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PREFERENCE OF FEMALE MOSQUITOES FOR NATURAL AND ARTIFICIAL RESTING SITES

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Abstract

At a wetland study site in Tuskegee National Forest, AL, resting female mosquitoes were collected from natural and artificial resting sites to identify species-specific resting sites and to evaluate various artificial resting sites for their utility in collecting resting mosquitoes. Natural resting sites included small tree cavities, large tree cavities, and understory vegetation. Artificial resting sites included resting boxes, fiber pots, and plastic trash cans. We collected 12,888 female mosquitoes, representing 23 species in 8 genera, during the 6-month study. Each mosquito species demonstrated a preference for a particular type of resting site. Resting *Aedes vexans* females were collected almost exclusively from understory vegetation, while the great majority of *Anopheles quadrimaculatus* females were aspirated from large tree cavities. *Culex erraticus* and *Cx. peccator* females preferred trash cans over other available resting sites. Females of *Cx. territans*, although collected most commonly in large tree cavities, were also collected frequently from understory vegetation and trash cans. A multiple regression of resting-site parameters (excluding vegetation), including volume, surface area, and opening size, indicated that 50% and 20% of the variability associated with *An. quadrimaculatus* and *Cx. territans* collections, respectively, could be explained by opening size. Inner surface area and volume accounted for 33% and 12% of variation in *Cx. erraticus* and *Cx. peccator* collections, respectively. Thus, female mosquitoes generally preferred larger resting sites over smaller resting sites. Similarly shaped artificial resting sites (fiber pots and trash cans) yielded comparable numbers of females per unit of volume (for those species that preferred artificial resting sites), indicating that shape of the resting site is an important factor in resting-site preference. In addition, trash cans proved to be a valuable novel tool for collecting resting female mosquitoes.

Keywords

Resting mosquitoes; Anopheles quadrimaculatus; Aedes vexans; Culex erraticus; Culex peccator; Culex territans

INTRODUCTION

Collecting mosquitoes from resting sites is a useful technique which, in certain situations, has several advantages over conventional mosquito traps. In studies of mosquito ecology, collecting mosquitoes from resting sites yields a more realistic representation of the natural mosquito population than do light traps, which are usually biased toward collecting host-seeking females of a limited group of species (Service 1977). Resting-site collections yield males and females, in natural sex ratios, of a greater variety of species (Mullen 1971a). Resting-site collections also yield a higher percentage of blood-engorged females than do traps (Komar et al. 1995). This is important for studies aimed at determining host specificity for various mosquito species, which require blood-engorged female mosquitoes in order to permit bloodmeal identification (Irby and Apperson 1988, Hassan et al. 2003, Cupp et al. 2004). Resting-site collections are more productive than traps for collecting certain mosquito species, e.g., *Anopheles quadrimaculatus* Say (Huffacker and Back 1943) and *Culiseta melanura* (Coq.) (Komar et al. 1995). Resting-site collections are also more time efficient than conventional CO_2-baited light traps for collecting these same species. Light traps must be set at field sites during the afternoon prior to a trapping occasion and then collected the following morning, necessitating 2 separate trips to a field site for a single collection. Resting-site collections, on the other hand, can be managed in single excursion, particularly when field personnel are equipped with information on favored resting sites of the species of interest in a particular study.

Despite its advantages, collecting resting mosquitoes is underutilized as a collecting technique, and therefore comparatively little information is available concerning resting sites of individual species. Mullen (1971b) reported on diurnal resting sites of mosquitoes in central New York. His meticulous observations were based solely on collections made by sweeping, a technique with limitations on the quantitative data that may be collected (Mullen 1971a). In coastal North Carolina, researchers (Irby and Apperson 1992) used a D-Vac backpack aspirator (D-Vac Corp., Riverside, CA) to investigate spatial and temporal distribution of resting mosquitoes. Their study, however, focused on habitat associations of each mosquito species and neglected to separate collections from different microhabitats, e.g., basal treeholes and swamp vegetation. Komar et al. (1995) compared conventional resting boxes with a novel surrogate (nestable fiber planter pot) for collecting resting mosquitoes; however, no comparison was made with that of collections from natural resting sites. The current study compared natural and artificial resting sites of various types to 1) gain insight into natural resting-site preferences of female mosquitoes, and 2) to identify which type of artificial resting site could be used to maximize collections of resting mosquitoes.

MATERIALS AND METHODS

The study site was a mixed-bottomland forest adjacent to a beaver-constructed marsh located in Tuskegee National Forest, Macon County, AL. Dominant tree species in the study area included sweetbay (*Magnolia virginiana* L.), tuliptree (*Liriodendron tulipifera L.*), sweetgum (*Liquidambar styraciflua* L.), spruce pine (*Pinus glabra Walter*), red maple (*Acer rubrum* L.), water oak (*Quercus nigra* L.), buttonbush (*Cephalanthus occidentalis* L.), and hazel alder (*Alnus serrulata* (Aiton)). Understory vegetation consisted of giant cane (*Arundinaria gigantea* (Walter)) and several fern species, including royal fern (*Osmunda regalis* L.), cinnamon fern (*O. cinnamonea* L.), and netted chain fern (*Woodwardia areolata* L.).

Mosquitoes were collected from resting sites with a novel portable backpack aspirator. The aspirator consisted of a 6-V electric motor mounted inside a 40-cm length of plastic plumbing pipe (7.7 cm inside diam), powered by 2 6-V, 12-amp, rechargeable, sealed gel-cell batteries linked in circuit. The motor drives a 4-blade axial fan (Thorgren Tool & Molding Co., Valparaiso, IN), which creates a directional flow through the plastic pipe. Mosquitoes are captured in 8-oz 30 × 30-mesh-bottom plastic collection cups (BioQuip Products, Inc., Rancho Dominguez, CA), which are secured to the aspirator by way of an 8.1-cm plastic pipe coupling (9.2 cm inside diam) that partially overlaps both the collection cups and the 40-cm plastic pipe. Batteries are carried in a padded, polyester, suede-bottom backpack (JanSport, Inc., San Leandro, CA).

Resting mosquitoes were aspirated from natural and artificial resting sites twice weekly from May 1, 2006, to September 30, 2006, once during the morning (between 7:00 and 8:30 a.m.) and once in the evening (between 4:00 and 7:00 p.m.). Natural resting sites included large tree cavities (hollow spaces within standing trees), small tree cavities, and understory vegetation.

Artificial resting sites included wooden resting boxes (constructed of 12-mm-thickness plywood), fiber planter pots (BWI, Jackson, MS), and plastic trash cans (Trashmaster, Sardis, MS). Physical parameters for the 5 shelter-type resting sites (i.e., fiber pots, resting boxes, trash cans, small tree cavities, and large tree cavities) are provided in Table 1.

To minimize the number of mosquitoes that escaped collection during aspiration from trash cans, a hole just large enough to accommodate the aspirator's collection cup was cut into the lid of the trash can. At the time of aspiration, the lid was placed onto the opening of a can with the aspirator barely penetrating the hole and the aspirator turned on. Resting boxes and fiber pots could be aspirated without considerable loss by way of escaping mosquitoes, and therefore no lids were used when aspirating from these artificial resting sites. Mosquitoes were aspirated from 6 of each type of natural and artificial resting site. To collect mosquitoes from understory vegetation, a sweep net was used to sweep vegetation from 6 predetermined 10 × 10-m plots that were interspersed among the other resting site types. Mosquitoes collected by sweeping were then aspirated from the net using the backpack aspirator. The study area was divided into 6 blocks, with each block having 1 resting box, 1 fiber pot, and 1 trash can. The position of each artificial resting within the block was assigned randomly. Blocks were separated by a distance of 10-20 m. Because the locations of natural resting sites could not be manipulated, tree cavities and understory vegetation were selected that were in proximity to (<50 m) artificial resting sites.

One MMX carbon dioxide trap (American Biophysics Corp., North Kingstown, RI) and 2 or 3 CO_2-baited Centers for Disease Control and Prevention (CDC) miniature light traps (BioQuip Products, Inc., Rancho Dominguez, CA) were run once weekly within the study area. These traps were used to supplement resting-site collections and to assess abundance of mosquito species that may not be effectively surveyed via aspirations from resting sites. All mosquitoes were returned to the laboratory alive, then anesthetized with CO_2 and sorted by species on a chill plate.

For the 6 mosquito species most commonly encountered in resting site collections, the mean numbers of females collected from each type of resting site were compared by analysis of variance (SAS 9.1.3. for Windows, Cary, NC). Data were log transformed. To determine which physical parameters of shelter-type resting sites (excluding understory vegetation) best explain the variation in captures for each mosquito species, a stepwise multiple regression analysis was performed. This analysis used mean volume, inner surface area, and opening size of resting sites as independent variables to examine their effects on the number of each mosquito species collected in shelter-type resting sites.

To illustrate seasonal abundance for the 5 most commonly collected species, mean females collected by light traps were plotted for each 2-wk collecting period (May 1-September 30). Daily surface-water discharge data (US Geological Survey 2007) were plotted with mosquito abundances to illustrate the effects of hydrologic events on mosquito abundance.

RESULTS

A total of 12,888 female mosquitoes, from 23 species in 8 genera, were collected during the study. Table 2 provides totals for each species collected for each sampling method—resting-site aspiration, CO_2-baited CDC miniature light traps, and MMX carbon dioxide trap. For several of the mosquito species collected, one or more of the sampling methods were ineffective and underestimated actual abundance (per species) at the study site. Compared to light traps and MMX traps, resting-site aspirations were less effective for collecting females of *Aedes vexans* (Meigen), *Anopheles crucians* Wied., *Coquillettidia perturbans* (Walker), and *Uranotaenia sapphirina* (Osten Sacken). Light traps were ineffective at collecting females of

Culex peccator (Dyar and Knab) and *Culex territans* Walker, while MMX traps were relatively poor at collecting *An. quadrimaculatus, Cq. perturbans, Cx. peccator*, and *Ur. sapphirina*.

Resting-site collections

For 5 of the 23 mosquito species collected during the study (*Ae. vexans*: $F_{4,145} = 20.48$, $P < 0.01$; *An. quadrimaculatus*: $F_{4,145} = 34.60$, $P < 0.01$; *Cx. erraticus* (Dyar and Knab): $F_{4,145} = 52.24$, $P < 0.01$; *Cx. peccator*: $F_{4,145} = 9.13$, $P < 0.01$; and *Cx. territans*: $F_{4,145} = 7.38$, $P < 0.01$), the mean number of females collected from each type of resting site differed significantly. For these 5 species, a comparison of morning and evening resting-site collections resulted in a significant difference only for *Cx. peccator* ($F_{4,145} = 5.66$, $P = 0.01$). For *An. quadrimaculatus* ($F_{4,145} = 27.70$, $P = 0.01$) and *Cx. erraticus* ($F_{4,145} = 27.97$, $P = 0.01$), sufficient numbers of blood-engorged females were collected from resting-site aspirations to show significant differences among the types of resting shelters. The results for these 5 species are treated individually in the following paragraphs.

Aedes vexans—Significantly more *Ae. vexans* females were collected from understory vegetation than from any other type of resting site (Fig. 1A). Of the 35 *Ae. vexans* females collected from resting sites, only 1 (from a resting box) was not recovered from vegetation sweeps. On average, 0.31 *Ae. vexans* females were collected per 10 × 10-m plot for each sampling session.

Anopheles quadrimaculatus—Large tree cavities were significantly more productive than other types of resting sites for collecting resting *An. quadrimaculatus* females, with an average of 7.24 females collected per cavity for each sampling session (Fig. 1B). Trash cans were the second most productive resting site (2.19 females per can), followed by small tree cavities (0.35 females per cavity), fiber pots (0.33 females per pot), resting boxes (0.23 females per box), and lastly understory vegetation (0.01 females per 10 × 10m plot). While blood-engorged *An. quadrimaculatus* females were also collected significantly more from large tree cavities (Fig. 1B), their numbers were less than one-tenth those of non-blood-engorged females (0.59 females per cavity for each sampling session). Stepwise multiple regression indicated that >50% of the variability in *An. quadrimaculatus* collections could be explained by the area of resting-site openings. Inner surface area and volume were not significant predictors of catch (Table 3).

Culex erraticus—Trash cans were the preferred resting site for both blood-engorged and non-blood-engorged *Cx. erraticus* females, yielding 1.44 and 5.53 females per trash can per collecting session, respectively (Fig. 1C). Large tree cavities were the second most productive resting sites for collecting *Cx. erraticus* females, with means of 0.35 blood-engorged and 1.21 non-blood-engorged females per cavity for each sampling session. Large tree cavities were followed (in order) by resting boxes, fiber pots, small tree cavities, and understory vegetation. All 3 physical parameters of shelter-type resting sites were significant in the regression analysis (Table 3). Inner surface area, area of opening, and volume explained 33%, 20%, and 3% of variability in *Cx. erraticus* collections, respectively. When artificial resting sites were compared using the total number of *Cx. erraticus* females aspirated per unit of volume, pots and cans performed equally well, yielding 87.4 and 87.1 females/m^3, respectively. Boxes, however, yielded only 37.9 females/m^3.

Culex peccator—Resting-site collections conducted during morning hours yielded significantly more *Cx. peccator* females than evening collections. During both times of day, however, more *Cx. peccator* females were collected from trash cans than from any other type of resting site (Fig. 1D), with means of 0.27 and 0.06 *Cx. peccator* females collected during morning and evening hours, respectively. Resting boxes were the second most productive type of resting site for collecting *Cx. peccator*, yielding 0.19 and 0.05 females per box during each morning and evening collecting session, respectively. Fiber pots were 3rd, from which 0.02 females were collected in both morning and evening collections. Large tree cavities yielded a mean 0.01 females per morning collection and none during evening collections. No *Cx. peccator* females were recovered from small tree cavities or understory vegetation. Twenty percent of the variation in *Cx. peccator* collections could be explained by the 3 physical parameters of resting sites combined. Volume, inner surface area, and area of opening explained 12%, 5%, and 3% of the variation, respectively (Table 3). When artificial resting sites were compared by the total number of *Cx. peccator* females aspirated per unit of volume, boxes performed best, yielding 4.0 females/m^3. Pots and cans performed similarly, yielding 2.6 and 2.9 females/m^3, respectively.

Culex territans—Significantly more *Cx. territans* females (0.17 per cavity per collection) were collected from large tree cavities than from any other type of resting site (Fig. 1E). All other resting sites did not significantly differ in the numbers of *Cx. territans* collected. Opening size of resting sites had a significant effect on *Cx. territans* collections, explaining 21% of the observed variation (Table 3).

Seasonal variation in species abundance

As the seasons progressed, a noticeable shift became apparent in the abundance of several of the more readily collected species. Figure 2 summarizes patterns of seasonal abundance for the 5 mosquito species collected in greatest abundance at the study site. The 2 species of *Anopheles* represented in the figure, *An. quadrimaculatus* and *An. crucians*, experienced their greatest abundances in mid- to late June. By mid- July, however, both species are observed at only very low numbers in collections and their abundance remained low through the rest of the collecting season. *Uranotaenia sapphirina* experienced a similar pattern of seasonal abundance, with its numbers peaking in the latter half of June and then quickly subsiding. *Aedes vexans* and *Cx. erraticus* are the only species to be collected in appreciable numbers past the middle of July. *Aedes vexans*, however, reached its greatest abundance during the first half of the collecting season, whereas populations of *Cx. erraticus* were relatively stable throughout the collecting season. A major rain event occurred on May 11, 2007. This precipitation event preceded the peaks of abundances recorded for each mosquito species by approximately 1 month.

DISCUSSION

All mosquito species which were collected in significant numbers (i.e., >30 total females from resting-site aspirations) exhibited a preference for 1 or rarely 2 types of resting sites. Only 1 species, *Ae. vexans*, was found resting in understory vegetation more than in any other type of resting site. This finding is supported by observations of other authors. Bidlingmayer (1971) reported *Ae. vexans* to rest most commonly on vegetation in woodland habitats, while Mullen (1971b) characterized *Ae. vexans* as resting “amidst grasses, ferns and other plants.” Irby and Apperson (1992) included *Ae. vexans* with several other mosquitoes in a group which “rested almost exclusively on vegetation.” Other species that rest on vegetation (*Ochlerotatus atlanticus/tormentor* Dyar and Knab, *Oc. canadensis* (Theobald), *Oc. triseriatus* (Say), and *Psorophora ferox* (Humboldt) [Bidlingmayer 1971, Mullen 1971b, Irby and Apperson 1992]) and occur at the Tuskegee National Forest study site were collected in numbers too low to draw meaningful conclusions.

Our conclusion that *An. quadrimaculatus* adults have a predilection for resting in large tree cavities is supported by observations of Mullen (1971b), who reported collecting resting *An. quadrimaculatus* adults from “stumps and rotholes in standing trees.” At the Tuskegee National

Forest study site, it was not uncommon to observe hundreds of *An. quadrimaculatus* adults of both sexes resting in a large tree cavity. Irby and Apperson (1992), however, indicated that *An. quadrimaculatus* rests on vegetation in North Carolina, a finding that was not supported by the collections reported here. Of the 1,769 total *An. quadrimaculatus* females aspirated from resting sites in the present study, only a single specimen was collected from vegetation. It should be noted that Irby and Apperson made no effort to "avoid sampling from basal treeholes and other natural resting shelters" while collecting from vegetation. The method of combining collections from various resting sites used by Irby and Apperson (1992) may account for the discrepancy between their findings and those of the current study. Our findings that both blood-engorged and non-blood-engorged females of *An. quadrimaculatus* were collected significantly more from the same type of resting site is supported by the work of Bidlingmayer et al. (1974), who concluded that physiological state did not affect the type of resting site used by mosquitoes. The positive effect of opening size of resting sites on mosquito collections, observed here for *An. quadrimaculatus*, has been documented previously by Morris (1981) and Edman et al. (1968), working with the mosquito *Culiseta melanura* in New York and Florida, respectively.

Culex territans was the least particular with respect to choosing resting sites. Although females of this species were collected most commonly from large tree cavities, they could also be collected from all types of resting sites examined in this study, including vegetation. This feature of being found commonly in vegetation as well as in shelter-type resting sites was unique to *Cx. territans*. All other species were found either in vegetation or not in vegetation. *Culex erraticus* and *Cx. peccator*, for example, were both collected most commonly from trash cans but were never collected from vegetation. *Aedes vexans*, on the other hand, was collected almost exclusively in understory vegetation. Our finding that *Cx. territans* is unselective with respect to resting sites is supported by other authors. Mullen (1971b) reported that this species "showed little discrimination" in choosing a resting site and could be collected from any "cool, shaded retreat." This characterization is further supported by Irby and Apperson (1992), who report this species as resting in "a wide variety of moist shelters and vegetational habitats."

Culex erraticus and *Cx. peccator* (subgenus *Melanoconion*) exhibited similar preferences for resting sites, being most commonly collected from trash cans. It is interesting that females of these species were more frequently encountered in an artificial than in natural resting sites. Irby and Apperson (1992) found larger numbers of *Cx. erraticus* and *Cx. peccator* under bridges than in natural habitats. They propose that this propensity for resting under bridges reflects a preference for resting in shelters, rather than on vegetation. In the current study, where both natural and artificial shelters were available, both species were still encountered more often in manmade shelters (i.e., trash cans). One possible explanation of this behavior is that the artificial shelters used here, especially trash cans, provide more inner surface area than natural resting sites, namely large tree cavities. In addition, trash cans may offer more "ceiling" surface area than large tree cavities. In another study (Burkett and Eubanks, unpublished data), overwintering *Cx. erraticus* females aspirated from inside underground culverts were observed more commonly on the "ceiling" than from side "walls" of the culverts. This suggests that adults of this species may prefer upper horizontal (ceiling) surfaces from which to hang, rather than vertical surfaces. In addition, the number of females of *Cx. erraticus* and *Cx. peccator* aspirated per cubic meter of volume from resting sites of similar shape was relatively constant. For these species, small and large truncated-cone-shaped resting sites (flower pots and trash cans) yielded remarkably similar numbers of conspecific females per unit of volume. Rectangular-prism-shaped resting sites (boxes), on the other hand, yielded greater numbers of *Cx. peccator* females per cubic meter and far fewer *Cx. erraticus* females per cubic meter than truncated-cone-shaped resting sites, respectively. This indicates that the shape of the resting sites is also important. Perhaps a large rectangular resting box (with the same volume as trash cans) may yield greater numbers of *Cx. peccator* females than would trash cans.

Whatever the reason, the fact that *Cx. erraticus* and *Cx. peccator* can readily be aspirated from artificial resting sites (trash cans) placed in a natural setting is an important finding for those interested in studying these otherwise difficult-to-collect species. *Culex peccator*, for instance, a species that may be important in maintenance of eastern equine encephalitis virus in the southeastern United States (Cupp et al. 2004), was never collected from light traps or MMX traps in 5 months of field work during the current study. All females of *Cx. peccator* were collected from resting sites, and 57% of these were aspirated from trash cans. Artificial resting sites, particularly trash cans, are an indispensable tool for studying species (like *Cx. peccator*) that are not collected through conventional methods.

Anopheles crucians, the mosquito collected from light traps in greater numbers than any other species, was seldom recovered from resting-site collections. While light traps yielded 2,740 females of *An. crucians*, resting-site aspirations yielded only 30 females. The disparity in light-trap and resting-site collections suggests that the preferred resting site of this species was not sampled during this study. A field study in the Dominican Republic failed to identify the outdoor resting sites of *An. crucians* and 3 other *Anopheles* spp. (Mekuria et al. 1990). Carpenter and LaCasse (1955), however, report this species as resting “underneath bridges, in hollow trees, culverts, and other similar shelters.” Hollow trees were sampled intensively throughout the current study, yet yielded only 11 specimens of *An. crucians*.

Coquillettidia perturbans was also poorly represented in resting-site aspirations. Only 2 females of this species were aspirated from resting sites, compared to 190 from light traps. Of the 2 resting females, one was collected from a resting box and the other from a large tree cavity. Root masses, although not sampled in the current study, were reported by Mullen (1971b) as a site in which *Cq. perturbans* adults were particularly abundant. Failure to include root masses in the study could account for the near absence of this species in resting-site collections at Tuskegee National Forest.

In conclusion, both size and shape of resting sites appear to play an important role in restingsite selection for female mosquitoes. Although larger resting sites are preferred over smaller resting sites, the shape of preferred resting sites varies for each species. Therefore, it would be difficult to design an ideal artificial resting site that would simultaneously collect a large number of mosquito species. However, when designing artificial resting sites for mosquito sampling, size and shape of the site should be considered. That said, trash cans proved to be an excellent tool for collecting resting mosquitoes of several species. In addition to being relatively inexpensive, they are readily purchased at a wide variety of home-supply stores. They are also nestable, lightweight, and relatively impervious to water and sunlight damage. The lid of the trash can may be used to enclose resting mosquitoes inside the can before they are aspirated through a hole cut in the lid, thereby maximizing the recovery of the resting mosquitoes from this type of container.

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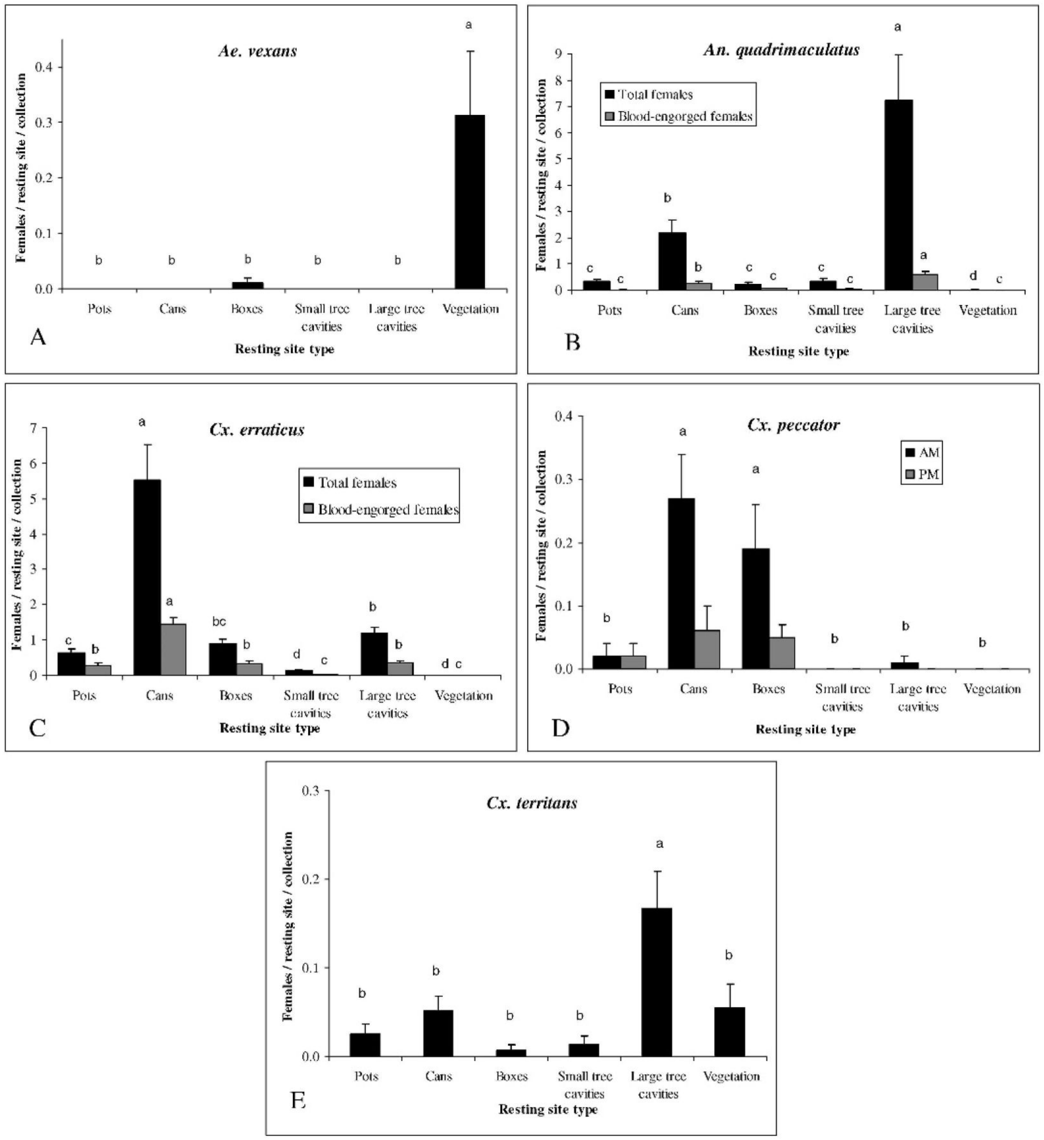

Fig. 1.

Mean females of (A) *Ae. vexans*, (B) *An. quadrimaculatus*, (C) *Cx. erraticus*, (D) *Cx. peccator*, and (E) *Cx. territans* collected from 6 resting-site types: fiber pots, trash cans, resting boxes, small tree cavities, large tree cavities, and understory vegetation, Tuskegee National Forest, Macon County, AL, 2006. Different letters denote values that are significantly different at a 95% confidence level.

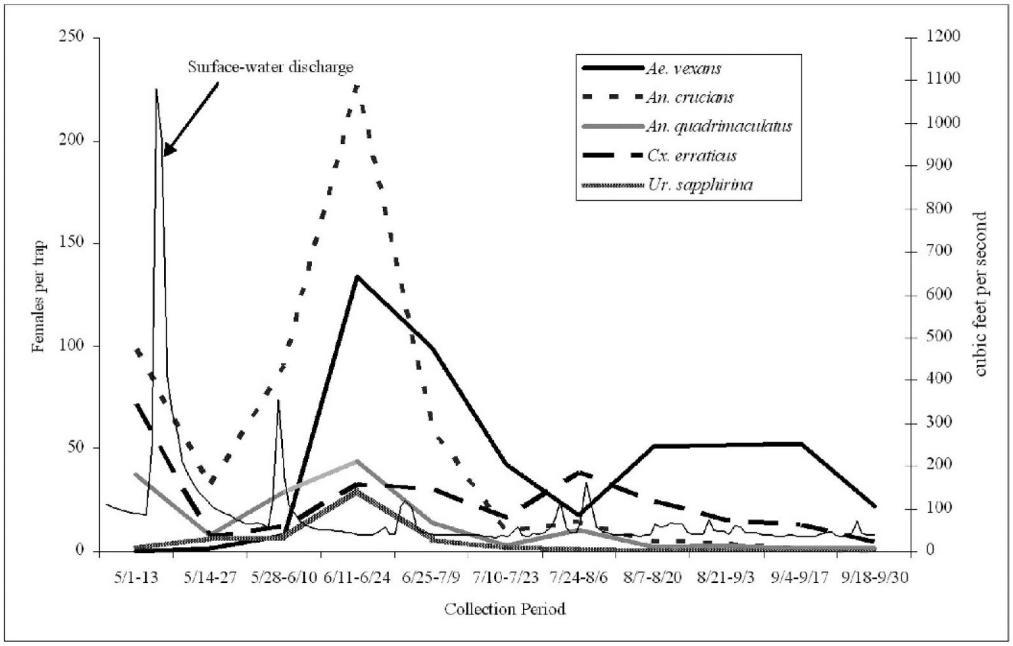

Fig. 2.

Females of *Ae. vexans, An. crucians, An. quadrimaculatus, Cx. erraticus,* and *Ur. sapphirina* collected by carbon dioxide-baited CDC light traps during a 5-month period at a wetland in Tuskegee National Forest, Macon County, AL, 2006. Points represent mean females collected during 2-wk collection periods. Surface-water discharge data provided by US Geological Survey (2007) (USGS 02419000 Uphapee Creek near Tuskegee, AL).

Table 1

Physical parameters of 5 different shelter-type resting sites (fiber pots, resting boxes, trash cans, small tree cavities, and large tree cavities; *n* = 6) used to collect resting mosquitoes, Tuskegee National Forest, Macon County, AL, 2006

Resting-site type	Inner surface area (m^2) Mean (± SE)	Volume (m^3) Mean (± SE)	Area of opening (m^2) Mean (± SE)
Fiber pots	0.21 (0.0)	0.01 (0.0)	0.06 (0.0)
Resting boxes	0.52 (0.0)	0.03 (0.0)	0.06 (0.0)
Trash cans	1.04 (0.0)	0.08 (0.0)	0.18 (0.0)
Small tree cavities	0.32 (0.23)	0.02 (0.004)	0.04 (0.03)
Large tree cavities	0.87 (0.63)	0.13 (0.03)	0.32 (0.26)

Table 2

Total female mosquitoes collected by resting-site aspiration, CO_2-baited CDC light traps, and MMX carbon dioxide traps at a wetland site, Tuskegee National Forest, Macon County, AL, 2006

	Collection method		
Mosquito species	**Resting-site aspiration**	**CO_2-baited light trap**	**MMX CO_2 trap**
Aedes albopictus	2	6	0
Ae. vexans	35	1,800	435
Ochlerotatus atlanticus	9	8	4
Oc. canadensis	0	15	1
Oc. fulvus pallens	0	1	0
Oc. sticticus	0	1	1
Oc. triseriatus	2	1	0
Anopheles barberi	3	0	0
An. crucians	30	2,740	241
An. punctipennis	2	3	0
An. quadrimaculatus	1,769	764	41
Coquillettidia perturbans	2	190	7
Culiseta melanura	3	3	0
Culex erraticus	1,822	1,088	409
Cx. nigripalpus	2	5	6
Cx. peccator	63	0	0
Cx. quinquefasciatus	2	0	0
Cx. salinarius	0	0	1
Cx. restuans	0	2	0
Cx. territans	55	6	0
Psorophora columbiae	0	1	0
Ps. ferox	5	11	15
Uranotaenia sapphirina	14	1,262	0
Total	3,820	7,907	1,161

Table 3

Effects of inner surface area, volume, and area of opening of 5 different shelter-type resting sites (fiber pots, resting boxes, trash cans, small tree cavities, and large tree cavities) on collections of 4 species of mosquitoes at a wetland study site, Tuskegee National Forest, Macon County, AL, 2006

	Inner surface area			Variable Volume			Area of opening		
Mosquito species	**Partial R^2**	**F**	***P***	**Partial R^2**	**F**	***P***	**Partial R^2**	**F**	***P***
Anopheles quadrimaculatus	ns[1]	ns	ns	ns	ns	ns	0.51	135.45	<0.001
Culex erraticus	0.33	64.41	<0.001	0.03	6.44	0.012	0.20	58.47	<0.001
Cx. peccator	0.05	6.64	0.011	0.12	18.70	<0.001	0.03	5.05	0.026
Cx. territans	ns	ns	ns	ns	ns	ns	0.21	35.31	<0.001

[1] ns, not significant.