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A SIMPLE AND EFFECTIVE CYLINDRICAL STICKY TRAP FOR FRUIT FLIES (DIPTERA: TEPHRITIDAE)

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ABSTRACT

A sticky trap for fruit flies was developed that is 2.5× more effective than yellow panel traps of equal surface area for capture of Mexican fruit flies (*Anastrepha ludens* (Loew)). The trap consists of a slightly conical yellow cardboard cylinder coated on the outside surface with trapping adhesive. In trapping efficacy, these stand-alone cylinders were equivalent to plastic Liquibaitor trap tops with similar cylinders fitted over the trap top with the sticky surface facing outward. Liquibaitor trap tops with cylinders mounted on the inside with their sticky surfaces facing inward were ineffective, and Liquibaitor tops with cylinders both inside and outside were not more effective than those with the sticky surface only on the outside. Besides the increased attractiveness of the stand-alone cylinders with the sticky surface outside, advantages of this design are that lures can be suspended from the trap hanger inside the cylinder where they do not contact the sticky surface, sticky cylinders can be changed in the field without disturbing lures that are suspended from the hangers, and traps can be stacked like Dixie cups for storage and transport.

Key Words: Mexican fruit fly, *Anastrepha ludens*, trap design, integrated pest management.

RESUMEN

Una trampa pegajosa para moscas de las frutas que es 2.5× más efectiva que las trampas de paneles amarillas de igual área de superficia para capturar la mosca mexicana de la fruta *(Anastrepha ludens* Loew) fue desarrollada. La trampa consiste de un cilindro de cartón un poco cónico de color amarillo con la superficie exterior cubierta con un pegamento para atrapar las moscas. En cuanto la eficacia de las trampas, estos cilindros que se sostienen solos fueron equivalentes a las trampas de tapa "Liquibaitor" con cilindros similares puestos sobre la trampa con la superficie pegajosa hacia afuera. Las trampas de tapa "Liquibator" montadas con la superficie pegajosa hacia adentro fueron inefectivas y las tapas de "Liquibator" con cilindros con la superficie exterior y la interior pegajosa no fueron mas efectivas que las trampas con solo la superficie exterior pegajosa. Aparte de que estos cilindros tienen la superficie exterior pegajosa y se pueden sostener solos y atrapan mas moscas, este diseño tiene la ventaja de que los señuelos pueden ser suspendidos de un gancho puesto dentro del cilindico donde no tiene contacto con la superficie pegajosa, se puede cambiar los cilindros pegajosos en el campo sin disturbar los señuelos que estan suspendidos de los ganchos y además puede guardar y transportar las trampas una encima la otra como vasos de la marca "Dixie".

Detection with traps is the first line of defense against exotic fruit flies and a critical element in programs to control resident species (Robacker & Landolt 2002). Two principal types of traps are in general usage: those that induce flies to land and become trapped on a sticky surface, and those that lure flies into an enclosed space where they drown in a liquid reservoir or contact a killing agent. Which type works better depends on the fly species and type of lure. Each type has found numerous niches in fruit fly programs around the world. Because of the need for earlier and more reliable detection to improve fruit fly control, development of better traps of both types is ongoing in many labs and agencies concerned with fruit fly management.

Synthetic lures for Mediterranean fruit fly (*Ceratitis capitata* Wiedemann) and various *Anastrepha* such as the Mexican fruit fly (*A. ludens* (Loew)) have been invented during the last decade (Biolure, Suterra, Inc., Bend, OR; *Anastrepha* Fruit Fly Lure, IPM Tech, Portland, OR). Whereas traditional baits for detection of *Anastrepha* were liquid suspensions that required McPhail-type traps, these new lures can be readily used with either enclosed traps or sticky traps. One of these lures (Biolure) has been used successfully in Multilure traps (Florence Agri Investment, Inc., Miami, FL) (Thomas et al. 2001) and other McPhail-type traps with liquid reservoirs including Liquibaitor traps (International Pheromone, South Wirral, UK) (Epsky et al. 1999; Katsoyannos et al. 1999; Papadopoulos et al. 2001). Although agencies charged with fruit fly trapping may actually prefer to use a dry trap, a change to dry traps is unlikely unless they are at least as attractive as existing McPhail-type wet traps. At this time, no commercially available

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dry traps can match trapping efficacy of McPhail-type traps.

Our goal is to develop a more effective sticky trap. In this work, we investigated effect of trap shape. It is well known that trap shape affects attractiveness of sticky traps. Although numerous shapes have been tested, little has been published on shapes other than panels and spheres (Katsoyannos 1989; Epsky & Heath 1998). Nakagawa et al. (1978) showed that cylinders were among the least attractive shapes to Mediterranean fruit flies. However, Heath et al. (1997) described a highly effective cylindrical sticky trap that was constructed with paper coated with an extremely tacky dry adhesive (Atlantic Paste and Glue Co., Inc., Brooklyn, NY). The relative effects of the cylindrical shape and the highly sticky surface on performance of the trap were not evaluated.

Because the cylindrical trap developed by Heath et al. (1997) was so effective, we wanted to re-investigate effectiveness of cylindrical traps. In this work we evaluate the cylindrical shape with a standard sticking agent rather than the dry adhesive used by Heath et al. (1997). In one experiment we investigated the effect of having the sticky surface on the inside vs. outside of cylinders mounted on the top of Liquibaitor trap tops. In the second experiment, we evaluated stand-alone cylinders vs. cylinders mounted on Liquibaitor trap tops. Traps were compared with a commercially available sticky trap for catching irradiated, laboratory-colony Mexican fruit flies released into a citrus orchard.

Materials and Methods

Experimental Traps

Four cylindrical trap types were constructed of yellow cardboard obtained from IPM Tech (Portland, OR) coated with Stickem Special (Seabright Laboratories, Emeryville, CA). For three of these types, the cardboard was formed into cylinders that fit snugly either inside or on the outside of the plastic top of a Liquibaitor trap (often referred to as an International Pheromone McPhail trap). The three trap types constructed this way consisted of Liquibaitor trap tops with sticky cylinders inside, outside, or both inside and outside.

The fourth trap was a stand-alone (without a Liquibaitor trap top) cylinder with the sticky coating on the outside, of the same dimensions as used to fit over the outside of the Liquibaitor trap top (Fig. 1). The trap is slightly conical with a top diameter of 13.5 cm, a bottom diameter of 16 cm, and a height of 13.5 cm. The total sticky surface area (618 cm^2) was approximately equal to that (644 cm^2) of a Pherocon AM trap (Trece, Inc., Salinas, CA). A wire with a loop in the center was fastened across the top diameter of the cylinder. The loop in the wire served for hanging the trap.

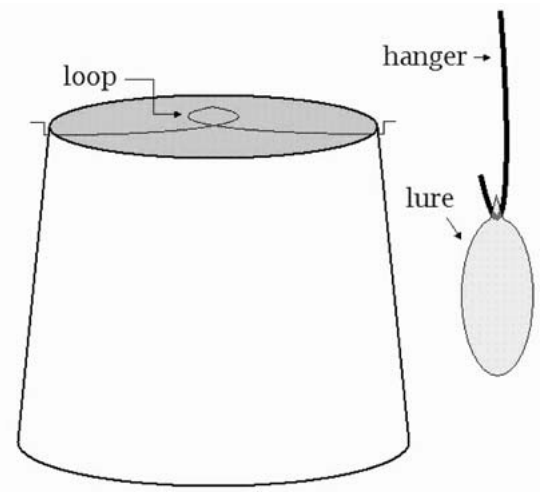


Fig. 1. Stand-alone sticky cylindrical trap for fruit flies constructed with yellow cardboard coated with Stickem Special (top diameter, 13.5 cm; bottom diameter, 16 cm; height, 13.5 cm). The lure and trap (at the loop in the wire) can be suspended separately from the trap hanger.

Insects

Mexican fruit flies (*Anastrepha ludens*) were used to evaluate the effectiveness of the trap. Flies were from a culture that originated from yellow chapote fruit, *Casimiroa greggii* (Rutaceae), collected in Nuevo Leon, Mexico, in 1987. Flies were irradiated, due to quarantine laws, with 70-92 Grays (Cobalt 60) 1 to 2 days before adult eclosion. Mixed-sex groups of 180-200 flies were kept in 473-ml cardboard cartons with screen tops until used in tests. Laboratory conditions for holding flies were 22 ± 2°C, 50 ± 20% relative humidity and photophase from 0630 to 1930 hours provided by fluorescent lights. Flies were fed sugar and water until they were released in test plots 3 to 8 days after eclosion.

Field Evaluations

The purpose of these experiments was to test the efficacy of the experimental traps against the Pherocon AM (no bait) trap. Pherocon AM traps are rectangular (14 × 23 cm) yellow cardboard panels coated with an adhesive similar to Stickum Special. Experiments were conducted in a mixed citrus orchard located near the laboratory in Weslaco, Texas. The orchard contained several varieties of orange, lemon, and tangerine trees of various ages. One row of Dancy tangerine (*C. reticulata*) was chosen for tests since it contained relatively large (2-3 m height) fruit-bearing trees. IPM Tech *Anastrepha* Fruit Fly Lures were suspended inside of Liquibaitor trap tops or from the hanger of the sticky cylinder traps at the loop in

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the wire. Pherocon AM (no bait) traps with IPM Tech *Anastrepha* Fruit Fly Lures attached to the trap hangers were used as the control. Traps were located one to a tree, north of center, at 1-2 m height. Trapped flies were counted and all of the traps were replaced each week. Lures were used for the duration of each of the two field experiments. Each week approximately 3000 flies were released onto trees in a row adjacent to the test row so as to create a uniform distribution of flies near the test trees. The first experiment was a test of the three trap designs with sticky cylinders on Liquibaitor trap tops compared with Pherocon traps. Three linear blocks of four consecutive trees were used in the row, with one buffer tree between blocks. Each of the three blocks contained one each of the four trap types. Trap types were randomized within each block the first time traps were put into the orchard, and then moved sequentially within each block when traps were serviced once per week. Eighteen replicates of each trap type were tested (3 blocks × 6 service weeks).

The second experiment tested sticky cylinders without Liquibaitor trap tops (Fig. 1) against sticky cylinders on the outside of Liquibaitor trap tops, and Pherocon traps. Four linear blocks of three consecutive trees were used in the row, with a buffer tree between blocks. Each of the four blocks contained one each of the three trap types. Procedure was the same as in the previous experiment. Twenty-eight replicates of each trap type were tested (4 blocks × 7 service weeks).

Statistical Analyses

The experimental design for both experiments was a randomized complete block. Replications over time (service weeks) were treated like replications over space (blocks of trees) for the purpose of statistical analyses. Data were subjected to analysis of variance with SuperANOVA (Abacus Concepts 1989).

Results and Discussion

Results of the experiment testing sticky cylinders on Liquibaitor trap tops are shown in Table 1. The analysis of variance was highly significant ($F = 11.4$; $df = 3,68$; $P < 0.0001$). Liquibaitor trap tops with sticky cylinders on the inside captured fewer flies than Pherocon traps. Traps with sticky cylinders on the outside did not differ in attractiveness from those with cylinders both inside and outside. Both of these designs were more attractive than Pherocon traps. Trap types did not differ regarding percentage of females captured.

Fly captures on stand-alone sticky cylinder traps did not differ from those on sticky cylinders fitted on the outside of Liquibaitor trap tops ($F = 8.9$; $df = 2,81$; $P < 0.001$) (Table 2). Both designs were more attractive than Pherocon traps. Trap types did not differ regarding percentage of females captured.

Cylindrical sticky traps with the sticky surface on the outside, either stand-alone or mounted on Liquibaitor trap tops, captured about 2.5×more Mexican fruit flies than Pherocon panel traps of approximately the same sticky surface area. These results indicate that cylinders are more attractive than panels.

As discussed in the introduction, Heath et al. (1997) described a highly effective cylindrical sticky trap made with an extremely tacky dry-adhesive paper. This trap captured twice as many Mexican fruit flies and Mediterranean fruit flies as glass McPhail traps with the same lures. Relative importance of cylindrical shape and the trapping adhesive were not evaluated, however, it now seems likely that the great effectiveness was at least partly due to the shape.

The cylinder traps with their sticky surfaces inside Liquibaitor trap tops were designed to function like a dry version of a McPhail trap. In both types of traps, flies must enter from below as they approach the attractive volatiles coming from either the liquid reservoir or the lure suspended inside the trap top. The poor performance of these traps was unexpected based on the historical effectiveness of McPhail traps. However, Heath et al. (1997) also reported poor captures of Mexican fruit flies with an open-bottom cylindrical dry trap that required flies to enter from the bottom or through small holes in the side.

Despite great promise, the cylindrical sticky trap described by Heath et al. (1997) was never produced commercially, possibly because small

Table 1. Mexican fruit fly captures per week on sticky cylinders attached inside or outside of Liquibaitor trap tops compared with Pherocon traps.[1,2]

Test trap	Males	Females	Total
Pherocon	1.3 ± 0.3 a	2.2 ± 0.4 b	3.5 ± 0.5 b
Sticky cylinder inside	0.3 ± 0.2 a	0.2 ± 0.2 a	0.5 ± 0.2 a
Sticky cylinder outside	4.0 ± 0.8 b	5.4 ± 1.1 c	9.4 ± 1.7 c
Sticky cylinders inside and outside	3.2 ± 0.5 b	4.2 ± 0.6 c	7.4 ± 0.9 c

[1]All traps were baited with an IPM Tech *Anastrepha* Fruit Fly Lure.
[2]Means (±SE) in the same column followed by the same letter are not significantly different by Fisher's protected LSD test ($P < 0.05$).

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TABLE 2. MEXICAN FRUIT FLY CAPTURES PER WEEK ON TWO TYPES OF STICKY CYLINDER TRAPS COMPARED WITH PHEROCON TRAPS.[1,2]

Test trap	Males	Females	Total
Pherocon	1.7 ± 0.3 a	2.4 ± 0.4 a	4.1 ± 0.6 a
Sticky cylinder on Liquibaitor trap top	5.1 ± 0.8 b	4.7 ± 0.5 b	9.8 ± 1.1 b
Sticky cylinder	5.1 ± 0.7 b	5.0 ± 0.6 b	10.0 ± 1.2 b

[1]All traps were baited with an IPM Tech *Anastrepha* Fruit Fly Lure.
[2]Means in the same column followed by the same letter are not significantly different by Fisher's protected LSD test ($P < 0.05$).

birds and lizards were sometimes trapped due to the extreme stickiness (Heath et al. 1997). Also, the sticky surface of these traps adheres flies so well that fly damage on removal renders identification difficult (T. Holler, USDA-APHIS, pers. comm). Also, experiments with panel traps made with the same paper (Robacker & Heath 2001) indicated that rain damages both the adhesive and the paper, making the traps ineffective.

The stand-alone cylindrical sticky trap developed in this work has numerous features that enhance its effectiveness and ease of use. First, the looped wire spanning the diameter of the top of the trap provides a point for attachment of the hanger and suspension of a lure in the center. If the lure is suspended from the trap hanger, then the disposable sticky trap body can be easily replaced without disengaging the lure. Further, the lure does not become sticky because it never comes in contact with the sticky surface of the trap. This is important because commercial synthetic lures are manufactured so as to last several months. Also, because the trap is slightly conical, the sticky surface can be covered with wax paper and traps can be stacked like Dixie cups for shipping and transport to the field. This feature gives this trap an advantage over spheres and non-conical cylinders. With regard to the adhesive, neither the cardboard nor the Stickem Special trapping adhesive are damaged by rain and trapping of birds or other small animals has not been observed. Most importantly, the cylindrical shape makes it much more attractive than yellow panel traps, greatly improving detection of Mexican fruit flies and perhaps other species of Tephritidae.

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