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Source: Florida Entomologist, 104(3) : 162-164

Published By: Florida Entomological Society

URL: <https://doi.org/10.1653/024.104.0303>

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# Comparison of modified CDC gravid, BG-Bowl, and CDC autocidal gravid ovitraps to collect gravid and host-seeking *Aedes aegypti* (Diptera: Culicidae) in northeastern Florida

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## Abstract

There are several kinds of commercial traps available in the market for surveillance and control of female mosquitoes. Usually these traps target only host-seeking or gravid individuals but not both. This study examined whether CDC gravid, BG-Bowl, and a fan-operated CDC-autocidal gravid ovitrap, each baited with a BG lure and southern live oak (*Quercus virginiana* Mill.; Fagaceae) leaf litter infusion, could collect host-seeking and gravid *Aedes aegypti* (L.) (Diptera: Culicidae) simultaneously. These traps were evaluated initially in a semi-field environment that consisted of outdoor screened enclosures where 200 female *Ae. aegypti* were released (half were gravid). For the field study, traps were placed at 3 sites in downtown St. Augustine, Florida, USA. All traps captured host-seeking and gravid females in the semi-field enclosures, but some did not collect both physiological stages in the field study. Only the BG-bowl trap in the semi-field and field studies collected the greatest number of females that included host-seeking and gravid *Aedes*.

Key Words: attractant; BG lure; oak leaf infusion water; oviposition; autocidal gravid ovitrap trap

## Resumen

Hay varios tipos de trampas comerciales disponibles en el mercado para la vigilancia y el control de mosquitos (zancudos) hembra. Por lo general, estas trampas se dirigen solo a individuos que buscan hospederos o grávidos, pero no a ambos. Este estudio examinó si las CDC Gravid, BG-Bowl y una ovitrap CDC-Autocidal Gravid operada por ventilador, cada una cebada con un señuelo BG y una infusión de hojarasca de roble vivo del sur (*Quercus virginiana* Mill.; Fagaceae), podrían recolectar los *Aedes aegypti* (L.) (Diptera: Culicidae) que buscan hospederos y grávidos simultáneamente. Se evaluaron estas trampas inicialmente en un ambiente de semi-campo que consistía en recintos con mosquiteros al aire libre donde 200 hembras de *Ae. aegypti* fueron liberadas (la mitad estaban gravidas). Para el estudio de campo, se colocaron trampas en 3 sitios en el centro de St. Augustine, Florida, EE. UU. Todas las trampas capturaron hembras grávidas y en busca de hospederos en los recintos de semi-campo, pero algunas no recolectaron ambos estadios fisiológicos en el estudio de campo. Solo la trampa BG-bowl en los estudios de campo y de semi-campo recogió el mayor número de hembras que incluyeron *Aedes* en busca de hospederos y grávidas.

Palabras Clave: atrayente; señuelo BG; agua de infusión de hoja de roble; oviposición; trampa autocida Gravid Ovitrap

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*Aedes aegypti* (L.) (Diptera: Culicidae) is the primary arboviral vector of yellow fever, dengue fever, chikungunya, and Zika (Smith et al. 2018). Population surveillance of container-inhabiting mosquitoes, specifically *Ae. aegypti*, is an important priority of Anastasia Mosquito Control District (Dixon et al. 2020). There are several types of adult mosquito traps available commercially for surveillance and control of mosquitoes (Popko & Walton 2016), but most primarily collect either gravid or host-seeking mosquitoes but not both. For example, Reiter et al. (1986) reported on a trap designed for the collection of gravid *Culex* mosquitoes referred to as the Centers for Disease Control and Prevention (CDC) gravid trap. Later, Mackay et al. (2013) and Barrera et al. (2014a) reported on the development of the CDC's autocidal gravid ovitrap designed to collect container-inhabiting gravid *Aedes*. Later this trap proved to be a useful method for trapping local populations of *Ae. aegypti* in Puerto Rico (Barrera et al. 2014b). Eiras et al. (2014) also reported on another gravid trap that was

later commercially developed as the Biogents Gravid (BG) *Aedes* Trap. A smaller economical version, called the BG Bowl Trap, was later developed by the company and marketed primarily for residential use for the control of container *Aedes*. All these traps use some form of fermented vegetative infusion to lure mosquitoes into them. During Anastasia Mosquito Control District surveillance and control operations, local residents and our mosquito control technicians always have been interested in commercial mosquito traps with multiple functions that could collect host-seeking and gravid mosquitoes simultaneously. Recently, Liu et al. (2019) reported on efforts to increase the collection of host-seeking and gravid *Ae. aegypti* into the CDC-autocidal gravid ovitrap trap by using a BG lure, whereas Zhu et al. (2019) added a suction fan to this trap for the same purpose. We report here on the continuation of a project to increase the functionality of commercial mosquito traps for simultaneous surveillance and control of host-seeking as well as gravid container-inhabiting *Aedes*.

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## Materials and Methods

A CDC gravid trap (John W. Hock, Gainesville, Florida, USA), BG-bowl trap (Biogents AG, Regensburg, Germany), and a modified CDC-autocidal gravid ovitrap trap, as described by Zhu et al. (2019), were used in this study. Each trap contained 200 mL of southern live oak (*Quercus virginiana* Mill. [Fagaceae]) leaf litter infusion (10 g of leaf litter per liter of reverse osmosis water fermented after 2 wk) plus a proprietary BG lure (Biogents AG, Regensburg, Germany) suspended inside (Fig. 1).

### SEMI-FIELD TEST

Evaluations were conducted in 3 screened enclosures (5 × 6 × 13 m) with a centrally located 11 m<sup>2</sup> covered pavilion on the grounds of the Anastasia Mosquito Control District. In each cage, 100 gravid (7–10 d old previously blood-fed 3 d prior) and 100 host-seeking *Ae. aegypti* mosquitoes (non-blood fed of similar age) were released into each screened outdoor enclosure that contained a single trap. Gravid status was sampled from the blood fed cage and determined by dissection of females with positive eggs in her ovaries before release. Study design followed a 3 × 3 Latin square rotation between enclosures. Mosquitoes were collected from traps after 24 h. The experiment was repeated 3 times for a total of 27 testing dates.

### FIELD TEST

All 3 trap types, baited with BG lures, were placed together at 3 different sites in downtown St. Augustine (29.8946889°N, 81.3145194°W),

Florida, USA. Specific locations were: South Street, Miruela Street, and Magnolia Street, which were selected based on previous *Ae. aegypti* larval surveillance (Dixon et al. 2020). Prior to placement, all traps were filled with 200 mL of southern oak leaf litter infusion as mentioned earlier in the semi-field study. A BG Bowl trap modified with a small catch mesh bag was attached to the bottom of the fan inside the trap to collect mosquitoes. All traps were placed in shaded locations 30 m apart, and collections removed at 24, 48, and 72 h post deployment. Batteries were replaced at the time of each mosquito collection. Mosquitoes were identified using the taxonomic key of Darsie and Morris (2003), and gravid status was verified by the presence of eggs in the ovaries after dissection under a stereomicroscope (United Scope LLC, Irvine, California, USA).

Mean trap data in the semi-field and field studies were subjected separately to a multivariate ANOVA using JMP statistic software (SAS Institute, Cary, North Carolina, USA). All differences were considered significant at  $P \leq 0.05$ . Due to the small data sets, the Tukey-Kramer HSD test was not performed.

## Results

In the semi-field experiments, average numbers of female mosquitoes collected by BG Bowl, autocidal gravid ovitrap, and CDC-gravid traps were  $100 \pm 15$ ,  $65.6 \pm 3$ , and  $50 \pm 8$ , respectively. We dissected an average of  $96.6 \pm 0.6$  females caught by BG Bowl,  $65.5 \pm 0.4$  females caught by autocidal gravid ovitrap, and  $43 \pm 0.3$  fe-

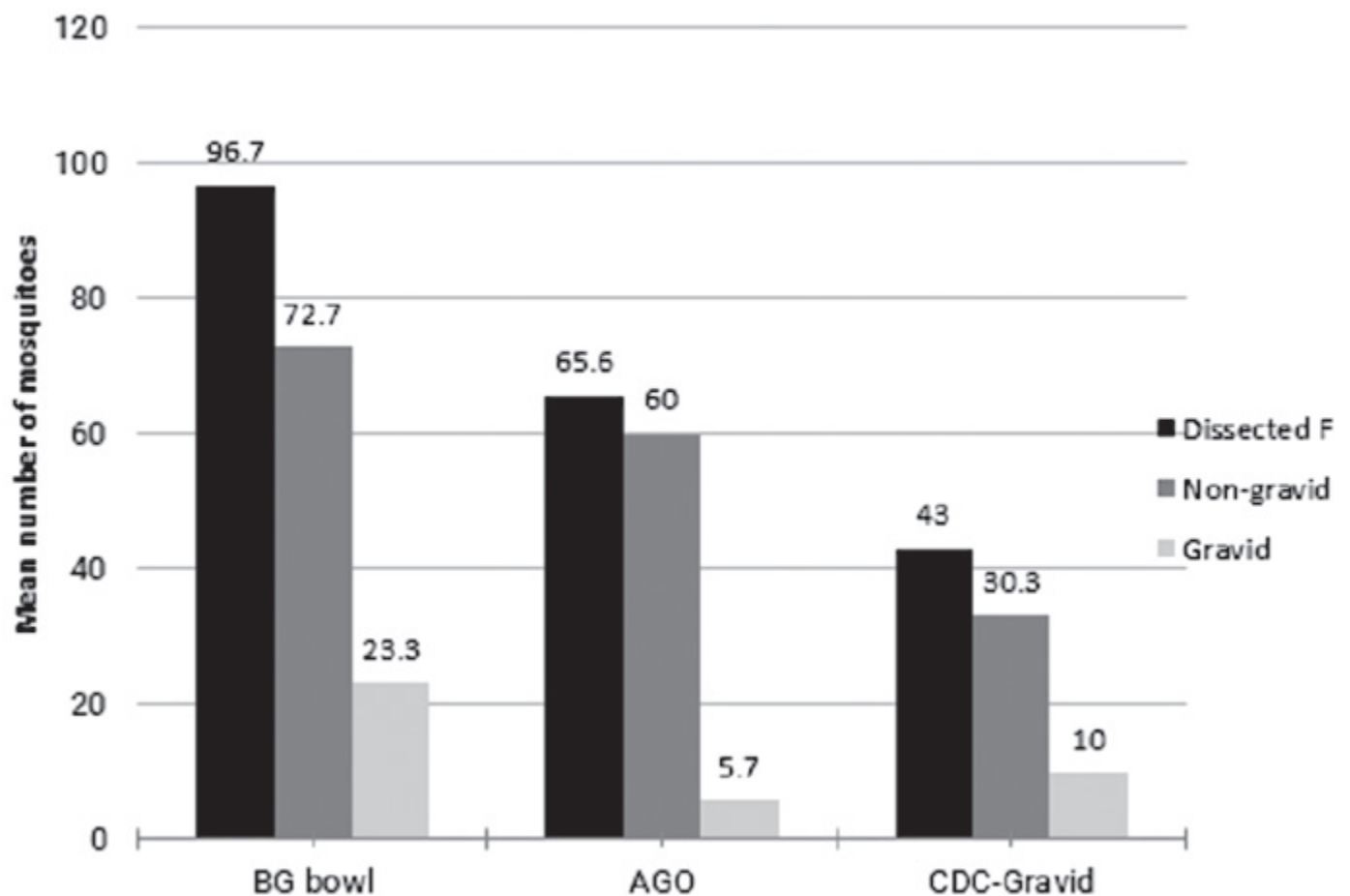


Fig. 1. Mean dissected female mosquitoes with non-gravid and gravid *Ae. aegypti* collected by 3 modified commercial mosquito traps after release in screened outdoor enclosures.

males caught by the CDC-gravid trap. Averages of  $72.7 \pm 0.53$  females caught by BG Bowl were host-seeking and non-gravid,  $60 \pm 0.4$  females caught by autocidal gravid ovitrap trap were host-seeking and non-gravid, and  $33.3 \pm 0.2$  females caught by CDC-gravid traps were host-seeking and non-gravid. We found a significant difference ( $F_{2,6} = 5.58$ ;  $P = 0.043$ ) between the mean numbers of host-seeking and gravid *Ae. aegypti* collected by each of the 3 traps in the screened outdoor enclosures; the BG-Bowl trap collected the most. However, there was no difference ( $F_{2,6} = 3.22$ ;  $P = 0.112$ ) between traps when comparing the mean number of gravid mosquitoes collected.

In field trials, a total of 443 adult female mosquitoes were captured, of which 94% were *Ae. aegypti*, 1% *Ae. albopictus* (Skuse) (Diptera: Culicidae), and 5% *Culex quinquefasciatus* Say (Diptera: Culicidae). The overall percentage of *Ae. aegypti* host-seeking and gravid individuals from all traps was 40% and 60%, respectively. Field collection site significantly influenced ( $F = 3.93$ ;  $P = 0.008$ ) the average number of mosquitoes of both physiological groups in traps, with the greatest number obtained from South Street (4.6) compared with the other 2 locations. The BG-bowl trap significantly collected the greater number of mosquitoes than the other 2 traps ( $F = 13.27$ ;  $P < 0.0001$ ).

## Discussion

Traps combined with attractants have been found to increase the collection of adult mosquitoes (Xue & Smith 2013; Irish et al. 2015, Acevedo et al. 2020). Our study showed that the CDC gravid trap baited with Southern oak leaf infusion and a BG lure collected more *Ae. aegypti* mosquitoes than *Culex*, the latter for which it was originally designed in the field. A previous study by Cilek et al. (2017) showed that the BG *Aedes* trap, CDC-autocidal gravid ovitrap, and CDC gravid trap each baited with Southern oak leaf infusion collected *Ae. aegypti*, *Ae. albopictus*, and *Cx. quinquefasciatus* mosquitoes in northeastern Florida. In that study, the CDC gravid trap collected significantly more gravid *Cx. quinquefasciatus* mosquitoes than the other 2 trap types. But the CDC-autocidal gravid ovitrap and the BG *Aedes* trap collected a similar number of gravid *Aedes* mosquitoes (Cilek et al 2017). Our results also showed that the 3 modified traps collected host-seeking as well as gravid *Ae. aegypti* in a similar region of northeastern Florida.

In summary, a simple addition to the BG-Bowl trap, baited Southern oak leaf infusion, and BG lure (including a small mesh collection bag), collected significantly more host-seeking and gravid *Ae. aegypti* in the semi-field and field studies, compared with the other 2 traps in our study. Moreover, we found that the CDC gravid trap similarly modified, collected a greater number of host-seeking and gravid *Ae. aegypti* compared with the CDC-autocidal gravid ovitrap that added a suction fan. This finding indicates that the modified BG-Bowl trap and CDC gravid trap could be used for the surveillance, and possibly as a control trap tool, for host-seeking and gravid container-inhabiting *Aedes*.

## Acknowledgment

We thank C. Efstathion, M. Pearson, T. Columbus, K. Blore, K. Gaines, V. Aryaprema, E. Zeszutko, and C. Cunningham for their technical help. We also thank the local St. Augustine residents for allowing us to use their properties for the study. This is a research report only. The name of the commercial products mentioned in this publication does not constitute nor imply endorsement by the Anastasia Mosquito Control District, and is used only for more complete information.

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