalapa, Veracruz, Mexico (N 19° 35' 38.30" W 96° 52' 37.65"). A glass McPhail trap baited with hydrolyzed protein (HP) was used as the control trap. The efficacy of fruit fly capture by the McPhail trap with HP was compared with those of the MaxitrapUV and Maxitrap Plus traps baited with the lure CeraTrap®, these being the most effective traps and lures identified in earlier tests. Traps were hung at a height of 3-4 m in hog plum trees, spaced 10-15 m between traps within a block. Three replicate blocks, at least 50 m apart, were established within a 6 ha test plot. Traps were randomized initially and rotated clockwise every 4 days at sampling. Insects captured in each trap were placed in 70% alcohol and taken to the laboratory where the number of males and females captured per trap were counted. Hydrolyzed protein was replaced every 8 days, whereas the CeraTrap did not require replacement and only needed to be topped up to the full 250 mL capacity after 12 days by adding 2-8 mL of lure.

For experiment #2, a similar block design with 3 trap/lure combinations was set up in a 4 ha mango orchard, between May and Jun 2013 in Apazapan, Veracruz, Mexico (N 19° 19' 47.05" W 96° 45' 18.65"). Three trap-lure combinations were compared. A glass McPhail trap baited with hydrolyzed protein (HP) was used as the control trap and was compared with other 2 trap-lure combinations, Maxitrap UV + CeraTrap and Tephri trap + CeraTrap. Traps were placed and checked as described in experiment #1. Insects captured in each trap were collected every 4 days, placed in 70% alcohol, and taken to the laboratory to be counted. Hydrolyzed protein lure in McPhail traps was replaced every 4 days and CeraTrap baited traps were topped up to 250 mL at the same time.

Statistical Analyses

For the evaluation of lures, the numbers of *A. obliqua* flies captured was transformed to Flies/Trap/Day (FTD) and number of lacewings to Lacewings/Trap/Day (LTD). Percentage of females, FTD, and LTD captured per trapping session were subjected to a non-parametric Kruskal Wallis test. Differences among treatments were determined by Mann-Whitney tests with the Bonferroni correction for multiple comparisons. All statistical analyses were performed using R (R Core Team 2012).

For the 2 field cage experiments comparing types of traps, the numbers of flies caught per trap per replicate were $\sqrt{(x + 0.5)}$ transformed to stabilize variance and subjected to one way analysis of variance (ANOVA).

For both field experiments comparing new trap-lure combinations against the McPhail + HP standard, total captures were converted to Flies/Trap/Day (FTP), log $(x + 0.1)$ transformed to stabilize variance and subjected to one way ANOVA. The percentage of females in trap catches was calculated for all traps that captured at least one fly; percentage values were normalized by arcsine transformation and subjected to one way ANOVA.

Results

Evaluation of Lures

During trap exposure in the mango orchard 5,570 fruit flies were captured of which 5,470 (98.2%) were *A. obliqua*, 84 (1.5%) were *A. serpentina* (Wiedemann) and 16 (< 1%) were *A. ludens*. For *A. obliqua* flies, only 34 (17 in HP and 17 in Biolure) could not be sexed. A total number of 1,473 flies, 3,515 flies and 482 flies were trapped in HP, CeraTrap and Biolure respectively. Flies captured per trap per day (FTD) differed significantly among lures (Kruskal Wallis, $\chi^2 = 38.57$; df = 2; $P < 0.01$). However, the percentages of females were similar among lures (Kruskal Wallis, $\chi^2 = 1.76$; df = 2; $P = 0.415$) (Table 1). The numbers of flies captured per lure per day in the 3 independent blocks of mango orchard are given in Fig. 2. The CeraTrap lure captured more flies per trap per day (FTD) than the other lures on most of the evaluation days and in most blocks (23 of 27; 85% of total). Differences observed in FTD

TABLE 1. MEAN (± S.E.) NUMBER OF *ANASTREPHA OBLIQUA* ADULTS CAPTURED PER TRAP PER DAY (FTD), PERCENTAGE FEMALE, AND NUMBER OF LACEWINGS PER TRAP PER DAY CAPTURED BY MCPHAIL TRAPS BAITED WITH HYDROLYZED PROTEIN, CERATRAP, OR BIOLURE IN A MANGO ORCHARD (N = 3).

	Flies/Trap/Day		
Trap + Lure	Total FTD ± S.E.	% Females ± S.E.	Lacewings/Trap/Day
McPhail + HP	13.6 ± 2.8 a	67.9 ± 2.4 a	0.05 ± 0.03 a
McPhail + CeraTrap	32.6 ± 8.6 b	72.6 ± 2.0 a	0.426 ± 0.109 b
McPhail + Biolure	4.5 ± 1.4 a	68.7 ± 4.3 a	0.213 ± 0.127 b

Means followed by the same letter within a column are not significantly different (Mann Whitney, $P < 0.05$).

values when populations were low were marginal in some cases, but a substantial difference was observed in all blocks when *A. obliqua* populations rose between 10 and 18 Jun 2013. Numbers of lacewings caught per trap per day (LTD) were significantly higher (Kruskal Wallis, $\chi^2 = 17.65$; df = 2; $P < 0.01$) for CeraTrap and Biolure than in HP (Table 1).

Traps Efficacy under Field Cage Conditions

Of 360 flies placed in cages (30 flies × 12 replicates) to compare the efficiency of various trap designs, 233 flies (64.7%) and 187 flies (51.9%) were captured in traps in experiments #1 and #2, respectively. Among the 12 trap designs evaluated, 3 trap designs were the most effective in capturing flies (Fig. 3). In experiment #1, the Maxitrap UV and Maxitrap Plus were significantly more effective than the other traps ($F = 8.13$; df = 5,66; $P < 0.001$), with the exception of the Conetrap, whose efficacy was intermediate between these groups. Tephri traps caught more flies than other trap designs in experiment #2 ($F = 33.91$; df = 5,66; $P < 0.001$), although it was not statistically better than the Tephri ecological trap.

Field Evaluation of Trap-lure Combinations

A total of 1,365 fruit flies were captured in the hog plum orchard, of which 95.2% were *A. obliqua*, 3.3% were *A. striata* (Schiner) and 1.5 % were *A. ludens*. Captures by Maxitrap UV and Maxitrap Plus traps baited with CeraTrap caught 2-fold more flies than did the McPhail + HP trap ($F = 7.55$; df = 2,105; $P < 0.001$) (Table 2). Maxitrap UV and Maxitrap Plus baited with CeraTrap were not statistically different from each other. Percentage of trapped females flies was also not significantly different among trap-lure combinations ($F = 0.317$; df = 2,69; $P = 0.729$). During the course of the experiment, on 23 (~64%) occasions, McPhail + HP did not capture any *A. obliqua* females. In contrast, Maxitrap UV and Maxitrap Plus traps baited with CeraTrap, failed to catch *A. obliqua* females on 11 (~30%) and 9 occasions (~25%), respectively. This suggests better detection by the new lure-trap combinations than by McPhail traps + HP, particularly when *A. obliqua* population densities were low.

In mango, no significant differences were observed among traps during peak captures. However, among 11,815 fruit flies captured in this trial, only 4,291 (36.3%) were *A. obliqua*. This was probably due to the presence of a large numbers of Sapotaceae plants surrounding the study area. Consequently, 7,235 captured fruit flies were *A. serpentina* (61.2%) and 289 (2.4 %) were *A. ludens*. In this case, although Maxitrap UV + CeraTrap and Tephi trap + CeraTrap captured between 35 and 45% more *A. obliqua* flies per trap per day (FTD) than the McPhail trap + HP, these differences were not statistically significant ($F = 0.1699$; df = 2,78; $P = 0.844$) (Table 2, part B). Similarly, the percentage of captured females flies did not differ statistically among trap-lure combinations ($F = 0.215$; df = 2,69; $P = 0.807$) (Table 2, part B).

DISCUSSION

Many studies have evaluated the attractiveness of lures against *A. obliqua*. Although several fruit extracts and fruit volatiles have been tested (Ortega & Cabrera 1996, Toledo et al. 2009; López-Guillén et al. 2010), proteinaceous baits such as torula yeast, Nulure, and Captor, together with dry lures such as Biolure, have been the most commonly studied lures for monitoring this pest in the Americas. In a study carried out during 2 consecutive years in Veracruz, Mexico, 3 protein lures, i.e., Nulure, Captor, and a protein from Bayer, showed similar attraction and capture of *A. obliqua* in mango orchards (Ortega & Cabrera 1996). In this case, torula yeast was least attractive to *A. obliqua*. Comparing liquid and dry lures, Epsky et al. (2003) observed that torula yeast or Nulure outperformed the ammonium acetate and putrescine lure in mango orchards in Mexico, Costa Rica, Colombia, and Honduras but not in Mexican mamey zapote (*Pouteria sapota* Jacq.; Ericales: Sapotaceae). Similar results, in which liquid lures outperformed dry lures, were described by Pingel et al. (2006) with torula yeast

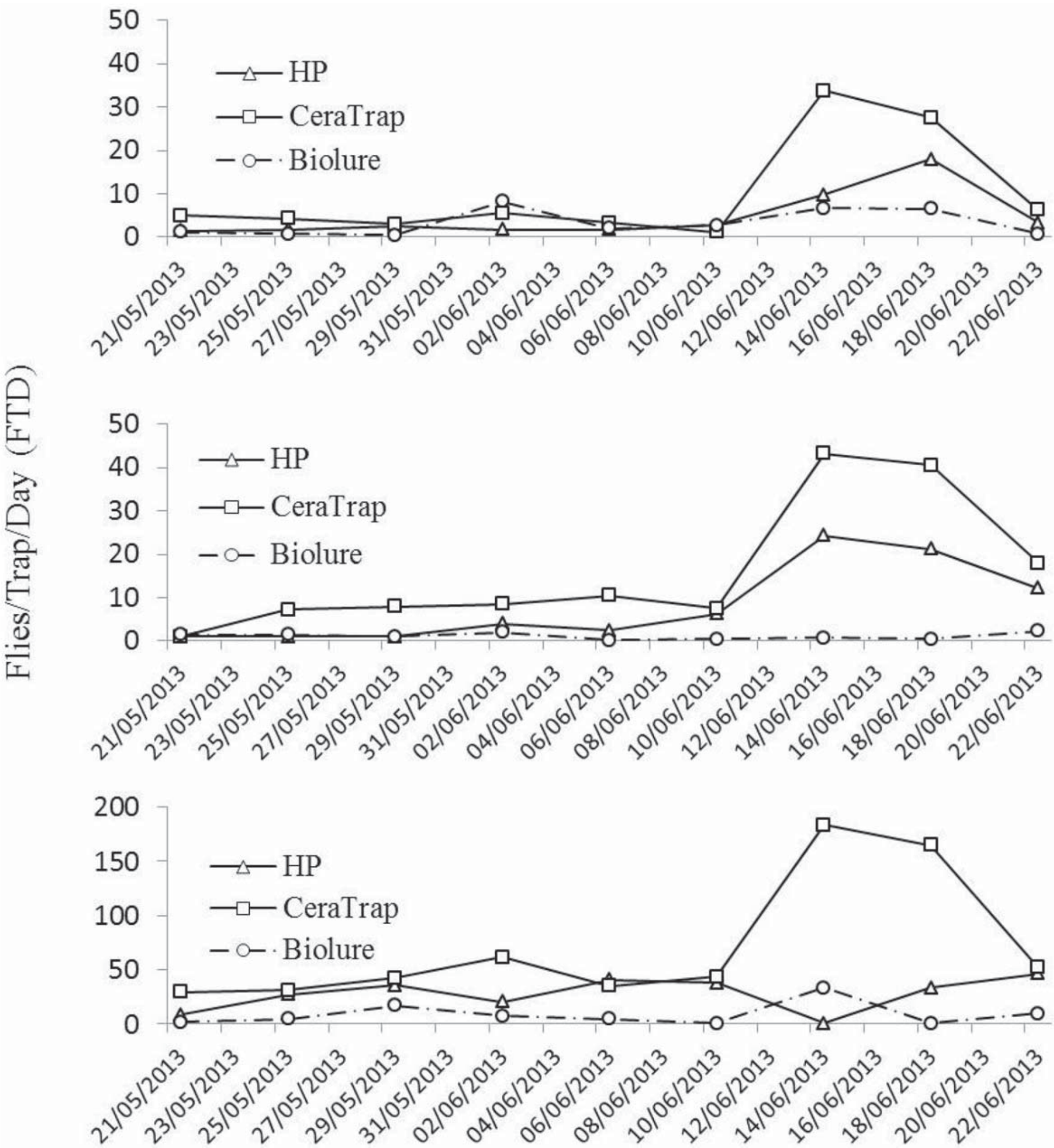

Fig. 2. *Anastrepha obliqua* adults captured per trap per day (FTD) in the three independent blocks where flies were monitored with McPhail traps baited with common hydrolyzed protein (HP), CeraTrap, or Biolure (ammonium acetate + putrescine).

in orchards of mamey zapote and sapodilla (*Manilkara zapota* L.) but not in orchards of carambola (*Averrhoa carambola* L.; Oxalidales: Oxalidaceae) in Puerto Rico. Thomas et al. (2008) also found that Nulure was more effective against *A. obliqua* than ammonium acetate and putrescine (AA + Pt) dry lures in mango orchards in the Dominican Republic. López-Guillen et al. (2010) observed a similar level of attraction of AA + Pt and Nulure against *A. obliqua* in mango orchards in Mexico. In contrast, Díaz-Fleischer et al. (2009) reported that AA + Pt out-performed Nulure with *A. obliqua* in caged mango studies in southern Mexico, as did Jenkins et al. (2011) in carambola orchards in Puerto Rico. Despite a generally higher attractiveness by liquid lures in many experiments, high variability among lures has been observed, that probably depend on several factors, including the prevailing conditions in different regions, different crop species, and different times of the

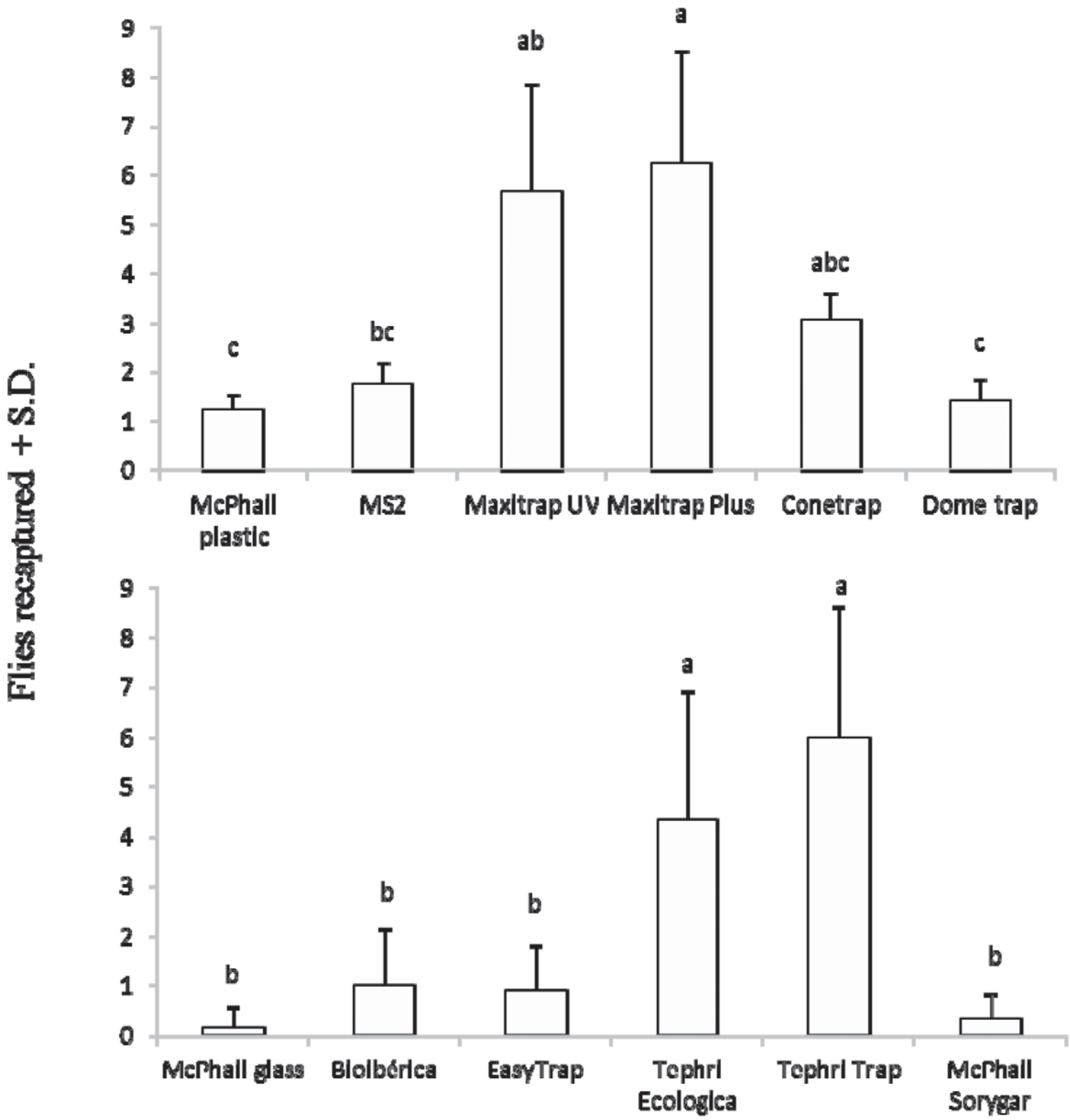

Fig. 3. Mean (+ SD) *Anastrepha obliqua* captured in 24 h in field cage tests of trap models baited with hydrolyzed protein (N = 12). Bars with the same letter within a test are not significantly different (Turkey's mean separation test on √(x + 0.5)-transformed data, *P* = 0.05; non-transformed means presented).

year (Jenkins et al. 2011). Weather conditions are also likely to influence efficacy, with liquid lures like torula yeast, Captor, and Nulure being more attractive during dry periods than in wet seasons (Heath et al. 1997).

Our results showed that the enzymatically hydrolyzed liquid protein lure (CeraTrap) outperformed both Biolure and the chemically hydrolyzed protein (Captor) in mango when using McPhail glass traps. About 3 times more *A. obliqua* were captured with the CeraTrap lure than with Captor. Higher attraction by CeraTrap was indirectly observed in a test of different traps and lures against *A. ludens* in a grapefruit (*Citrus* × *paradise* Macfad.; Sapindales: Rutaceae) orchard in Mexico (Lasa et al. 2013, 2014a). As reported previously (Lasa et al. 2013), in the present study we also observed that CeraTrap was more attractive to lacewings than the other lures we tested in the mango orchard.

Maxitrap Plus, Maxitrap UV, Tephri traps, and Ecological Tephri traps were the most effec-

TABLE 2. MEAN (± S.E.) NUMBER OF *ANASTREPHA OBLIQUA* ADULTS CAPTURED PER TRAP PER DAY (FTD) AND PERCENTAGE FEMALES CAPTURED IN FIELD TESTS CONDUCTED IN A) HOG PLUM OR B) MANGO (N = 3 PER SITE).

	Flies/Trap/Day	
Trap + Lure	Total FTD ± S.E.	% Females ± S.E.
Hog Plum		
McPhail + HP	1.3 ± 0.4 a	55.1 ± 5.8 a
Maxitrap UV + CeraTrap	2.8 ± 1.2 b	61.1 ± 4.1 a
Maxitrap Plus + CeraTrap	2.3 ± 0.9 b	58.6 ± 4.5 a
Mango Orchard		
McPhail + HP	10.42 ± 1.12 a	68.0 ± 2.2 a
Maxitrap UV + CeraTrap	14.09 ± 2.44 a	66.6 ± 3.0 a
Tephri + CeraTrap	15.27 ± 2.13 a	68.4 ± 2.2 a

Means in columns followed by the same letter within each field site and column were not significantly different (Turkey's mean separation test on arcsine-transformed data, $P = 0.05$; non-transformed means presented).

tive trap designs under cage conditions. Traps with spherical shapes, together with cylindrical and cubical shapes, have been reported as the most attractive for *A. obliqua* (López-Guillén et al. 2009). Captures are also affected by the model size and the 3-dimensional shape of the traps, with flies being most attracted to spheres between 8 to 12 cm diam compared to larger or smaller sized spheres (Martínez et al. 2007). Although the shapes and sizes of the traps we evaluated could have influenced attraction, the presence of lateral entry holes in the traps, a feature lacking in McPhail-like traps, seems to have enhanced fly capture under field cage conditions when baited with liquid lures. Lateral holes seem to favor capture in 2 ways: first, by improving attraction through greater volatile emission and second, by providing flies with readily accessible points of entrance after landing. McPhail traps are still included as the official trap in the Mexican Government's Phytosanitary Guidelines (NOM-023-FITO-1995) for use in surveillance programs in Mexico (Anonymous 1999) despite a number of disadvantageous characteristics, such as low efficacy, excessive weight, fragility (glass construction), high cost, and being inherently difficult to service, re-bait and to collect all the trapped insects. The 3 commercial traps that were highlighted in our caged condition tests and that were then compared in the field, lack all of the McPhail trap design and performance problems, and are significantly cheaper. These traps are also more economical to use than the plastic McPhail-like trap and Multilure® trap, which are now being used to overcome some of the problems posed by glass McPhail traps. The CeraTrap lure did not require re-baiting during the entire duration of experiments and only a few milliliters of lure were added during each service time to maintain the lure at a volume of 250 mL. The response of *A. obliqua* to CeraTrap after 4 wk of field exposure demonstrates this lure's attraction and durability. Even under these conditions, CeraTrap was more effective than HP or Biolure. Lure longevity represents a significant advantage because traps remain effective over extended periods and require less servicing (depending on evaporation), which simplifies the logistical aspects of running trapping programs. If used for monitoring fruit flies at the orchard level, traps with this lure could be checked by growers at longer intervals (2-3 wk) when fruit fly populations are sparse, provided that weather conditions do not cause excessive lure evaporation. In a mass trapping experiment, CeraTrap proved very effective against *A. ludens* even after 3 months of use, and all specimens trapped at the end of this prolonged period could be correctly identified and sexed (Lasa et al. 2014b), probably because CeraTrap includes a potent preservative. Only about half of the lure evaporated during the 3 months of the trial reported by Lasa et al. (2014b), favoring its use as a lure for mass trapping the pest. Our results show that trap-lure combinations including CeraTrap were better, or at least similar, to McPhail-like traps baited with HP, but their cost and logistics of trapping are greatly improved if these new trap-combinations are used and if CeraTrap lure were re-used for several weeks.

This study contributes additional information on the response of *A. obliqua* to the new commercial lure CeraTrap, new traps, and trap-lure combinations that could be potentially used for mass trapping programs targeted at *A. obliqua,* or to monitor populations of this pest. Due to the high variability in the response of this pest to previous combinations of traps and lures, additional tests to corroborate the attraction of *A. obliqua* to CeraTrap should be performed under several cycles of wet and dry season conditions and in a diversity of crop systems affected by this pest.

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