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COMPARISON OF BI-DIRECTIONAL FAY, OMNI-DIRECTIONAL, CDC, AND DUPLEX CONE TRAPS FOR SAMPLING ADULT *AEDES ALBOPICTUS* AND *AEDES AEGYPTI* IN NORTH FLORIDA

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ABSTRACT. We compared the number of *Aedes albopictus* and *Aedes aegypti* females collected in CDC, duplex cone, bi-directional Fay, and new omni-directional traps in a series of trials in northern Florida during 1992 and 1993. Bi-directional Fay and omni-directional traps collected significantly more *Ae. albopictus* females than did the other traps tested. The bi-directional Fay trap collected significantly more *Ae. aegypti* females than did any other trap. The results of these studies indicate that these traps may be useful tools for sampling *Ae. albopictus* and *Ae. aegypti* adults.

INTRODUCTION

Aedes albopictus (Skuse) became established in the eastern United States in 1986. It is a vector of dengue (see Hawley 1990) and can transmit endemic arboviruses (Culley et al. 1992), and eastern equine encephalitis virus has been isolated from field collected *Ae. albopictus* females (Mitchell et al. 1992). This mosquito also is an important biting pest of humans in many areas. Though *Aedes aegypti* (Linn.) abundance has decreased since the introduction of *Ae. albopictus* (Hawley 1990), it is still present in northern Florida (T. Fukuda, unpublished data).

Traps are the principal means for monitoring and sampling adult populations of most mosquito species (Service 1977); but traps that collect large numbers of other mosquito species collect few *Ae. albopictus* (Hawley 1990) and *Ae. aegypti* (Service 1977). Thus, surveillance of these mosquitoes is limited to man-biting collections that are difficult to standardize (Hawley 1990) and potentially dangerous. Standardized techniques are necessary to monitor changes in the relative abundance and age structure of mosquito populations, to monitor the effectiveness of mosquito control programs, and for surveillance of arbovirus activity in the mosquito population.

The objective of these studies was to assess the effectiveness of different traps for collecting *Ae. albopictus* and *Ae. aegypti* females. Traps used were the duplex cone trap (Freier and Francy 1991), the CDC trap (Sudia and Chamberlain 1962), a bi-directional modified Fay trap (Fay and Prince 1970), and an omni-directional trap.

In a preliminary study, a Fay trap collected as many *Ae. albopictus* females as a CDC trap (T. Jensen, unpublished data). We observed that *Ae. albopictus* females approaching the open side of the trap were more likely to be collected because the extended arms and barrier funneled these mosquitoes toward the trap opening. In contrast, mosquitoes approaching from other directions had to fly to the other side of the trap in order to be collected. We felt that we could increase the number of females collected by improving access to the trap opening. We developed the bi-directional Fay and omni-directional traps in order to combine the visual attractiveness of the Fay trap with traps that would collect mosquitoes approaching from all directions.

MATERIALS AND METHODS

Bi-directional Fay trap: Two Fay traps were fastened back to back using a 12-inch (30.5-cm) square metal plate (Fig. 1) so that there was a 4-inch (10.1-cm) space between the traps. The clear plastic panels were removed so the trap arms would funnel approaching mosquitoes toward the center of the trap from all directions.

Omni-directional trap: The omni-directional trap (Figs. 2 and 3) funnels approaching mosquitoes into the trap center with 4 extended arms. Mosquitoes are pulled down through an opening in the center by an attached CDC trap and collected in a mesh cage. The 12 × 5.5-inch (30.5 × 41.0-cm) arms come together at the center of the trap and are attached to the trap top and base. A 1 × 1.5-inch (2.5 × 3.8-cm) notch has been cut into the lower inside section of each arm to increase accessibility to the CDC trap. The top and base are 12 inch^2 (30.5 cm^2). We constructed omni-directional traps from ¼-inch-thick plywood and from translucent red plastic. The plywood traps were painted dark red or black.

We conducted trapping trials in tire yards located near Citra, Marion County, and Bronson, Levy County, Florida. *Aedes albopictus* and *Ae. aegypti* were present at both sites. We compared the number of *Ae. albopictus* and *Ae. aegypti*

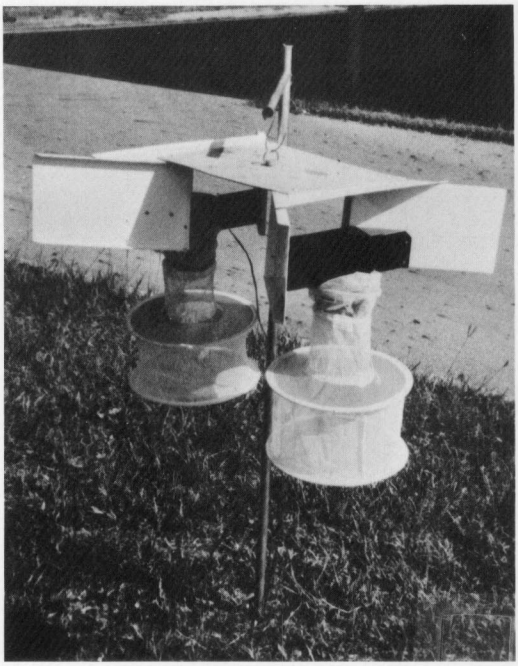

Fig. 1. Bi-directional Fay trap.

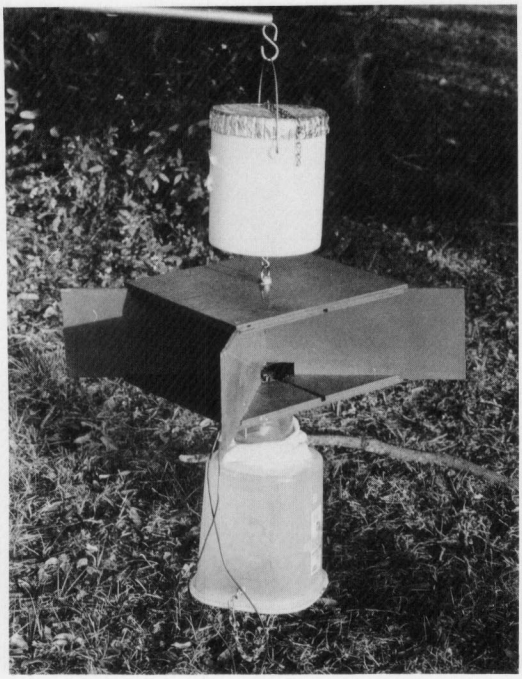

Fig. 3. Omni-directional trap in use.

females in CDC, duplex cone, and bi-directional Fay trap collections made at Citra on July 21–24, 1992, and Bronson on July 27–30 and August 2–5, 1992; CDC and omni-directional traps at Bronson on August 16–20, 1992; and CDC, bi-directional Fay, and omni-directional traps at Bronson on July 19–23, 26–29 and August 2–3, 1993.

We used Latin square designs (Cochran and Cox 1957) in all trials: a 3 × 3 design comparing CDC, duplex cone, and bi-directional Fay traps and a 4 × 4 design comparing CDC and omni-directional traps, and CDC, bi-directional Fay, and omni-directional traps. Traps ran for 24-h sampling periods, and trap type was assigned to each location randomly but was not replicated between locations. We set up traps 25 m apart with trap openings located 1 m above ground and insulated containers containing 2 kg of dry ice (CO_2) placed directly above each trap. The only exceptions were for duplex cone traps that were placed on the ground and the dry ice container placed inside the inner cone.

Data were analyzed using analysis of covari-

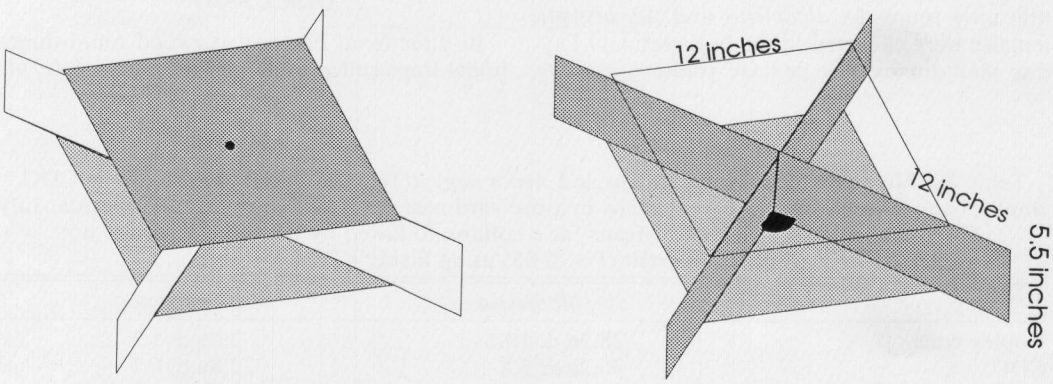

Fig. 2. External and internal views of the omni-directional trap.

Table 1. Numbers of *Aedes albopictus* and *Aedes aegypti* females (mean ± SE) collected each day in CDC, duplex cone, and bi-directional Fay traps in a tire yard near Citra, Marion County, Florida, July 21–24, 1992. Means for a column followed by the same letter are not significantly different ($P < 0.05$) using Fisher's LSD method.

Trap type	*Ae. albopictus*	*Ae. aegypti*
Duplex cone	8.0a ± 4.7	0.3a ± 0.3
CDC	38.0a,b ± 11.0	6.3a,b ± 4.1
Bi-directional Fay	53.0b ± 10.0	20.0b ± 11.0

ance (ANCOVA) and analysis of variance (ANOVA) using the procedure ONEWAY (Minitab 1991). Pairwise comparisons of the mean number of females collected using the different trap types were made using Fisher's LSD method at the 95% confidence interval.

RESULTS

The numbers of *Ae. albopictus* and *Ae. aegypti* females collected each day in CDC, duplex cone, and bi-directional Fay traps at Citra are presented in Table 1. Trap type was significant for the number of *Ae. albopictus* females collected each day (df = 2,6, F = 6.45, $P < 0.04$). Pairwise comparison indicated that the bi-directional Fay trap collected significantly greater numbers of *Ae. albopictus* females than did the duplex cone trap. Trap type was not, however, significant for the number of *Ae. aegypti* females. Location and day did not have a significant effect on the number of either species collected.

The numbers of *Ae. albopictus* and *Ae. aegypti* females collected each day in the Bronson study in CDC, duplex cone, and bi-directional Fay traps are presented in Table 2. Trap type was highly significant for the number of both *Ae. albopictus* (df = 2,15, F = 9.91, $P < 0.002$) and *Ae. aegypti* females (df = 2,15, F = 15.09, $P < 0.001$). Location and day did not have a significant effect on the number of either species collected. Significantly more *Ae. albopictus* and *Ae. aegypti* females were collected in the bi-directional Fay trap than duplex cone or CDC traps.

The mean numbers of *Ae. albopictus* and *Ae. aegypti* collected in CDC traps and in omni-directional traps made from translucent plastic and plywood at the Bronson site are presented in Table 3. Totals of 1,146 and 257 *Ae. albopictus* and *Ae. aegypti* females, respectively, were collected during this study. Trap type had a significant effect on the number of *Ae. albopictus* females collected (df = 2,13, F = 19.0, $P < 0.05$), with significantly more females collected in the plywood omni-directional trap. The number of *Ae. aegypti* collected did not vary significantly by trap type.

Data from the 1993 study comparing the number of mosquitoes collected in CDC, bi-directional Fay, and omni-directional traps are summarized in Table 4. In total, 2,613 *Ae. albopictus* and 1,802 *Ae. aegypti* females were collected over 8 days of sampling. Numbers of *Ae. albopictus* and *Ae. aegypti* females differed significantly by trap type (*Aedes albopictus*: df = 2,32, F = 3.25, $P < 0.05$; *Aedes aegypti*: df = 2,32, F = 20.6, $P < 0.001$). Significantly fewer *Ae. albopictus* were collected in the CDC trap. Differences in the number of females collected in the bi-directional and omni-directional were not, however, significantly different. The bi-directional Fay trap collected significantly more *Ae. aegypti* than did CDC and omni-directional traps.

DISCUSSION

Bi-directional Fay and plywood omni-directional traps collected greater numbers of *Ae. al-*

Table 2. Numbers of *Aedes albopictus* and *Aedes aegypti* females collected each day in CDC, duplex cone, and bi-directional Fay traps in a tire yard near Bronson, Levy County, Florida, July 27–30 and August 2–5, 1992. Means for a column followed by the same letter are not significantly different ($P < 0.05$) using Fisher's LSD method.

Trap type	*Ae. albopictus*	*Ae. aegypti*
Duplex cone	28.3a ± 10.1	2.5a ± 1.1
CDC	36.2a ± 5.4	22.8a ± 6.1
Bi-directional Fay	81.8b ± 11.0	35.2b ± 3.9

Table 3. Numbers of *Aedes albopictus* and *Aedes aegypti* females collected each day in CDC and translucent and solid omni-directional traps in a tire yard near Bronson, Levy County, Florida, August 16–20, 1992. Means for a column followed by the same letter are not significantly different ($P < 0.05$) using Fisher's LSD method.

Trap type	*Ae. albopictus*	*Ae. aegypti*
CDC	60.0a ± 10.5	22.5a ± 7.3
Translucent omni-directional	36.2a ± 4.3	7.5a ± 3.0
Solid omni-directional	130.0b ± 5.7	11.8a ± 3.4

Table 4. Numbers of *Aedes albopictus* and *Aedes aegypti* females collected each day in CDC, bi-directional Fay, and omni-directional traps in a tire yard near Bronson, Levy County, Florida, July 19–23 and 26–30 and August 2–3, 1993. Means for a column followed by the same letter are not significantly different ($P < 0.05$) using Fisher's LSD method.

Trap type	*Ae. albopictus*	*Ae. aegypti*
CDC	49.4a ± 7.7	39.2a ± 9.4
Bi-directional Fay	94.8b ± 10.2	98.7b ± 11.1
Omni-directional	86.3b ± 10.2	33.0a ± 4.7

bopictus females than duplex cone, translucent omni-directional, and CDC traps, suggesting that the omni-directional design and dark color attract *Ae. albopictus*. These findings indicate that bi-directional Fay and omni-directional traps may be useful for monitoring and studying adult *Ae. albopictus* populations. Differences in the number of *Ae. albopictus* females collected in translucent and solid omni-directional traps indicate that *Ae. albopictus* females, like *Ae. aegypti* females (see Service 1976), are more attracted to dark than to light objects.

Our results indicating duplex cone and CDC traps were equally as effective for collecting *Ae. albopictus* do not agree with the findings of Freier and Francy (1991), who found that the duplex cone trap collected more *Ae. albopictus* females than the CDC and 7 other trap types in a study in Louisiana. Their sampling period, between 0900 and 1500 h only, was substantially shorter than the 24-h period in our study. Though *Ae. albopictus* is diurnal, females are active at dusk (T. Jensen, personal observation).

The bi-directional Fay trap collected greater numbers of *Ae. aegypti* than did the other traps tested, indicating that this trap will be useful for monitoring and sampling adult populations of this species. The original Fay trap was designed to collect *Ae. aegypti* males (Fay and Prince 1970); however, Service (1977) considered it to be of limited value because of the low numbers of *Ae. aegypti* collected. Our results indicate that the bi-directional Fay trap, with the addition of dry ice, was substantially more effective for collecting *Ae. aegypti* females than were the other traps tested. This suggests that CO_2 and modification of the design to increase mosquito access substantially increase the effectiveness of the Fay trap.

In contrast to its effectiveness for collecting *Ae. albopictus* females, the omni-directional trap collected only as many *Ae. aegypti* females as did the CDC trap. This difference suggests that *Ae. albopictus* and *Ae. aegypti* females do not respond equally to the visual cues of the bi-directional Fay and omni-directional traps. *Aedes aegypti* females may be more strongly attracted to the contrasting shiny black and white markings of the bi-directional Fay trap than to the dark omni-directional Fay trap.

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