Traps and Baits for Flies (Diptera) on Pacific Islands

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J. Med. Entomol. 31(6): 828–832 (1994)

ABSTRACT Studies conducted on Oahu, HI, and on islands of the Kwajalein Atoll, Marshall Islands, demonstrated that adult house flies, *Musca domestica* L., were attracted to a mixture of cooked rice and chicken and to a commercial bait, whereas adults of *Chrysomya megacephala* F. and *Musca sorbens* Wiedemann were attracted to shark fluids or to ripe breadfruit. *M. domestica* and *M. sorbens* could be captured in standard inverted-cone traps, whereas *C. megacephala* could be captured in traps fitted with horizontal entry cones or in cone traps in which the bait was placed inside the cone chamber. *M. sorbens* and *C. megacephala* were killed by horizontal electric grids placed over yellow plastic or paper at ground level. *M. sorbens* was attracted to 15-cm cubes, but not to larger objects.

KEY WORDS traps, baits, flies

MUSCA SORBENS WIEDEMANN, *Musca domestica* L., and *Chrysomya megacephala* F. are the major fly disseminators of disease in the South Pacific, Malaysia (Bohart & Gressitt 1951, Legner et al. 1974, Sulaiman et al. 1988, Taylor 1988), and China (Meng & Winfield 1938). *M. sorbens* is attracted to decomposing sharks and to rotten eggs (Legner et al. 1974), and both *M. domestica* and *M. sorbens* are attracted to feces, ripe fruits, and sugars (Meng & Winfield 1938, Bohart & Gressitt 1951, Legner et al. 1974). The blow fly *C. megacephala* is attracted to ripe breadfruit and to carrion (Bohart & Gressitt 1951). Although *M. sorbens* adults were attracted to white panels in Egypt (Hafez & Attia 1958), no visually attractive traps have been developed for this species. We report here the results of tests to locate the breeding sites of the major pest flies on Kwajalein Atoll, Marshall Islands; to discover visual or olfactory attractants for the flies; and to design traps that can be used for their control. The colors and shapes that we evaluated as fly attractants had all been reported to be attractive for other species of flies or for *M. sorbens* in other countries (Hafez & Attia 1958, Pickens et al. 1977, Pickens 1991).

Materials and Methods

Hawaii Tests. The attractancy of trap shapes and colors to *M. sorbens* were first tested on Oahu Island, HI at private residences and at a horse stable. Flies alighting on all of the traps were captured by a coating of colorless adhesive (Sticky-stuff, Olson Products, Medina, OH). Four colors (white, yellow, gray, and blue) of plastic panels (Olson Products) and gray Alsynite (Reichhold Chemical, Houston, TX) panels were tested for attractancy to *M. sorbens* adults at each of three locations for 21 d. The panels measured 15 cm square, were orientated vertically, and were placed 1 m apart in a line. The positions of each panel were changed randomly every day to complete a randomized block design. The reflective properties of the colored panels were determined by illuminating the panels with a xenon-arc bulb and measuring the energies of the reflected radiation at 20-nm intervals with a spectroradiometer (Optronics, Orlando, FL). Three trap shapes (cube, cylinder, and pyramid) also were tested. Each shape was made of plastic and measured 45 cm high. The different shapes were covered with adhesive and rotated randomly as was done for the panel traps. Results of the tests of color and shape were analyzed by analysis of variance (ANOVA) and the means compared by Duncan's multiple range test (Steel & Torrie 1962). The cylinders, cubes, and pyramids were constructed of clear, translucent, Alsynite fiberglass and were tested over a 9-day period.

Marshall Island Tests. *Identification of Pest Species.* The species of nuisance flies in the Marshall Islands were determined by collecting samples of adult flies on Kwajalein, Ebeye, and Ennylabegan (Carlos) Islands by netting or by placing baited cone-type traps and sticky plastic panels near garbage cans and by obtaining larvae from animal feces and garbage. Flies were identified using the keys of Bohart & Gressitt (1951).

Location of Fly Breeding Sites. Fly breeding sites on the three islands were located by walking over the entire area of each of the islands and examining all feces, garbage, and trash dumpsters for the presence of fly larvae. Estimates of

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0022-2585/94/0828–0832$02.00/0

the abundance of adult *M. sorbens* were obtained by making counts of the numbers of flies that landed on each of four people every 15 min. Two of the counts were made in full sunlight and two in shade at each interval.

Tests of Shapes and Colors. Eight trap designs and four colors (clear, green, white, and yellow) were tested for attractancy to three fly species on three islands of the Kwajalein Atoll, Marshall Islands. The designs and colors tested were chosen because they had been reported as being attractive to various species of flies (Bohart & Gressitt 1951, Hafez & Attia 1958, Legner et al. 1974, Pickens & Miller 1987) or because they were similar to naturally occurring objects observed to attract flies. The four colors were tested by covering 15-cm cubes with the test colors as was done in the Oahu tests and placing them 4 m apart in a line at the city dumps. Each cube was covered by Sticky-stuff adhesive, and cube positions were rotated randomly every 15 min to complete three randomized blocks. Results were analyzed by ANOVA and the means compared by Duncan's multiple range test (Steel & Torrie 1962).

The shapes tested at Kwajalein Atoll were cubes (15 by 15 by 15 cm), pyramids (45 cm high), and vertical and horizontal sheets (30 cm by 12 cm) of sticky paper (Silva Enviro-Control, Westport, CT; Aeroxon Products, New York, NY). Solar-powered electric grids (Pickens 1991) were tested over bait and oriented vertically or horizontally on panels. The electric grids had an edge-to-edge wire spacing of 10 mm and an electric pulse of 10,000 to 12,000 volts (peak to peak) of 0.05-s duration presented at 1-to-1.5- s intervals. Cone-type baited traps (Tiger Farms, Hopedale, MA) were used both as delivered and with a row of horizontally directed fly entry cones placed around the base of the trap. Eight tests were made of each trap and the results analyzed by ANOVA and the means comapred by Duncan's multiple range test (Steel & Torrie 1962).

Twelve baits were tested by placing 500 ml of each bait under a standard cone-type trap and then placing four traps 4 m apart in each of three lines. The captured flies were killed and their volume measured every hour, with a 10-ml subsample counted. The positions of the baits in each line were exchanged randomly. After 4 h, the best bait from each of the three lines was placed in a fourth line and tested for 3 h with hourly collections and changes of position. Baits tested included the following: (1) Tiger Farms bait (50 g in 1 liter of water); a mixture of dried fish, sugar, yeast, bicarbonate, honey, and other ingredients; (2) Beltsville bait (50 g in 1 liter of water) a mixture of dried blood, sugar, yeast, urea, honey, and double-acting baking powder with sodium aluminum sulphate (Pickens & Miller 1987); (3) fish sauce (50 ml in 500 ml of water), commercial, bottled for flavoring soups; (4) shark meat or fluids; (5) cooked rice; (6) cooked rice and beef; (7) cooked rice and chicken; (8) apples (red and green); (9) apple sauce; (10) broken, ripe breadfruit; and (11) dairy creamer. Seven tests were made of each bait and results were analyzed by ANOVA and Duncan's multiple range test (Steel & Torrie 1962).

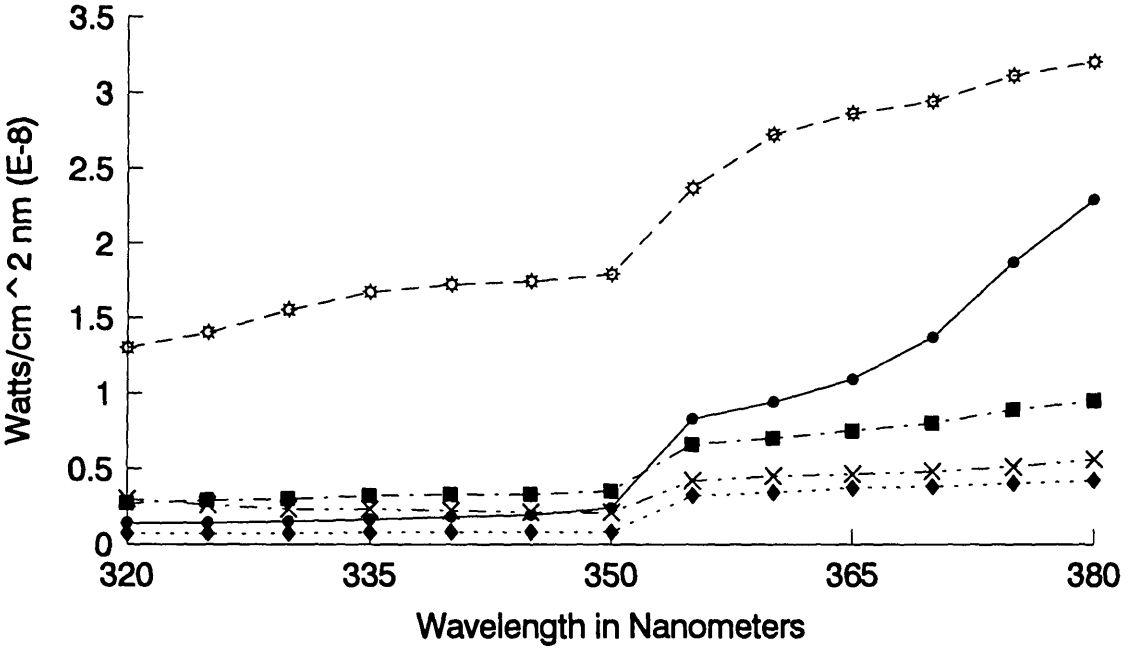

Fig. 1. Radiances and wavelengths of light reflected by yellow panels that were used to attract *Musca sorbens*.

Table 1. Relative attractiveness of colors to flies in Hawaii and the Marshall Islands (means ± 95% probability ranges)

Test location	Fly	Plastic panels						Paper, yellow	Cloth, yellow
		n	White	Gray	Blue	Green	Yellow		
Hawaii	*M. domestica*	21	44 ± 17a	21 ± 14ab	10 ± 2b		25 ± 4a	NT	NT
	Musca sorbens	21	14 ± 4b	38 ± 3a	8 ± 6b		47 ± 8a	NT	NT
	C. megacephala	21	24 ± 10a	17 ± 6a	23 ± 8a		35 ± 15a	NT	NT
Marshall Islands	*M. domestica*	12	139 ± 30ab	149 ± 28a		110 ± 10ab	139 ± 35ab	NT	99 ± 15b
	Musca sorbens	12	26 ± 2b	14 ± 2b		NT	83 ± 14a	71 ± 5a	NT
	C. megacephala	12	115 ± 12a	98 ± 8a		87 ± 15b	116 ± 13a	102 ± 9a	54 ± 20b

Means in each row followed by the same letter are not significantly different ($P > 0.05$; Duncan's multiple range test [Steel & Torrie 1962]); *n*, number of replicates; NT, not tested.

Results

Fly Fauna. Three-fourths of the fly complaints on Kwajalein Island involved Calliphoridae, whereas the major problems on Ebeye and Carlos Islands were *M. domestica* and *M. sorbens*, respectively. The rankings of the abundance and nuisance levels of the three species of flies were the same as reported by Meng & Winfield (1938) in China, with *C. megacephala* being the most numerous fly around picnic areas and dumpsters, *M. domestica* being most numerous around city dumps, and *M. sorbens* being the most common fly around pig sties and dog feces. Although one or two *M. sorbens* adults landed on human faces and arms, many more landed on ankles and feet, which is contrary to reports in the literature (Hafez & Attia 1958, Legner et al.1974). *M. sorbens* landing rates varied markedly between people at all of the locations tested; one person attracted 12 flies per minute, but a person about 1 m away only attracted one fly during the same period. This variability is not mentioned in the literature, but renders fly landing rate counts (Legner et al. 1974) unreliable as estimates of adult abundance. Very few *M. sorbens* adults were observed to fly >15 cm above the ground, but large numbers of adult *C. megacephala* often were seen on the underside of tree leaves and branches at heights of >2 m. We found *M. domestica* and *C. megacephala* larvae in piles of discarded human food at the Ebeye City dump, in improperly cleaned home garbage cans, in the garbage composting dump at Kwajalein, in rusted-out dumpsters, and in discarded sandwiches in open trash cans. Larvae of *M. sorbens* were found in dog feces on Kwajalein, in dog and human feces on Ebeye Island, and in pig feces on Carlos Island.

Traps. *M. sorbens* were attracted to cubes of yellow plastic or to yellow paper (Fig. 1; Tables 1 and 2), but not to white or clear plastic, whereas house flies were most attracted to white plastic cubes (Table 1). Blow flies showed no color or shape preference (Tables 1 and 2), but were most often found on vertical dark or shaded objects. House flies were captured readily by standard, inverted-cone-type traps (Schoof 1952), but horizontal fly-entry cones (Patton 1920, Vogt & Havenstein 1974) or baffles (Blair 1945) were required to capture most (3,000) of the 3,900 blow flies that were attracted to baits placed under the standard cone-type traps. The addition of ripe breadfruit bait increased the catch of *M. sorbens* at yellow or grey plastic cubes by 6.3 and 3.1 times, respectively, but did not increase the catch at white cubes. House flies also were killed by horizontal electric grids placed on the ground (Pickens 1991).

Baits. House flies were attracted to Tiger Farms bait and to cooked rice and chicken. Blow flies were most attracted to shark meat or fluids, rice and chicken, broken, ripe breadfruit, and to a lesser degree to sliced red apples, dairy creamer, and Tiger Farms bait. *M. sorbens* adults were attracted to shark fluids, animal feces, and broken, ripe breadfruit (Table 3). Blow flies and *M. sorbens* were killed in great numbers (2,000 per 30 min) by a horizontal electric grid placed over a yellow tray 5 cm deep that contained shark meat or fluids (Table 2). Both of those species also were captured by 15-cm sticky cubes placed on the ground and baited with shark fluids.

Table 2. Effects of trap shape on catches of *Musca sorbens* adults

	Cylinder	45-cm Cube	90-cm Cube	Pyramid	Horizontal	Grid
Location	Mean error ms	Mean error ms	Mean error ms	Mean error ms	Mean error ms	Replicates
Hawaii	1.9b 0.2	Oc 0	4.3a 0.1	4.1a 0.15	NT	8
Kwajalein	Oc 0	NT	83.0b 7.2	3.0c 0.3	142a 8.5	8

Means in each row followed by the same letter are not significantly different ($P > 0.05$; Duncan's multiple range test (Steel & Torrie 1962); NT, not tested.

Table 3. Mean numbers of flies attracted to baits under cone-type traps in the Marshall Islands in 1992

Bait	n	*Musca domestica*		*Musca sorbens*		*Chrysomya megacephala*	
		Mean	SD	Mean	SD	Mean	SD
Tiger Farms	7	4,500b	251	0b	0	250b	80
Shark meat or fluids	7	20c	15	102a	40	4,500a	300
Cooked rice & chicken	7	5,300a	370	NT	NT	150b	74
Breadfruit	7	NT	NT	136a	53	175b	62
Dairy creamer	7	50c	40	NT	NT	50c	41
Red apple	7	0d	0	NT	NT	50c	20
Green apple	7	0d	0	NT	NT	0d	0
Fish sauce	7	50cd	61	0b	0	50bc	44
Beltsville bait	7	0d	0	NT	NT	0d	0
Cooked rice	7	0d	0	NT	NT	0d	0
Cooked rice & beef	7	0d	0	NT	NT	0d	0
Apple sauce	7	0d	0	NT	NT	3d	4

Means in each column followed by the same letter are not signficiantly different ($P > 0.05$; Duncan's multiple range test [Steel & Torrie 1962]); NT, not tested.

Discussion

We hypothesize that *M. sorbens* adults did not land on surfaces >15 cm above the ground because of selection by the winds, which blow more or less constantly over the islands (i.e., those flies that flew at greater heights would have been more likely to be blown out to sea). In contrast, adult *C. megacephala* were stronger fliers and therefore, less likely to be blown offshore. We do not know why *M. sorbens* would not land anywhere on objects whose vertical dimensions were larger than 15–20 cm. Possibly the combination of constant wind and small, low-placed breeding materials (fecal scats) selected adult behavior to the point that only low, small objects are of interest to the flies. The preference of *M. sorbens* adults for yellow was unexpected, because they are attracted to white in other countries (Hafez & Attia 1958). The yellow color used in our tests was very similar to the color of ripe breadfruit, which also was very attractive to the flies.

The attraction of the flies to shark fluids agreed with the findings of Legner et al. (1974); however, direct comparison was impossible because they treated the fluids with chemicals to kill the attracted flies and did not attempt to design fly traps that utilized bait. It would be interesting to test bacterial digestions of trimethylamine oxide, which is a product of decaying fish, as an attractant for *M. sorbens* (Kim & Chang 1974). The attraction of *M. domestica* to chicken–rice mixtures is unreported in the literature, although chicken entrails are known to be attractive (Mer & Paz 1960). Although cone-type traps and flat panels have been reported to catch *M. sorbens* adults (Meng & Winfield 1938, Taylor 1988), this is the first report of using small cubes or horizontal grids to attract or kill them.

We surmise that the best traps for the three fly species are as follows: (1) *M. domestica,* Tiger Farms bait or chicken and rice under a standard cone-type trap with white framing; (2) *M. sorbens,* shark meat and fluids or ripe, broken breadfruit in yellow cubes or on yellow panels beneath horizontal electrocuting grids at ground level; and (3) *C. megacephala,* shark fluids or Tiger Farms bait in blow fly-type cone traps or under horizontal electrocuter grids near the ground.

Acknowledgments

We particularly thank Steven R. Bennett (USA–PEHA), George Chalmers at Kwajalein, and Abon Jeadrik of Ebeye Island). Many thanks also to the personnel of the Pest Management Units at both Kwajalein and Ebeye Islands for their outstanding cooperation and assistance in the performance of this study.

References Cited

Blair, D. M. 1945. Baited fly traps. Rhod. Agric. J. 42: 488–492.

Bohart, G. E. & J. L. Gressitt. 1951. Filth-inhabiting flies of Guam. Bull. Bernice P. Bishop Mus. 204.

Hafez, M. & M. A. Attia. 1958. Studies on the ecology of *Musca sorbens* Wied. Egypt. Bull. Soc. Entomol. (Egypte) 42: 83–121.

Kim, K. E. & G. W. Chang. 1974. Trimethylamine oxide reduction by *Salmonella.* Can. J. Microbiol. 20: 1745–1748.

Legner, E. F., B. B. Sugerman, H. Yu & H. Lum. 1974. Biological and integrated control of the bush fly, *Musca sorbens* Wiedemann and other filth breeding Diptera in Kwajalein Atoll, Marshall Islands. Bull. Soc. Vector Ecol. 1: 1–14.

Meng, Ch'ing-hua & G. F. Winfield. 1938. Studies on the control of fecal-borne diseases in North China. V. A preliminary study of the density, species make up, and breeding habits of the house frequenting fly population of Tsinan, Shantung, China. Chin. Med. J. 2: 463–486 (suppl.).

Mer, G. G., & M. Paz. 1960. Control of house flies in rural areas by means of traps. Riv. di Parassit. (Rome) 21: 143–150.

Patton, W. S. 1920. Mesopotamian house flies and their allies, part II. Indian J. Med. Res. 7: 751–777.

Pickens, L. G. 1991. Battery-powered, electrocuting trap for stable flies (Diptera: Muscidae). J. Med. Entomol. 28: 822–830.

Pickens, L. G., & R. W. Miller. 1987. Techniques for trapping flies on dairy farms. J. Agric. Entomol. 4: 305–313.

Pickens, L. G., R. W. Miller & J. J. Grasela. 1977. Sticky panels as traps for *Musca autumnalis*. J. Econ. Entomol. 70: 549–552.

Schoof, H. F. 1952. The attached bait pan fly trap. J. Econ. Entomol. 45: 735– 736.

Steel, R. G. D. & J. H. Torrie. 1960. Principles and procedures of statistics. McGraw–Hill, New York.

Sulaiman, S., A. R. Sohadi, H. Yunus & R. Iberahim. 1988. The role of some cyclorrhaphan flies as carriers of human helminths in Malaysia. Med. Vet. Entomol. 2: 1–6.

Taylor, H. R. 1988. A simple method for assessment of association between synanthropic flies and trachoma. Am. J. Trop. Med. Hyg. 38: 623–627.

Vogt, W. G. & D. E. Havenstein. 1974. A standardized bait trap for blowfly studies. J. Aust. Entomol. Soc. 13: 249–253.

Received for publication 16 December 1993; accepted 27 April 1994.