Evaluation of commercial and field-expedient baited traps for house flies, *Musca domestica* L. (Diptera: Muscidae)

Christopher J. Geden[1]✉, Daniel E. Szumlas[2], and Todd W. Walker[2]

[1]*USDA, ARS, Center for Medical, Agricultural and Veterinary Entomology, 1600 SW 23rd Dr., Gainesville, FL 32608, U.S.A.*
[2]*Navy Entomology Center of Excellence, Naval Air Station, P.O. Box 43, Building 937, Jacksonville, FL 32212, U.S.A.*

Received 7 September 2008; Accepted 9 January 2009

ABSTRACT: A comparison of nine commercial baited fly traps on Florida dairy farms demonstrated that Terminator traps collected significantly more (13,323/trap) house flies (*Musca domestica* L.) than the others tested. Final Flight, Fly Magnet, and FliesBeGone traps collected intermediate numbers of flies (834-2,166), and relatively few were caught with ISCA, Advantage, Fermone Big Boy, Squeeze & Snap, or OakStump traps (<300). Terminator traps collected about twice as many flies (799.8/trap) as FliesBeGone traps (343.8) when each trap was baited with its respective attractant, but when the attractants were switched between the two trap types, collections were significantly lower (77-108) than was observed with traps baited with their respective attractant. Solutions of molasses were significantly more attractive to house flies than honey, maple syrup, or jaggery (date palm sugar). Field-expedient traps constructed from discarded PET water bottles were much less effective than commercial traps, but painting the tops of such traps with black spray paint resulted in a six-fold increase in trap capture. ***Journal of Vector Ecology* 34 (1): 99-103. 2009.**

Keyword Index: House fly, *Musca domestica*, trapping.

INTRODUCTION

Traps have been a mainstay of house fly (*Musca domestica* L.) control for at least a century (Howard 1911). There is now a vast literature on attractants for house flies, perhaps originating with the description of a trap baited with fish heads, watermelon rinds, corncobs, and ice cream (Howard 1911). Much of this work has focused on identifying components of food odors that can be incorporated into lures (Frishman and Matthysse 1966, Mayer 1971, Mulla et al. 1978). Early efforts with baits relied on natural products such as fermented egg slurries (Willson and Mulla 1973) or combinations of such items as molasses, milk, yeast, grain, blood, and banana extract (Pickens et al. 1973, Pickens and Miller 1987). Brown et al. (1961) tested a range of defined chemical attractant candidates and found that combinations were superior to any individual component tested alone, and Mulla et al. (1977) reported that blends of trimethylamine, ammonia, indole, and linoleic acid were as attractive to house flies as natural food baits. These feeding attractants in general provide flies with volatile stimuli indicative of metabolism of either sugars or protein food resources. In addition to feeding attractants, flies are attracted to the pheromone (Z)-9-tricosene (muscalure) (Carlson et al. 1971, Carlson and Beroza 1973). This research has led to development of a variety of commercial traps with proprietary attractants that are available to the consumer. Most of these can be categorized as bag- or jug-style traps that are designed to hold a liquid bait. Flies enter the traps through small openings and eventually fall into the bait reservoir.

Fly control is important to U.S. military operations at home and in deployed settings, and traps provide a simple ready-to-use tool for such control efforts. The Armed Forces Pest Management Board is charged with selecting a limited number of arthropod control products to be assigned a national stock number (NSN) by the Department of Defense central depot, allowing it to order and warehouse sufficient quantities to fill orders that meet military pest control needs. Although there are many commercially available fly traps, there is little published information on their relative efficacy (Geden 2005). At the time of this study, a single product, the FliesBeGone trap, had been assigned a NSN, in part because of the collapsible nature of the product. It is also possible to construct homemade fly traps from empty water or soda bottles. Although the instructions for making such "field-expedient" traps have been available for some time (Prendergast 2002), we are unaware of any data supporting the selection of appropriate baits for them or if the design can be improved with minor re-engineering. The objectives of the present study were to compare the relative effectiveness of commercial and field-expedient baited fly traps.

MATERIALS AND METHODS

Commercial traps

Nine commercial fly traps were included in the evaluation at the request of personnel at the Navy Entomology Center of Excellence in Jacksonville, FL: 1) Terminator: (Farnam Co., P.O. Box 34820, Phoenix, AZ 85067-4820); 2) Final Flight (Troy Biosciences Inc. 113 South 47th Avenue, Phoenix, AZ 85043); 3) Victor Fly Magnet (Woodstream Co. 69 N. Locust Street, Lititz, PA 17543); 4) FliesBeGone (Combined Distributors, Inc. 2505 Riverglenn Circle, Atlanta, GA 30338); 5) ISCA Ball Trap (ISCA Technologies, Inc., 2060

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **SEP 2008**	2. REPORT TYPE	3. DATES COVERED **00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE **Evaluation of commercial and field-expedient baited traps for house flies, Musca domestica L. (Diptera: Muscidae)**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Navy Entomology Center of Excellence,Naval Air Station,P.O. Box 43, Building 937,Jacksonville,FL,32212**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
see report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Chicago Avenue, #C2, Riverside, CA 92507); 6) Advantage Flying Insect Trap (J.F. Oakes Sales and Marketing L.L.C., Yazoo City, MS 39194); 7) Fermone Big Boy Fly Trap (Troy Biosciences Inc., 113 South 47th Avenue, Phoenix, AZ 85043); 8) Squeeze and Snap (Trece, Inc., 7569 Highway 28, West Adair, OK 74330); and 9) OakStump Farms Fly Trap (SpringStar, Inc., P.O. Box 2622, Woodinville, WA 98072). The traps were all new (unused) at the time of testing and all were tested with their respective attractants and placed in accordance with the manufacturers' label instructions.

In the first trial, all nine traps were tested in June, 2006 on four dairy farms in Gilchrist and Alachua counties, FL. Traps were placed near the calf pens on three of the farms and by the commodity barn (where cattle feed components are kept in separate open storage bunkers) at the fourth farm. Traps were suspended 1 m off the ground by shepherd-hook plant hangers >10 m apart and their positions were rotated in a random pattern daily for seven days, after which flies were collected and counted. On all four farms, the traps were in full sun for several hours each day. The great majority of the flies collected were house flies; a smaller number of unidentified calliphorids was collected as well.

Two traps were selected for additional evaluation in a follow-up trial, the Terminator and FliesBeGone models. In this trial, each trap was tested with its respective attractant and with the attractant provided by the other product to evaluate the relative effects of trap geometry vs attractant on fly collections. This test was conducted over a two-week period in July, 2007. Five traps/treatment combination were tested near the calf pens of one of the dairies used in the first trial. Trap positions were rotated randomly every two to three days during the two weeks that the traps were deployed. Flies were collected and counted at the end of the test as before.

Field-expedient traps

An initial test was first conducted to evaluate sugar-based attractants that would be commonly available in military kitchens; molasses, honey, and maple syrup, all diluted to 25% in water to improve odor dispersion (Geden 2005), and a water control. In addition, a 25% dilution was prepared from jaggery, a date palm sugar widely used in south Asia that is highly attractive to other sugar-seeking insects (Landoldt 1995). All solutions were tested by placing 300 ml of each solution in small commercial jar traps (Captivator traps, Farnam Co., P.O. Box 34820, Phoenix, AZ 85067), and placing the traps in nine 3.7 x 4.3-m outdoor cages (Coleman Instaclip Screen Room, Coleman, Wichita, KS) in which 2,500 two- to three-day-old colony house flies had been released (Geden 2006). Traps (one trap of each bait type plus control/cage) were left in place with the flies for 24 h, after which they were removed and the flies counted. Cages were provisioned with water but not food during the test. The test was repeated a second time using flies that had been starved for 6 h before testing.

Water was drained from 12 1.5-liter PET bottles of drinking water (ZephyrHills, P.O. Box 628, Wilkes Barre, PA 18703). Following the instructions in Prendergast (2002), the tops of the bottles were cut off with a razor knife at a point just below where the top tapers towards the cap. The caps were removed from six of the bottles. For the other six, the caps were left in place and a 10-mm hole was drilled in the caps. (This was done to determine whether a narrower opening would deter flies from escaping the traps after capture.) A 25% molasses solution (300 ml/trap) was added to each bottle. The bottle tops were then inverted, inserted into the bottom of each bottle, and held in place with clear adhesive tape. In addition, six Captivator traps were prepared with 300 ml of 25% molasses as a positive control. Traps were placed in six outdoor screen cages (1 trap of each type/cage) with 2,500 two- to three-day-old flies for 6 h (10:00-16:00), after which they were collected and the captured flies counted. The test was repeated a second time in an outdoor area near the commodity barn at a Florida dairy farm (six traps of each type) using the same methods except that traps were left in place for 24 h.

Twenty-four 1.5-liter water bottles were drained and cut for trap preparation as before. Half (12) of the traps were baited with 300 ml of 25% molasses solution and assembled, without caps, as in Prendergast (2002). The remaining traps were spray-painted before assembly so that the top half of each trap was painted black. The traps were tested first in outdoor screen cages (six cages with two of each trap type) with 2,500 two- to three-day-old flies for 24 h. In a second test, the traps were placed near the calf pens of a Florida dairy farm for 24 h.

Statistical analysis

Trap collection data were subjected to log transformation and analyzed using the ANOVA Procedure of the Statistical Analysis System (SAS Institute 1992). Means were separated using the Means/Tukey statement of Proc ANOVA.

RESULTS AND DISCUSSION

Collections of house flies in commercial traps fell into three groups. Terminator traps collected 12,323 flies/trap, significantly more than any of the others (Table 1). The second tier of traps, including Final Flight, Fly Magnet, and FliesBeGone, collected 800-2,200 flies. The remaining five traps collected <300 flies, significantly fewer than the top four. Collections of calliphorids were modest and there were few differences among trap types except that Terminator traps collected more calliphorids than six of the others (Table 1). Terminator traps (Farnam Co.) are baited with a fly attractant composed of a blend of trimethylamine chloride, indole/skatole and muscalure (Warner 1991). Although the ratio of the blend is proprietary, the individual constituents were identified by previous researchers (Carlson and Beroza 1973, Mulla et al. 1977). The nitrogenous components evidently signal the presence of protein, which may explain why the Farnam attractant collects proportionately more females than sugar-based lures (Warner 1991, Geden 2005). Our results and those of an earlier study (Geden 2005) indicate that this attractant is highly effective for capturing house flies in outdoor situations, even in the presence of

Table 1. Collection of house flies and blow flies over seven days on four Florida dairy farms using different commercial fly traps.

Trap type	Mean (SE) no. flies per trap	
	House flies	Blow flies
Terminator	12,323.0 (8444.8)a	81.0 (76.4)a
Final Flight	2,166.5 (1266.4)b	10.0 (7.1)b
Victor Fly Magnet	1,287.0 (471.9)b	39.5 (32.9)ab
FliesBeGone	833.8 (344.2)bc	40.3 (28.4)ab
ISCA Ball	276.8 (147.7)c	1.5 (0.9)b
Advantage	202.5 (199.8)c	5.3 (3.1)b
Fermone Big Boy	132.8 (106.7)c	1.3 (0.6)b
Squeeze & Snap	76.0 (29.6)c	2.5 (1.2)b
Oak Stump	15.5 (8.1)c	0.0 (0.0)b
ANOVA ***F***	13.80**	2.42*

**, $P \leq 0.01$; *, $P \leq 0.05$. Means within columns followed by the same letter are not significantly different at P=0.05 (Tukey's method).

competing food odors.

This study was done with fresh baits that were left in the field for only seven days because previously we found that some attractants lost potency after several days in the field (Geden 2005). The instructions with several of the traps suggested that longer-term placement would result in improved collections, presumably due to fermentation or the presence of decomposing flies in the bait reservoir. An evaluation of long-term collections was beyond the scope of the present study, in which we wished to determine which traps would collect the most flies immediately after deployment to simulate a response to a fly outbreak. It may be that some of the other products have desirable properties for long-term management of relatively low fly populations.

In a follow-up study with a smaller number of trap types, Terminator traps collected about twice as many flies (799.8/trap) as FliesBeGone traps (343.8) when each trap was baited with its respective attractant (Table 2). When the attractants were switched between the two trap types, collections were significantly lower (77-108) than was observed with traps baited with their own attractant. These results were quite surprising and suggest that there is an interaction between the different attractants and the physical properties of the traps themselves.

Table 2. Collections of house flies in Terminator and FliesBeGone traps baited with their respective baits or the bait of the other product. Tests conducted on a Florida dairy farm over a two-week period.

Trap type	Bait used	Mean (SE) no. flies collected/trap
Terminator	Terminator	799.8 (145.9)a
Terminator	FliesBeGone	77.4 (29.1)c
FliesBeGone	Terminator	107.6 (37.8)c
FliesBeGone	FliesBeGone	343.8 (144.6)b
ANOVA ***F:***		6.41*

*, $P \leq 0.05$. Means within columns followed by the same letter are not significantly different at P=0.05 (Tukey's method).

Table 3. Collections of house flies (either fed or starved) in Captivator jar traps baited with water or 25% solutions of four natural sugar products. Tests run in outdoor screen cages with 2,500 flies/cage.

Trap bait	Mean (SE) no. flies collected	
	Fed	Starved 6 h
Water control	6.7 (2.6)b	56.1 (18.8)c
Honey	18.4 (6.8)b	171.4 (31.8)ab
Jaggery	7.9 (3.1)b	141.6 (28.7)b
Maple syrup	18.5 (8.6)b	167.8 (35.3)b
Molasses	86.0 (12.0)a	561.4 (61.2)a
ANOVA ***F***	8.53**	10.80**

**, $P \leq 0.01$. Means within columns followed by the same letter are not significantly different at P=0.05 (Tukey's method).

Results of tests with different sugar baits, presented in Table 3, demonstrated that molasses was more attractive to hungry flies (561 flies/trap) than honey or maple syrup (<200 flies/trap). These results are in agreement with previous work in which molasses was shown to be highly attractive to food-seeking house flies (Geden 2005, Quinn et al. 2007). The effectiveness of molasses, along with its low cost and ready availability worldwide, makes it a good choice for field-expedient traps. Although jaggery is highly attractive to some sugar-seeking moths (Landolt 1995), it was no more attractive to house flies than honey or maple syrup in the present study.

Capture of flies that had not been starved for several hours before testing was much lower, regardless of the bait used (Table 3). This underscores one of the challenges of using baited traps in general. Because traps baited with feeding attractants can only be effective if the target fly population does not have access to high-quality food resources, sanitation remains a critical complement to their use.

Field-expedient water bottle traps baited with molasses collected very few flies (26-69 flies/trap) compared with a commercial trap using the same bait (1,692 flies/trap) in outdoor screen cages (Table 4). Similar results were obtained when traps were tested on a dairy farm (Table 4). One of the features of commercial traps is that there is almost always a cover over the trap opening(s) that functions as a light baffle to deter captured flies from using light to locate the trap opening and thus escape. Field-expedient traps made from clear plastic have no such light baffle, and this may

Table 4. Collections of house flies in field-expedient water bottle traps versus a commercial trap (Captivator) baited with 25% molasses.

Testing site	Mean (SE) flies collected by trap type			
	Field-expedient, no cap	Field-expedient, cap with 8 mm hole	Captivator	ANOVA ***F***
Outdoor screen cages	69.2a (25.1)	25.7a (7.8)	1691.8b (250.7)	111.94**
Dairy farm	2.3a (0.6)	0.5a (0.2)	403.8b (49.0)	41.24**

**, P≤0.01. Means within columns followed by the same letter are not significantly different at P=0.05 (Tukey's method).

explain in part why they collected so few flies. Our initial attempt to address this was to limit the size of the openings in the traps by using a bottlecap with a drilled hole; results in Table 4 show that this had no effect on trap collections. However, the simple act of painting the top halves of the traps black resulted in a six-fold increase in fly collections, both in outdoor screen rooms and in the field (Table 5).

In summary, there are substantial differences among the many house fly traps that are available, and there is no *a priori* way of predicting their effectiveness for consumer or military uses. Moreover, other factors such as cost and size may influence the selection of a trap for a given application. For example, Terminator traps collected more flies than the others tested, but the FliesBeGone has an efficient spatial geometry that allows packing large numbers of traps in a small cargo space. In those instances where no commercial traps are available, molasses is an effective attractant to use in homemade field-expedient traps. Although such traps may not collect as many flies as commercial models, their effectiveness can be improved by painting the top of the trap and many can be fabricated at near-zero cost.

Acknowledgments

The authors thank H. McKeithen, A. Campbell, and A. Latorre for assisting with field work and fly counts. This research was supported in part by the Deployed Warfighters Protection Program.

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Table 5. Collections of house flies in unpainted field-expedient bottle traps and in traps with the top one-third sprayed with black paint. Traps baited with 25% molasses.

Testing site	Mean (SE) no. flies collected/trap		ANOVA ***F***
	Unpainted	Top half painted black	
Outdoor screen cages	87.2 (43.3)	674.1 (169.2)	11.08**
Dairy farm	33.0 (15.8)	202.5 (44.4)	9.04**

**, P≤0.01.

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