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EVALUATION OF THE MOSQUITO MAGNET PRO™ TRAP WITH AND WITHOUT 1-OCTEN-3-OL FOR COLLECTING *AEDES ALBOPICTUS* AND OTHER URBAN MOSQUITOES

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ABSTRACT. During the summer of 2004, 3 field studies were performed to evaluate the Mosquito Magnet Pro™ trap with and without 1-octen-3-ol (octenol) in enhancing collections of *Aedes albopictus* (Skuse). At Field Site 1, 1,501 *Ae. albopictus* were collected, with 89% collected with octenol. At Field Site 2, 570 *Ae. albopictus* were collected, with 86% collected with octenol. *Aedes albopictus* collections were significantly enhanced in both preliminary Field Trials 1 and 2 ($P < 0.03$). There was a 3-fold increase in collections of *Anopheles punctipennis* and an 18-fold increase in collections of *Ae. vexans* at Field Site 2. At Field Site 3, 5,571 were *Ae. albopictus*, with 75% collected with octenol. Results from the 3rd field trial indicated that *Ae. albopictus* ($P < 0.03$), *Coquillettida perturbans* ($P < 0.01$), and *Ochlerotatus triseriatus* ($P < 0.03$) were significantly more attracted to traps supplemented with octenol than to traps operating without octenol. There was a 2.4-, 6-, and 3.5-fold increase in collections of *Ae. albopictus* with octenol in Field Trials 1, 2, and 3, respectively.

KEY WORDS *Aedes albopictus*, octenol, *Ochlerotatus triseriatus*, *Coquillettida perturbans*, Diptera, Culicidae

INTRODUCTION

In recent years trapping devices have been developed utilizing catalytic combustion of propane to produce CO_2, heat, and water vapor as a means of managing some mosquito populations (Kline 2002). The Mosquito Magnet Pro™ (MMP) (American Biophysics Cooperation, East Greenwich, RI) is one of the propane-powered traps that uses a counterflow technology™ to emit a plume of CO_2, heat, and water vapor. The MMP also utilizes octenol as an attractant. Studies have shown that these traps with octenol collect large numbers of different mosquito species when trapping in salt marshes (Takken and Kline 1989, Kemme et al. 1993, Rueda et al. 2001). However, there have been a few studies reported in urban areas to determine if these traps supplemented with octenol are effective in trapping urban mosquitoes. Kline and Mann (1998) concluded that, in order to develop a strategy of mosquito control using octenol as an attractant, knowledge of each species' response pattern to octenol is important and should be taken into consideration.

The MMP trap is commercially available to homeowners. The pamphlet that comes with the traps cautions "that recent studies show that octenol may actually repel the Asian Tiger Mosquito." This species, *Aedes albopictus* (Skuse), is the number-one nuisance mosquito in many urban communities in the United States. Only a few studies have addressed the response of *Ae. albopictus* to octenol-supplemented traps (Shone et al. 2003, Dennett et al. 2004). Shone et al. (2003) used the Fay–Prince trap baited with CO_2 and CO_2 + octenol to evaluate the ability of this trap to collect *Ae. albopictus*. They found no statistically significant differences in the response of *Ae. albopictus* to these 2 combinations of attractants. Traps using either carbon dioxide alone or CO_2 + octenol were, on the other hand, statistically more attractive to *Ae. albopictus* than traps that were either unbaited or used only octenol. These results suggested that CO_2 is driving the response of *Ae. albopictus*, not octenol. Shone et al. (2003) did not indicate that octenol was acting as a repellent to *Ae. albopictus*.

Propane traps have not been fully evaluated in urban areas, with only a few studies having been reported (Dennett et al. 2004). This leaves unanswered questions as to whether or not octenol is a repellent to certain urban mosquitoes, including *Ae. albopictus*. This study evaluated the effectiveness of the MMP with and without octenol in attracting *Ae. albopictus*. The specific objective of this study was to determine if *Ae. albopictus* and other urban mosquitoes are attracted to octenol-supplemented traps in an urban setting.

MATERIALS AND METHODS

Study sites

During the summer of 2004, Field Trials 1 and 2 were conducted at Auburn, AL, and Field Trial 3 at Phenix City, AL. Field Trial 1 was conducted with the use of 2 MMP traps at an auto-repair shop. Behind the auto-repair shop was an outdoor tire-storage area where about 200 discarded tires, ranging from compact-car tires to tractor-trailer tires, were stored. About half of these tires were sheltered in a covered tire rack. Because the tires were protected, the tires did not hold water and subsequently were not sites of

mosquito larval development. The remaining tires were stored in an open area adjacent to the tire rack. These tires were either lying flat on the ground or propped up against other tires. Mosquito larvae were observed in many of these tires. A fence covered with kudzu (*Pueraria montana* (Lour)) bordered the perimeter of the auto shop just behind the area where the tires were located.

Field Trial 2 was conducted with the use of 2 MMP traps placed in the proximity of 4 greenhouses located on the Auburn University Campus. Two MMP traps were placed 2 m apart in a low-lying drainage area that collected runoff from the irrigation system used in the greenhouses. Small runoff pools were formed in this area, allowing mosquito breeding. Loblolly pine (*Pinus taeda* L.), American holly (*Ilex opaca* Ait.), wild dwarf chinkapin oak (*Quercus prinoides* Willd.), and willow oak (*Q. phellos* L.) were the predominant vegetation in the drainage area. Ornamental ponds that held about 4–6 in. of standing water were located near the greenhouses and were possible mosquito breeding sites.

Field Trial 3 was conducted in a salvage yard, which is a 3-acre fenced lot with cars, car parts, and discarded tires scattered throughout. The site mostly consisted of wrecked cars that were lined up in rows in the front and back of the lot. At the front end of the lot approximately 25 tires were stacked horizontally on top of each other and held very little rainwater. Along the back-fence corner there were approximately 40 tires of varying sizes that consistently held water during the 8-wk field trial. Mosquito larvae were observed in these tires. In the center of the salvage yard a wooded area consisting of predominantly sweet gum (*Liquidambar styraciflua* L.) and coastal plain willow (*Salix caroliniana* Michx.) separated the front lot from the back lot. Other vegetation in this area included tulip tree (*Liriodendron tulipifera* L.), goldenrod (*Solidago* spp.), cattails (*Typha latifolia* L.), and rush (*Juncus patens* E. Mey.). Approximately 500 tires were scattered throughout the adjacent wooded area. These tires were lying on their sides, propped up against one another, or piled haphazardly in tire mounds. Mosquito larvae were observed in these tires.

Trap evaluation

Mosquito Magnet Pro traps were used in all field trials. Each trap has a catalytic combustion of propane, which converts 20 lb of propane to 60 lb of CO_2, and generates the power to run the counterflow suction fan for insect entrapment while producing the long-range attractants. Replaceable 1.7-g octenol cartridges (American Biophysics Corporation) were placed in the compartment located at the bottom of the MMP fan unit. Octenol cartridges and propane tanks were replaced every 2 wk.

Field Trials 1 and 2 were conducted over a 4-wk period, the 1st trial from May 27 to June 23 and the 2nd trial from June 2 to June 23. Two MMP traps were placed at each site; 1 trap was operated with octenol, whereas the other trap was not. Collection nets were removed and replaced each day. All mosquito collections were brought to the laboratory for identification to species in accordance with the Darsie and Ward (1981) *Identification and Geographical Distribution of the Mosquitoes of North America, North of Mexico*.

Field Trial 3 was conducted at an automobile salvage and tire yard, from July 7 to September 29. Four MMP traps were placed 20 m apart in a 1×2 factorial design in the wooded area located at the center of the salvage yard. Four traps were operated weekly, 2 traps with octenol and 2 traps without octenol, throughout the 12-wk field trial. Octenol was replaced at the end of each 2-wk period and rotated to occupy all trapping positions. Mosquito collections were removed at the end of each 7-day period, and the species identified and counted.

Six tires were randomly sampled for larvae each week. All the water was removed from the tires and the mosquito larvae recovered. The samples were brought back to the laboratory for larval identification. Tires were sampled throughout the trial to determine which mosquito species were breeding at the salvage yard.

Statistical analysis

For preliminary Field Trials 1 and 2, *Ae. albopictus* collections were transformed to log $(n + 1)$ for analysis with the use of a repeated-measures ANOVA to determine if there was a significant difference between the treatments, with the dependent variable, time.

Treatment (octenol vs. no octenol), position, and week effects were analyzed with the use of a 3-way ANOVA for the collections of *Ae. albopictus* at Field Trial 3. The 3-way ANOVA was used to determine the effectiveness of octenol in enhancing collections of *Ae. albopictus* and other species with collections greater than 100. Catches for Field Trial 3 were transformed to log $(n + 1)$ before analysis. A Tukey's test was used if there were any significant interactions between the variables tested in the 3-way ANOVA. A chi-square analysis was used for collections of other mosquito species in numbers less than 100.

RESULTS

Field Trial 1

A total of 1,501 mosquitoes, representing 7 species in 5 genera, were collected during the 4-wk

Table 1. Mosquito species collected with and without octenol in Field Trials 1, 2, and 3, 2004. Species are listed in alphabetical order.

	Field Trial 1		Field Trial 2		Field Trial 3	
	With octenol	Without octenol	With octenol	Without octenol	With octenol	Without octenol
Mosquito species	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Aedes albopictus	1,051 (71)	421 (29)	489 (86)	81 (14)	4,334 (75)	1,237 (22)
Ae. vexans	2 (50)	2 (50)	18 (95)	1 (5)	2 (67)	1 (33)
Anopheles crucians	0 (0)	0 (0)	0 (0)	0 (0)	4 (80)	1 (20)
An. punctipennis	0 (0)	14 (100)	27 (77)	8 (23)	33 (94)	2 (6)
Coquillettida perturbans	0 (0)	0 (0)	0 (0)	0 (0)	125 (95)	6 (5)
Culex erraticus	0 (0)	0 (0)	0 (0)	0 (0)	8 (89)	1 (11)
Cx. quinquefasciatus	4 (57)	3 (43)	17 (63)	10 (37)	1 (12)	7 (88)
Cx. restuans	2 (100)	0 (0)	0 (0)	0 (0)	20 (69)	9 (31)
Cx. salinarius	0 (0)	0 (0)	0 (0)	0 (0)	13 (100)	0 (0)
Cx. territans	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)	0 (0)
Ochlerotatus triseriatus	1 (100)	0 (0)	0 (0)	2 (100)	1,202 (92)	100 (8)
Psorophora columbiae	1 (100)	0 (0)	1 (50)	1 (50)	28 (85)	5 (15)
Ps. ferox	0 (0)	0 (0)	0 (0)	0 (0)	2 (67)	1 (33)
Totals	1,061 (71)	440 (29)	552 (84)	103 (16)	5,773 (81)	1,370 (19)

field trial (Table 1). A total of 1,061 (71%) of the mosquitoes were collected in MMP traps provided with octenol, compared to 440 (29%) collected in the MMP traps without octenol. The most frequently collected species in the octenol-supplemented traps was *Ae. albopictus* (1,472/1,501), comprising 98% of the collections. Only numbers of *Ae. albopictus* were sufficient to make meaningful comparisons of octenol versus no octenol. On 5 individual trap-nights, collections of *Ae. albopictus* were significantly enhanced with use of octenol (Fig. 1). The next most frequently collected species were *Anopheles punctipennis* (Say), *Culex quinquefasciatus* (Say), *Ae. vexans* (Meigen), *Cx. restuans* Theobald, *Psorophora columbiae* (Dyar and Knab), and *Ochlerotatus triseriatus* (Say).

There was a significant difference between treatments for collections of *Ae. albopictus* ($P < 0.03$), as determined by a repeated-measures

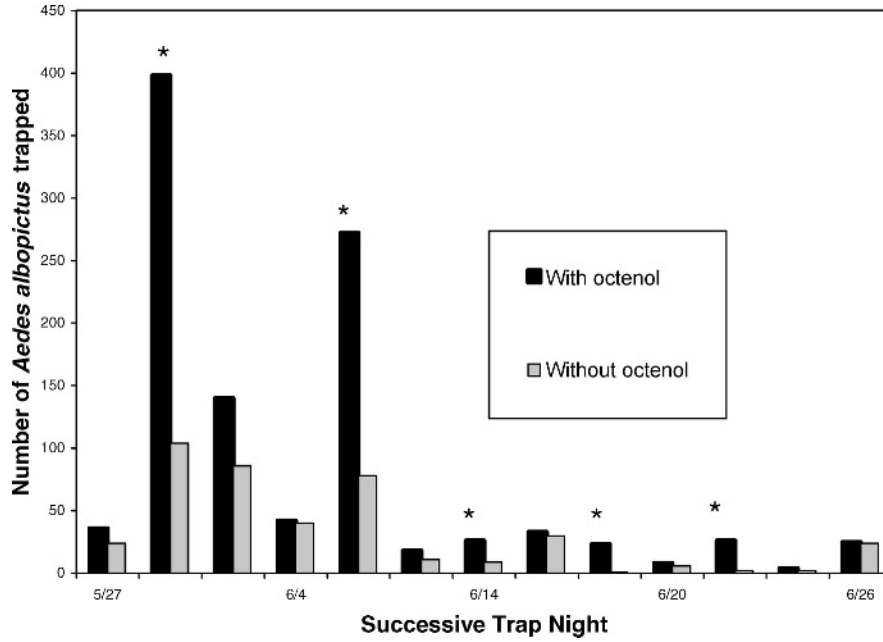

Fig. 1. Collections of *Aedes albopictus* with and without octenol in Field Trial 1 during successive trap-nights. Five trap-night collections were significantly enhanced with octenol ($P < 0.05$), as indicated by asterisks, based on a chi-square analysis.

Table 2. Repeated-measures ANOVA values for *Aedes albopictus* collected in Field Trials 1 and 2.

	Treatment			Treatment × time		
Field trial	*P*	F	df	*P*	F	df
1	0.0321	29.64	1	0.5384	0.89	7
2	0.0280	34.24	1	0.0872	2.67	5

ANOVA (Table 2). Collections of *Ae. albopictus* were 2.5-fold greater with octenol (1,051, or 71%) than without octenol (421, or 29%).

Field Trial 2

A total of 655 mosquitoes, representing 6 species in 5 genera, were collected during the 3-wk field trial (Table 1). A total of 552 (84%) of the mosquitoes were collected using octenol. Only 103 (16%) mosquitoes were collected without octenol. Of these collections 570 (80%) were *Ae. albopictus*, with 489 (86%) collected with octenol, versus 81 (14%) collected without octenol. Again, only the numbers of *Ae. albopictus* collections were sufficient to make meaningful comparisons of octenol versus no octenol. On 9 individual trap-nights, *Ae. albopictus* collections were significantly enhanced with octenol (Fig. 2). The next most frequently collected species were *An. punctipennis*, *Cx. quinquefasciatus*, *Ae. vexans*, *Oc. triseriatus*, and *Ps. columbiae*. There was a significant difference between treatments (octenol vs. no octenol) in the collections of *Ae. albopictus* ($P < 0.02$) as determined by a repeated-measures ANOVA (Table 2). Octenol significantly increased the collections of *Ae. albopictus* by 6-fold.

Field Trial 3

A total of 7,143 mosquitoes, representing 13 species in 5 genera, were collected over the 12-wk study period (Table 1). A total of 5,773 mosquitoes (81%) were collected with octenol, versus 1,370 (19%) in the MMP traps operated without octenol. Of these collections 5,571 (75%) were *Ae. albopictus*, with 4,334 (78%) collected with octenol. On 7 individual trap-nights, *Ae. albopictus* collections were significantly enhanced with octenol (Fig. 3). The next most frequently collected species were, in descending order, *Oc. triseriatus*, *Coquillettida perturbans* Walker, *An. punctipennis*, *Ps. columbiae*, *Cx. restuans*, *Cx. salinarius* Coq., *Cx. erraticus* (Dyar and Knab), *Cx. quinquefasciatus*, *An. crucians* Wiedemann, *Ae. vexans*, *Ps. ferox* Humboldt, and *Cx. territans* Walker. All 13 mosquito species trapped, with the exception of *Cx. quinquefasciatus*, were collected in greater numbers with octenol than without octenol. There were 4 times more total mosquitoes collected with octenol than without octenol.

There was an effect between treatments (octenol vs. no octenol) in collections of *Ae. albopictus*, *Cq. perturbans*, and *Oc. triseriatus* based on a 3-way ANOVA (Table 3). Significantly more *Ae. albopictus* were collected with octenol ($P < 0.01$). *Aedes albopictus* collections were increased 3.5-

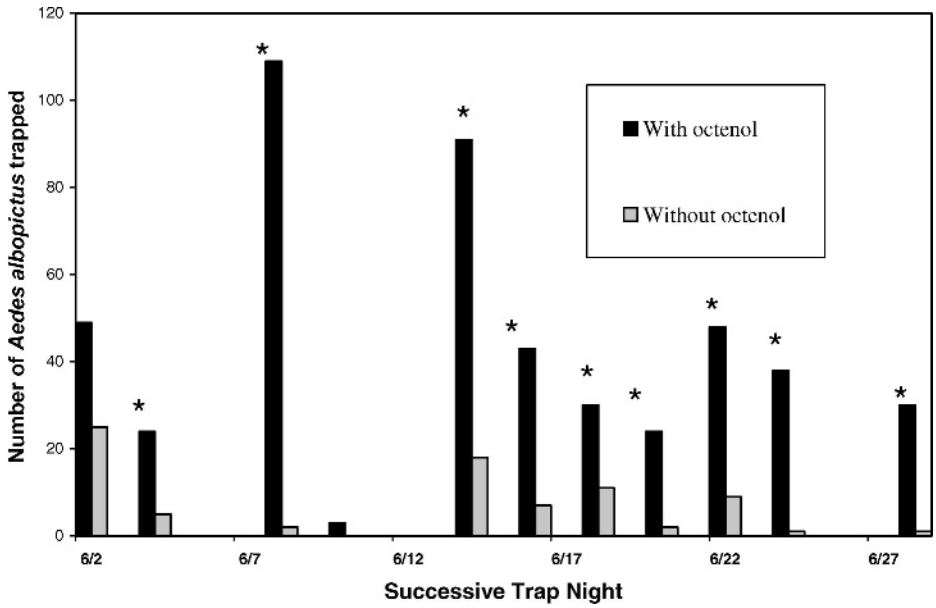

Fig. 2. Collections of *Aedes albopictus* with and without octenol in Field Trial 2 during successive trap-nights. Nine trap-night collections were significantly enhanced with octenol ($P < 0.05$), as indicated by asterisks, based on a chi-square analysis.

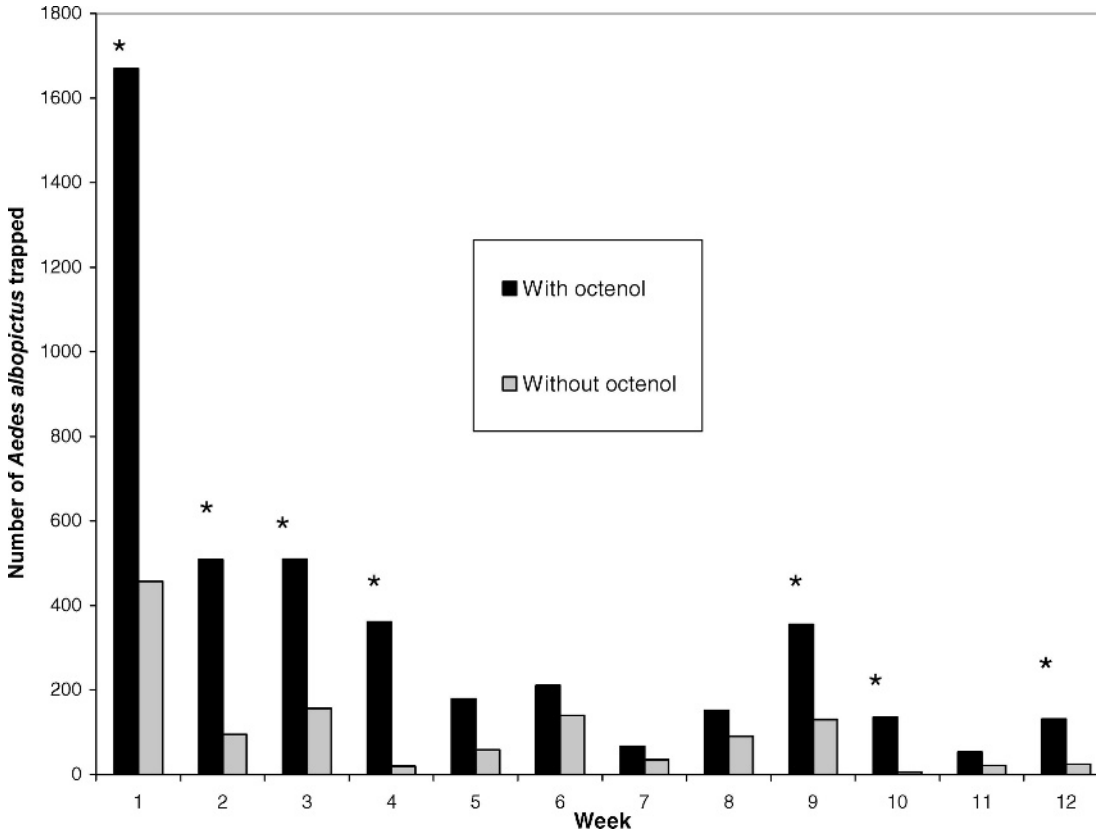

Fig. 3. Collections of *Aedes albopictus* with and without octenol in Field Trial 3 during successive trap-nights. Seven trap-night collections were significantly enhanced with octenol ($P < 0.05$), as indicated by asterisks, based on a chi-square analysis.

fold with octenol. Octenol increased *Cq. perturbans* collections by 20-fold. *Ochlerotatus triseriatus* collections were increased 12-fold with use of octenol.

DISCUSSION

Previous studies have shown that the combination of CO_2 and octenol significantly increased collections of *Cq. perturbans*, *An. punctipennis*, *Ps. columbiae*, *Cx. restuans*, and *Cx. salinarius* (Kline et al. 1990, 1991; Kline 1994; Rueda et al. 2001). The results of the field trials in our study support these reports. The use of octenol with the MMP trap was effective in enhancing the response of many mosquito species, making octenol a suitable attractant for general monitoring of mosquito populations in urban settings.

The results of Field Trials 1 and 2 indicate that there is a general trend of increased response of most species collected with the MMP and octenol. About 75% of mosquito collections throughout the trials were trapped with octenol. Octenol significantly enhanced collections of *Ae. albopictus* at Field Sites 1 and 2. *Aedes vexans*, *An. punctipennis*, and *Cx. quinquefasciatus* collections were significantly enhanced at Field Site 2 but not at Field Site 1. However, with the exception of *An.*

Table 3. ANOVA values for mosquito species with trap collections > 100 specimens in Field Trial 3, Auburn, AL, July 7–September 29, 2004.

	Treatment			Treatment × position			Treatment × week		
Mosquito species	*P*	F	df	*P*	F	df	*P*	F	df
Aedes albopictus	0.0003	38.04	1	0.402	1.11	3	0.0114	6.1	6
Ochlerotatus triseriatus	0.0003	38.56	1	0.769	0.38	3	0.0004	16.13	6
Coquillettida perturbans	< 0.0001	51.06	1	0.4318	1.02	3	0.0541	3.47	6

punctipennis, these species were collected in greater numbers with octenol-baited traps. There was a negative effect of octenol observed in the collections of *An. punctipennis* in Field Trial 1. Kline et al. (1991) found that octenol at times enhances collections of anopheline mosquitoes and at other times it appears to repel these species. This observation is supported by our data.

The mosquitoes trapped at Field Site 3 showed a positive response to the MMP baited with octenol (81% of mosquito collections). *Aedes albopictus*, *Oc. triseriatus*, *Cq. perturbans*, *An. punctipennis*, *Ps. columbiae*, *Cx. restuans*, and *Cx. salinarius* showed a significant positive response to octenol-baited traps with overall collections increased 4-fold.

Our study showed that *Ae. albopictus* and *Oc. triseriatus* are significantly attracted to combinations of CO_2 and octenol. Because *Ae. albopictus* was collected more in traps with octenol compared to those without octenol during all 3 field trials, *Ae. albopictus* was not repelled by octenol in this study. In Field Trial 3, *Ae. albopictus* was trapped more with octenol throughout each week's trap rotation with a 3-fold increase in collection numbers throughout the study. The claim (American Biophysics Corporation Brochure) that *Ae. albopictus* is repelled by octenol may be attributed to the fact that most studies evaluating traps baited with octenol were conducted in salt marshes where *Ae. albopictus* is not likely to be collected. Our study showed that octenol significantly enhances collections of *Ae. albopictus* in urban environments.

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