Seasonal and diel patterns of biting midges (Ceratopogonidae) and mosquitoes (Culicidae) on the Parris Island Marine Corps Recruit Depot

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ABSTRACT: The Marine Corps Recruit Depot on Parris Island, SC, is surrounded by tidal salt marshes, which are breeding habitats for many pestiferous biting flies. Knowledge of biting fly behavior patterns is needed to develop effective pest management strategies in urban areas adjacent to salt marshes. We measured biting midge (Ceratopogonidae) and mosquito (Culicidae) seasonal abundance and diel activity patterns on Parris Island using CO2-baited suction traps from November 2001 – November 2004. Of the three biting midge species collected, Culex furens was most abundant (86.2% of total) and was present in high numbers from late March to November. Culicoides hollensis (12.0% of total) was present during spring and fall but absent in summer and winter; and Culicoides melleus (1.7% of total) was present in spring through fall but absent in winter. Abundance of C. furens had a positive linear correlation with air temperature and rainfall. There were nonlinear correlations between air temperature and C. hollensis and C. melleus numbers, which were most abundant at moderate temperatures. Of 18 mosquito species collected, the most abundant were Aedes taeniorhynchus (42.7% of total), Aedes sollicitans (26.3% of total), Culex salinarius (15.6% of total), Culex quinquefasciatus (7.3% of total), and Aedes vexans (5.7% of total); other species comprised <5% of collections. Aedes taeniorhynchus numbers were positively correlated with temperature and rainfall, and Cx. salinarius was correlated with soil moisture. Activity of most biting midges and mosquitoes were highest the first two hours following sunset. Species of biting flies were present in all months, suggesting that year-round control measures are necessary to reduce exposure to potential disease vectors and nuisance biting. Journal of Vector Ecology 34 (1): 129-140. 2009.

Keyword Index: Aedes, biting flies, Culicoides, Culex, salt marsh, South Carolina.

INTRODUCTION

Long-term studies of species abundance coupled with an understanding of host-seeking activity are needed to plan efficient strategies to control pestiferous biting flies. Potential Integrated Pest Management (IPM) methods for biting flies include physical barriers (e.g., screens, bed nets), cultural controls (e.g., diking and draining), biological control agents, and chemical pesticides. Pest control in salt marshes often relies on adulticides or larvicides (Blanton and Wirth 1979), because cultural control methods such as wetland drainage have negative environmental impacts (Cilek and Hallmon 2005) and no suitable potential biological control agents for biting midges exist. Although narrow-spectrum larvicides (e.g., endotoxins from Bacillus thuringiensis subsp. israelensis and methoprene insect growth regulators) are available for mosquito control (Mulla 1995) in freshwater habitats, these are not effective in salt marshes due to tidal flushing. Information about the seasonal and diel periodicity of biting flies can assist existing programs because applications of adulticides should coincide with times when the target pests are host-seeking (WHO 2003). In contrast, resting insects are found within dense vegetation (Bidlingmayer 1961) and are unlikely to be exposed to aerial sprays. Knowledge about biting fly behavior can also be used to schedule outdoor activities to avoid peak exposure periods or use methods such as repellants or permethrin-treated clothing.

At least 32 species of biting midges (Ceratopogonidae) are found in South Carolina (Snow et al. 1957, Wirth et al. 1985), including some the most notorious pest species along the Atlantic Coast: Culicoides furens (Poey), Culicoides hollensis (Melander and Brues), and Culicoides melleus (Coq.). Peak flight activity of many biting midge species is at dusk and dawn (Kettle 1969, Barnard and Jones 1980, Linhares and Anderson 1990, Mullens 1995), but others are diurnal or nocturnal (Foulk 1969, Schmidtmann et al. 1980). In general, biting midges are not important human disease vectors, but their painful bites cause severe annoyance when they are present in high numbers. They also can cause skin lesions leading to secondary infections that require hospitalization (Dorsey 1947, Haile et al. 1984).

Sixty-two mosquito (Culicidae) species occur in South Carolina (Evans and Wills 2002). Several important pestiferous species inhabit salt marshes including the black salt marsh mosquito, Aedes taeniorhynchus (Wiedemann), the eastern salt marsh mosquito, Ae. sollicitans (Walker), and Culex salinarius Coq. (Nayar 1985). Mosquitoes display...
a range of flight activities, including nocturnal, crepuscular, and diurnal (Wright and Knight 1966, Guimarães et al. 2000, Strickman et al. 2000). The host-seeking activity of salt marsh mosquitoes causes annoyance and also potential disease transmission. Eastern equine encephalomyelitis virus is vectored by mosquitoes in South Carolina (Ortiz et al. 2003, Fonseca et al. 2004). West Nile virus (WNV) was detected in the region in 2002 (Adler and Wills 2003) and has led to increased biting fly control efforts.

The United States Marine Corps facility on Parris Island, SC, is used for basic training of over 25,000 recruits each year. The facility is located within extensive tidal salt marshes, which provide breeding habitat for significant populations of biting midges and mosquitoes. Spanish explorers in 1570 reported intense biting fly activity in these marshes (Connor 1925), and currently, recruits spend many hours outdoors and are repeatedly exposed to pestiferous biting flies. An extensive aerial spray program is conducted by the U.S. Air Force Aerial Spray Unit at this site, but there is little information on the best times to apply pesticides or when the major species in the region are most numerous. Therefore, information on biting fly populations would assist control programs at Parris Island and other salt marsh sites in the southeastern United States.

Pest surveillance is a keystone feature of any IPM program (Kogan 1998). Increased knowledge of biting fly bionomics will allow pest managers to anticipate species prevalence and establish appropriate application schedules for insecticides. Therefore, we conducted a multi-year trapping study to monitor seasonal changes in species and population sizes of biting flies at the Parris Island MCRD, SC. We also determined the peak diel activities of biting midges and mosquitoes at Parris Island.

MATERIALS AND METHODS

Research site

The Marine Corps Recruit Depot at Parris Island is approximately 3,200 hectares, over half of which is tidal salt marsh and dominated by smooth cordgrass (Spartinaria alterniflora Loisel.). Nearby coastal areas are similar in habitat and have extensive salt marshes with breeding areas for biting flies. Upland portions of Parris Island are composed of open, mowed grassy areas, buildings, and wooded (pine and hardwood) areas. Parris Island is bounded by Archers Creek to the North, the Beaufort River to the East, Port Royal Sound to the South, and the Broad River to the West.

Seasonal abundance

Seasonal occurrence of biting flies was monitored on the Marine Corps Recruit Depot from November 2001 through November 2004. Four sampling locations were chosen near to military training and recreational areas (Figure 1): 1) Horse Island (HI) (N32°21.218, W80°42.957) was bordered by salt marsh and was densely vegetated with mature live oaks; 2) Provo Marshal's Office (PMO) (N32°21.199, W80°40.691) was bordered by salt marsh to the north and the main parade grounds and barracks to the south; 3) Weapons (WEP) (N32°20.015, W80°42.083) was bordered to the south by salt marsh and the rifle range to the north; 4) Golf Course (GC) (N32°18.452, W80°40.639) was bordered to the south by salt marsh and north by Page Field.

Meteorological data (temperature and rainfall) were recorded at the Parris Island Water Treatment Facility near the PMO trap site. Times of sunrise/sunset were obtained from the U.S. Navy Observatory Applications Department database (http://aa.usno.navy.mil/data/docs/RS_OneYear.php). In addition, the Palmer Drought Severity Index (PDSI) (National Climatic Data Center, http://www.ncdc.noaa.gov/oa/climate/research/monitoring.html#drought) was used to determine moisture conditions during the study. A PDSI <0 indicates “dry” conditions and >0 indicates “moist” conditions (-6 to +6 scale)(Palmer 1965).

Each sampling location was outfitted with a single CO₂-baited CDC-style suction trap (Clarke Mosquito Control Products, Chicago, IL) that was operated one day each week. These traps attract host-seeking female biting flies with CO₂ (Sudia and Chamberlain 1962), and flies are captured in a collection chamber by suction with a battery-operated fan. Traps were hung on a tree limb or fence 1.5 m above ground. All trap locations were at least 2.5 km apart and were within 1 km of tidal-influenced salt marshes.

Trap contents were collected after 24 h and processed in the laboratory. Large samples were split using a grid system and a 50% or 25% subset was randomly selected. Specimens within each selected subset were identified to species and counted, and numbers were extrapolated to the entire trap collection. The remainder of the sample was also scanned to avoid missing any rare species. All biting flies were identified to genus or species using taxonomic keys (Darsie and Ward 1981, Blanton and Wirth 1979).

Monthly trap collection data were checked for normality and were log transformed (X + 1) when needed. Monthly mosquito and biting midge counts were compared with temperature, rainfall, and PDSI using linear and non-linear regression analysis. Statistical analyses were conducted with SPSS for Windows (Version 13.0, SPSS, Chicago, IL).

Diel activity

Diel activity of biting flies was also examined at Parris Island using a standard CDC-style trap (BioQuip Products, Rancho Dominguez, CA) to collect biting midges and mosquitoes at HI, GC, and PMO locations. The CDC-style trap had a suction fan and a rotating motorized turntable with eight collection chambers filled with 25 ml of water and detergent surfactant. The chambers were sealed as the turntable rotated to take independent collections for 2-h intervals. A Mosquito Magnet® (American Biophysics, East Greenwich, RI) was used to provide CO₂ to attract biting flies to the rotating trap. Mesh netting was placed over the Mosquito Magnet intake to assure that only the CDC-style trap collected insects.

Diel trapping was conducted on 1-7, 12,13 October 2003, 13-20 April 2004 and 25 August -1 September 2004. Photophase was 11 h, 4 min on the first day of the study.
Figure 1. The Marine Corps Recruit Depot on Parris Island, SC, showing the four trapping locations and the water treatment facility with weather station.

Trap locations and weather station:

1. Horse Island (HI)
2. Provo Marshal’s Office (PMO)
3. Weapons (WEP)
4. Golf Course (GC)
5. Water Treatment Facility

Figure 2. Seasonal abundance of Culicoides furens, C. hollensis, and C. melleus at Parris Island. Numbers are an average of weekly samples from November 2001 - November 2004. Note counts are on a log scale.
and decreased by approximately two min each day during October. During the April collection dates, photophase increased by 9 min. Collection intervals were established in two-hour increments (e.g., 08:00-10:00, 10:00-12:00, etc.). In this arrangement, the first sampling period began at least five h prior to sunset and trapping was continuous within the study periods. Samples were transferred from collection chambers to 75% ethanol, and flies were identified and counted under a microscope.

RESULTS

Seasonal patterns of biting fly abundance

A range of environmental conditions were encountered during the study. Monthly temperatures during the 36-month study averaged 1.2° C above the historical monthly averages (1911-2004, National Climatic Data Center, Ashville, NC). At the beginning of the study from November 2001-July 2002, rainfall amounts were much lower than normal (PDSI was about -4 indicating a moderate drought). After this period, rainfall increased and amounts were higher than normal (PDSI were 2 - 3 indicating moist conditions) during May to October 2003. Rainfall declined after November 2003, and conditions remained around normal (PDSI 1 to -2) for the remainder of the study. Overall, monthly rainfall totals during the study were approximately 4% higher than the historical average rainfall (141 mm).

A total of 480,811 biting midges were collected during the study, and they were present year-round. All individuals were identified as three species: *C. furens*, *C. hollensis*, and *C. melleus*. *Culicoides furens* was the most abundant biting midge at Parris Island, representing 86.2% of total biting midges collected (Table 1). It was also the most abundant taxa at all sites except PMO. *Culicoides hollensis* was the next abundant biting midge (12.0% of total). *Culicoides melleus* was relatively uncommon (1.7% of total), and its populations reached high levels only briefly.

*Culicoides furens* numbers had a weakly bimodal seasonal pattern. They appeared in spring in late March or early April and peaked at over 1,000 individuals per trap night in late May. They declined afterwards but remained at relatively high numbers (>150 individuals per trap night) throughout the summer. They had a second peak in September and disappeared after November (Figure 2). The single largest trap collection for a 24-h sample occurred on 6 May 2003 when >120,000 *C. furens* were collected at the HI site. Although numbers of *C. furens* during summer were usually high, there was substantial weekly variation. Trap collections differed by an average of 1,563 (SE ±517) biting midges from week to week.

*Culicoides hollensis* also had a bimodal activity pattern with peak numbers in fall and spring (Figure 2). These biting midges appeared in January and had the highest numbers in March and April and then were absent from June to August. Numbers during a second peak in fall were highest in November and declined in December. The largest numbers of *C. hollensis* were collected on 20 March 2002 when 6,463 biting midges were collected at the PMO trap site. Weekly variation in numbers was high, and collections differed by an average of 301 (SE ± 81) biting midges from week to week.

*Table 1. Abundance of adult biting midges (Ceratopogonidae) and mosquitoes (Culicidae) collected from November 2001 to November 2004 at four trapping locations on the Marine Corps Recruit Depot, Parris Island. Locations are Horse island (HI) Golf course (GC), Provo Marshal’s Office (PMO), Weapons (WEP).*

<table>
<thead>
<tr>
<th>Ceratopogonidae</th>
<th>HI</th>
<th>GC</th>
<th>PMO</th>
<th>WEP</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Culicoides furens</em></td>
<td>209,611</td>
<td>100,281</td>
<td>16,986</td>
<td>87,758</td>
<td>86.2</td>
</tr>
<tr>
<td><em>C. hollensis</em></td>
<td>7,609</td>
<td>13,203</td>
<td>26,915</td>
<td>10,051</td>
<td>12.0</td>
</tr>
<tr>
<td><em>C. melleus</em></td>
<td>864</td>
<td>1,363</td>
<td>2,242</td>
<td>3,928</td>
<td>1.7</td>
</tr>
<tr>
<td>Total</td>
<td>218,084</td>
<td>114,847</td>
<td>46,143</td>
<td>101,737</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Culicidae</th>
<th>HI</th>
<th>GC</th>
<th>PMO</th>
<th>WEP</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aedes taeniorhynchus</em></td>
<td>18,165</td>
<td>15,915</td>
<td>4,883</td>
<td>157</td>
<td>42.7</td>
</tr>
<tr>
<td><em>Ae. sollicitans</em></td>
<td>756</td>
<td>1,053</td>
<td>809</td>
<td>21,494</td>
<td>26.3</td>
</tr>
<tr>
<td><em>Culex salinarius</em></td>
<td>1,955</td>
<td>8,148</td>
<td>811</td>
<td>3,374</td>
<td>15.6</td>
</tr>
<tr>
<td><em>Cx. quinquefasciatus</em></td>
<td>1,954</td>
<td>219</td>
<td>1,023</td>
<td>3,499</td>
<td>7.3</td>
</tr>
<tr>
<td><em>Ae. vexans</em></td>
<td>1,506</td>
<td>2,245</td>
<td>108</td>
<td>1,324</td>
<td>5.7</td>
</tr>
<tr>
<td><em>Ae. atlanticus</em></td>
<td>424</td>
<td>163</td>
<td>26</td>
<td>1,070</td>
<td>1.8</td>
</tr>
<tr>
<td><em>Anopheles bradleyi</em></td>
<td>79</td>
<td>64</td>
<td>17</td>
<td>118</td>
<td>0.3</td>
</tr>
<tr>
<td>Other Culicidae spp.</td>
<td>55</td>
<td>65</td>
<td>57</td>
<td>66</td>
<td>0.3</td>
</tr>
<tr>
<td>Total</td>
<td>24,894</td>
<td>27,872</td>
<td>7,734</td>
<td>31,102</td>
<td>100</td>
</tr>
</tbody>
</table>
Figure 3. Seasonal abundance of *Ae. taeniorhynchus*, *Ae. sollicitans*, *Cx. salinarius*, *Ae. vexans*, and *Cx. quinquefasciatus* at Parris Island. Numbers are an average of weekly samples from November 2001- November 2004. Note counts are on a log scale.
week to week. 

_Culicoides melleus_ was collected in relatively low numbers with a spring and fall peak (Figure 2). The largest collection of _C. melleus_ occurred 8 April 2003 at the WEP site (n=944 midges). However, numbers varied between years. For example, collections were never >100 biting midges / trap night in 2004. Weekly variation was less pronounced than for other species, and weekly trap collections differed only by an average of 109 biting midges (SE ± 24).

A total of 91,602 individual mosquitoes in 18 species was collected during the study (Table 1). The most abundant species were: _Aedes taeniorhynchus_, _Ae. sollicitans_, _Cx. salinarius_, _Cx. quinquefasciatus_ Say, _Ae. vexans_ (Meigen), _Ae. atlanticus_ Dyar & Knab, and _Anopheles bradleyi_ King. The other 11 species were: _Aedes albopictus_ Kuse, _Ae. mitchellae_ (Dyar), _Anopheles atrop_ Dyar & Knab, _An. quadrimaculatus_ Say, _Cx. nigripalpus_ Theobald, _Culiseta melanura_ (Coq.), _Orthopodomyia signifera_ (Coq.), _Psorophora ciliata_ (Fabr.), _Ps. columbiae_ (Dyar & Knab), _Ps. ferox_ (von Humboldt), and _Uranotenia lowii_ Theobald. These comprised less than 0.3% of collections. Adult host-seeking mosquitoes were present at Parris Island year-round. Mosquito populations generally reached 100 individuals per trap night by late-March. Populations increased to >1,000 individuals/night by August but decreased in winter.

_Aedes taeniorhynchus_ was the most abundant mosquito and comprised 42.8% of the total mosquitoes collected. This species exhibited a unimodal distribution from mid-March to November (Figure 3). Populations peaked in mid-September, but collections over 100 mosquitoes per trap night occurred on most dates between mid-August and mid-October. The largest sample taken was >5,200 individuals collected on 12 Sept 2002.

Other mosquito species exhibited bimodal distributions. This included _Ae. sollicitans_ (26.4% of collected mosquitoes), which peaked in spring and had a larger peak in fall (Figure 3). _Culex salinarius_ was present nearly the entire year but had two peaks during spring and November - December (Figure 3). _Aedes vexans_ was present in March - June and then disappeared until a second peak occurred in November - January (Figure 3).

Other species populations did not have an obvious seasonal pattern. For example, _Cx. quinquefasciatus_ was common throughout the year, but it occurred in relatively low numbers (Figure 3). _Aedes atlanticus_ and _An. bradleyi_ were intermittently collected in low numbers throughout spring to early winter.

Several meteorological factors were correlated with biting midge abundance. _Culicoides furens_ abundance was positively correlated with temperature (r²=0.67, n=36, P<0.001), and reached the highest numbers in mid-summer when temperatures were ~30° C (Figure 4). There were also significant non-linear correlations between temperature and _C. hollensis_ and (r²=0.74, P<0.001) and _C. melleus_ (r² =0.41, P<0.001) numbers. These species peaked at air temperatures between 15 to 25° C. _Culicoides furens_ was positively correlated with rainfall (r²=0.29, n=36, P=0.001), but _C. hollensis_ was negatively correlated with rainfall (r²=

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**DISCUSSION**

The biting midge and mosquito communities on Parris Island were comprised of species that are common in tidal salt marshes along the Atlantic and Gulf Coasts (Blanton and Wirth 1979, Rueda and Gardner 2003). These species are well adapted to the harsh conditions of fluctuating water level and saline environment. As a result, they are dominant pest species in similar habitats throughout the region.

Temporal changes of biting midge abundance on Parris Island were similar to patterns reported in other salt marshes. For example, we found few _C. hollensis_ during the summer months and the winter. Although _C. hollensis_ sometimes is present year-round (e.g., southern Florida, Blanton and Wirth 1979), most studies found the same pattern as we report here (Jamnback 1965, Kline and Axtell 1976). Moreover, the dates of peak numbers of biting...
Figure 4. Correlations between *Culicoides* numbers and meteorological data. A. *Culicoides furens* vs air temperature B. *C. hollensis* vs air temperature C. *C. melleus* vs air temperature D. *Culicoides furens* vs rainfall E. *C. hollensis* vs rainfall.
midges at Parris Island fit an expected temporal shift along a geographic ecocline. For example, peak numbers of *Culex furens* on Parris Island occurred in late May. This is similar to dates of peak numbers reported at similar latitudes in the southeastern United States (Khalaf 1967, Kline and Axtell 1976, Lillie et al. 1987). In contrast, peak numbers further north in Connecticut and New York occur in July (Lewis 1959, Jannback 1965), and peak numbers further south along the Gulf Coast are earlier (Kline and Roberts 1981). Likewise, the seasonal peak of *Culex melleus* numbers on Parris Island also occurred at the time expected at this latitude (Jannback 1958; Kline and Axtell 1975, Lillie et al. 1987).

There were also strong correlations between weather conditions and biting fly numbers, and this information may help pest managers predict which species should be targeted at different times of the year. *Aedes taeniorhynchus* and *Culex furens* were positively correlated with increasing temperature. *Culex furens* is widely distributed and reaches as far south as Brazil (Wirth et al. 1988). *Aedes taeniorhynchus* is also a tropical species that is found in southern Brazil and Peru (WHO 1989). Therefore, these are adapted to warm temperatures. Other biting fly species reached peak numbers at moderate temperatures: *Culex hollensis* ~17°C and *Culex melleus* at ~21°C. Unlike *Culex furens*, the distribution of *Culex hollensis* and *Culex melleus* does not extend into Central America, reflecting the preference of these species for moderate temperatures.

Rainfall was also correlated with biting fly numbers. Some species were more abundant during high rainfall (*Culex furens*, *Aedes taeniorhynchus*), but others increased during dry periods (*Culex hollensis*, *Culex salinarius*). For example, seasonal patterns of *Culex furens* and *Aedes taeniorhynchus* numbers were almost identical because they were both abundant during the hot and humid months of the year and are likely to be more pestiferous in relatively hot years. *Culex salinarius* and *Culex hollensis* often decline during the wettest months (Janousek and Olson 2006), which indicates they are less dependent on rainfall and can use standing water or are highly mobile during larval development.

Peak activity of most species of biting midges and mosquitoes were during the crepuscular period around sunset, which has been reported in other studies (Service 1971). Furthermore, *Culex salinarius* have extended nocturnal activity (Gladney and Turner 1970, Anderson et al. 2007), and we also found that *Culex* spp. activity (which were predominantly *Culex salinarius*) was high throughout the night. However, some flight activity patterns on Parris Island were different than expected. For example, mosquitoes and biting midges often have two peak activity periods, one immediately at sunset and one at sunrise (Trapido 1947, Bidlingmayer 1961, Carroll and Bourg 1977, Esbary and Crans 1977). We did not observe this pattern for any species. We observed a minor activity peak of *Culex furens* two h after dawn, but it was only in one month (April 2004). Lillie et al. (1987) reported that diel activity of biting midges can vary with the season but reported a consistently greater peak in the evening similar to our findings at Parris Island.
Figure 6. Diel activity patterns of *Culicoides furens*, *C. hollensis*, and *C. melleus* from October 2003 to September 2004. Vertical dotted lines indicate the shift in sunset and sunrise times within the study period.

Figure 7. Diel activity patterns of *Aedes* spp. and *Culex* spp. from October 2003 to September 2004. Vertical dotted lines indicate the shift in sunset and sunrise times within the study period.
Management implications

Exposure to nuisance biting and potential epizootic disease vectors can be a health concern for people living near tidal salt marshes. We found that biting midges were most abundant on Parris Island during spring and autumn. Although there was some temporal segregation between the three species, peak numbers of the most common species, *C. furens*, overlapped the fall peak of the other two species. This caused extremely intense biting activity at this time and our traps collected >1,000 biting midges per night. Mosquitoes were also the most abundant in autumn, although they were present throughout the year. Ironically, spring and fall are the periods when the region’s climate is most enjoyable and levels of outdoor activity by humans are the highest. Our data can help pest managers anticipate peak annual abundance of aggressive human biters and make plans for appropriate control measures during this time frame.

Knowledge about diel activity patterns of biting flies on Parris Island will also be useful for developing effective pest management strategies. Scheduling night-time training operations to begin at least two h after sunset would ease some biting fly intensity, although it is important to note that some mosquito vectors of WNV (e.g., *C. quinquefasciatus*) are active throughout the night. When chemical adulticiding is used, applications between one h prior and two h after sunset should cause maximum mortality of the dominant species in the region. This timing would also reduce exposure of some non-target insect species, such as honeybees, that are active during the day.

The United States Marine Corps conduct extensive outdoor training on Parris Island, and subsequently recruits are more exposed to potential disease vectors and nuisance biting than the general population. Several mosquito species at Parris Island are known vectors of human pathogens. For example, the most abundant species were *Ae. taeniorhynchus* and *Ae. sollicitans*, which are severe biters and vectors of encephalitides (Crans 1977, Ortiz et al. 2003). Other abundant mosquitoes include species from which WNV isolations have been made and they may be important vectors locally (e.g., *Cx. salinarius, Cx. quinquefasciatus*) (Hayes et al. 2005, Anderson et al. 2007). Thus, our results demonstrate that there are few calendar dates when biting fly activity is not a potential public health problem and some pest management strategies are needed year-round.

Potential public health risks can be examined by looking for patterns between peak pest insect numbers and disease outbreaks. While biting midge species on Parris Island are not vectors of human disease (Blanton and Wirth 1979), they may precipitate dermatitis cases (Haile et al. 1984). For example, the peak *Culicoides* numbers in 2002 coincided with an outbreak of methicillin-resistant *Staphylococcus aureus* (MRSA) skin infections on Parris Island (August – November 2002) (Zinderman et al. 2004). MRSA infections start with cuts on the skin and some recruits reported that their MRSA infections started with insect bites. This suggests that there may be an undocumented risk caused by biting flies to recruits on the base. Our data may assist public health organizations in nearby coastal urban areas (e.g., Hilton Head, SC, Charleston, SC, and Savannah, GA) because the bionomics of biting flies in their salt marshes are likely to be similar to those on Parris Island.

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