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# OPERATIONAL NOTE

## NIGHTTIME AERIAL SPRAYS FOR CONTROL OF CREPUSCULAR BITING MIDGES IN SOUTH CAROLINA

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ABSTRACT. Nighttime aerial spray applications with naled were conducted to evaluate their efficacy in controlling crepuscular biting midges (*Culicoides* spp.) in South Carolina, using a US Air Force C-130. Local populations of *Culicoides* spp. were monitored before and after the sprays with Mosquito Magnet traps to assess the efficacy of postsunset applications. Biting midge populations were consistently decreased by the aerial spray applications in this study. This indicates that nighttime sprays can be used to control these pests, even when their peak flight activity is focused around sunset.

**KEY WORDS** *Culicoides*, mosquito, space sprays

Biting midges (Diptera: Ceratopogonidae) are persistent and aggressive pests with painful bites. Mammal-feeding *Culicoides* spp. are serious pests in coastal areas across North America, including on the Marine Corps Recruit Depot Parris Island (MCRDPI), SC (Breidenbaugh et al. 2009, Sloyer et al. 2019). *Culicoides* spp. are vectors of arboviruses and parasites (Yates et al. 1982, Fecchio et al. 2018, Peck et al. 2020).

The MCRDPI has served as a model site for studies on pestiferous *Culicoides* spp. due to seasonally high pest populations coupled with intense outdoor military training and subsequent potential to cause cellulitis from scratching at bites (Haile et al. 1984, Breidenbaugh et al. 2009). Haile et al. (1984) showed that evening aerial spray operations can reduce *Culicoides* spp. over large areas, fundamentally matching the host-seeking period of the primary pest species, which are predominantly active at dusk and dawn (Lillie et al. 1987, Breidenbaugh et al. 2009). However, nighttime aerial pesticide applications may be advantageous to maximize pesticide exposure to night-flying vectors (e.g., *Culex* spp.), minimize exposure to nontarget day-active pollinators, and benefit from favorable meteorological conditions to reduce the effects of unwanted pesticide drift (Haagsma et al. 2015). The recent development of nighttime aerial spray operations by the US Air Force (USAF) Aerial Spray Unit (AFASU) (Haagsma et al. 2015) presents new opportunities to test the efficacy of these techniques for the control of *Culicoides* spp. at the MCRDPI. The present report describes our findings on nighttime aerial spray operations targeting *Culicoides* spp.

Active populations of biting midges were measured using 3 or 4 Mosquito Magnets® (MMs) (MM3200; Woodstream Corp., Lititz, PA) as a sampling tool before and after aerial spraying. Number and placement of MMs on MCRDPI are shown in Fig. 1A–C. Trapping with MMs began 1 or 2 days prior to the application and ran continuously (1500 h to 1500 h daily) until 1 or 2 days after the spray, using only the $CO_2$ produced by the trap as an attractant and no additional lure (e.g., octenol). Insects were not collected during the 24-h period, which included the insecticide application. Otherwise, daily catches of insects were collected in catch bags and killed by freezing. The *Culicoides* spp. were selectively sorted from often the thousands of mosquitoes by pouring the daily collections onto 50-µm metal mesh strainers (Gilson Company, Lewis Center, OH) with continuous agitation for 5 min. Mosquitoes and other large insects do not pass through the mesh, but *Culicoides* do and they were captured on a plastic tray below the strainers. These *Culicoides* spp. were spread across the tray, enumerated, and identified using characters illustrated by Wirth et al. (1985). Voucher specimens of *C. furens* (Poey) and *C. hollensis* (Melander and Brues) were deposited in the Charles A. Triplehorn Insect Collection, Ohio State University, Columbus, OH.

Aerial spraying was carried out using a USAF C-130H plane modified and outfitted with the Modular Aerial Spray System (Haagsma et al. 2015). Following standard operating procedures for biting midge control at MCRDPI, the USAF made the applications using an undiluted naled mosquito insecticide (Dibrom concentrate, 87% AI; AMVAC, Los Angeles, CA) on April 9, 2015, April 21, 2016, and April 20, 2017. Applications were initiated 15

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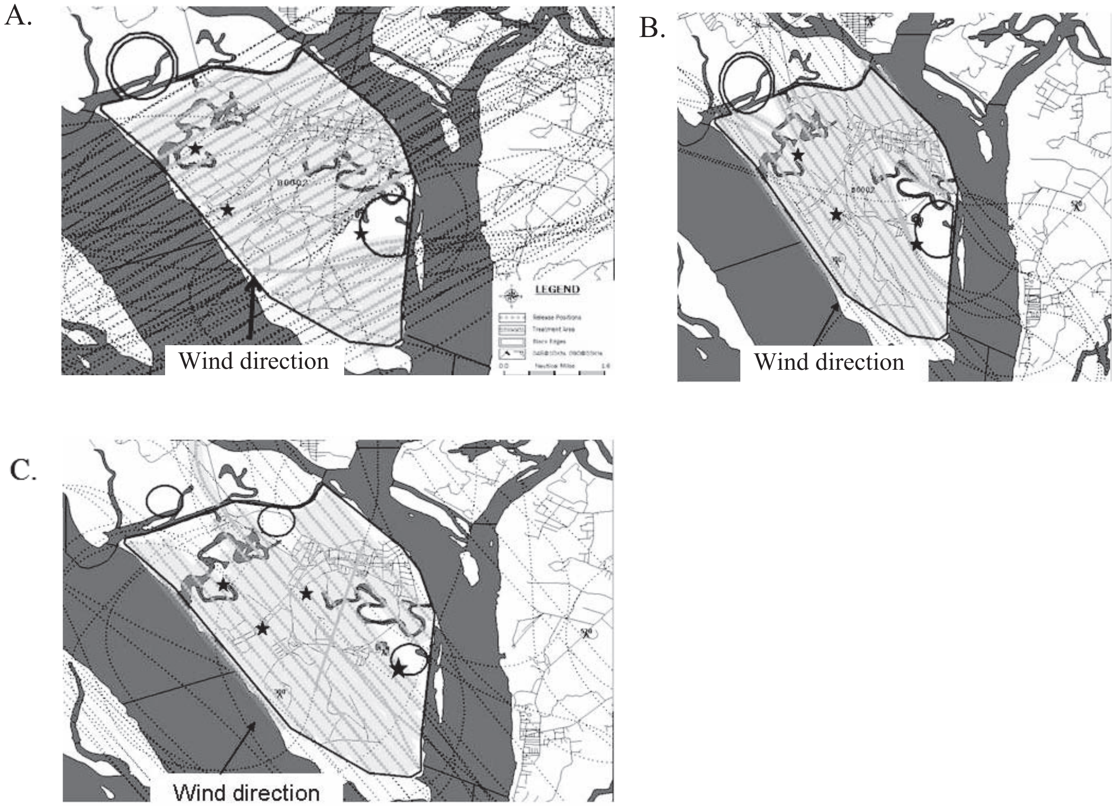


Fig. 1. Flight path (dotted lines) and application area (shaded) on Marine Corps Recruit Depot Parris Island (MCRDPI), showing wind direction (black arrow). Black stars indicate the location of Mosquito Magnet traps. The circles indicate no-fly zones to avoid eagle nests and are twice the diameter of the minimum area of avoidance. Flight parameters and environmental conditions are also given by date of trial and can be matched to flight path image by letter (i.e., A, B, C).

min after sunset, using night-vision goggles and continued until the treatment area was covered, which was optimized based on the wind direction and the type of flight obstacles associated with a given flight direction (Fig. 1A–C). The spraying was done with flat fan nozzles (8003; TeeJet, Wheaton, IL), angled at 90 degrees, pressurized at 275 kPa (40 psi), and using a release height of 91 m above ground level. Additional flight parameters are given in Fig. 1A–C.

During the April application dates of this multiyear analysis, populations of biting midges were found to be well above levels that cause considerable negative impacts to the human activities on the MCRDPI (i.e., 350+ midges/trap-night). *Culicoides furens* was the prevalent midge species collected in each year, with *C. hollensis* found to be present at disruptive levels in 2015 and 2017. *Culicoides melleus* (Coquillett) was collected in 2015 and 2017, but only represented 4% and 12% of the total midges collected in those years, respectively.

Midge populations were consistently and pointedly decreased by aerial spray applications of naled across the 3 applications tracked for population changes in this study (Fig. 2A–C). However, there was a single instance of an increase in numbers after an application seen with *C. hollensis* in April 2017 (Fig. 2C). Percent decrease in midge numbers ranged from 70% to 98% across the sampling period relative to prespray abundance.

Aircraft Global Positioning System tracking showed good coverage over the majority of the target area, with some variation depending on the direction the aircraft flew (Fig. 1A–C).

Nighttime aerial pesticide applications provided notable decreases in midge numbers (70–98% reductions) across all years and treatments, with the single exception of *C. hollensis* collections actually increasing following the April 2017 application (Fig. 2A–C). Such increases are typically a function of large emergence events occurring during the application period and directly afterward. Thus, it is likely that the *C. hollensis* increase in 2017 was a result of a punctuated emergence event. Nonetheless, salt-marsh *Culicoides* spp. do not have a single synchronized emergence event but have several emergence peaks across their developmental periods that overlap for

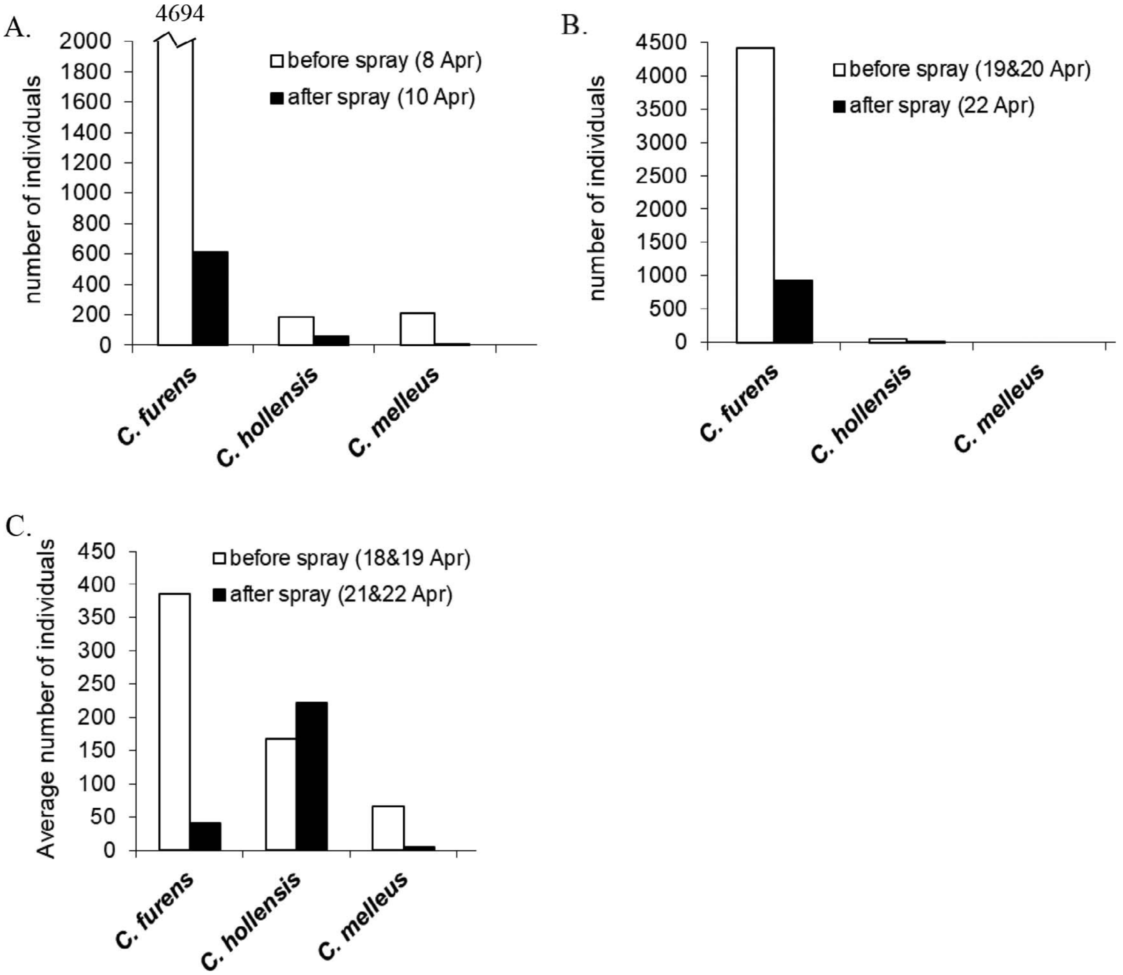


Fig. 2. *Culicoides* spp. densities before and after sprays, collected in Mosquito Magnet traps at the Marine Corps Recruit Depot Parris Island, SC. (A) Before sprays collected April 8, 2015; after sprays collected April 10, 2015. (B) Before sprays collected and averaged April 19–20, 2016; after sprays collected April 22, 2016. (C) Before sprays collected and averaged April 18–19, 2017; after sprays collected and averaged April 21–22, 2017.

all 3 pestiferous midge species at MCRDPI during April–May (Breidenbaugh et al. 2009), and add difficulty to determining the best timing for a midge adulticide application.

These data indicate that making applications following sunset yield results that match or exceed the previous method of utilizing the last 2 h prior to sunset, while taking advantage of the nighttime benefits of reduced pollinator impacts and stable weather. The reduction of midges in the present study (70–98% reductions) fall within the ranges reported previously (25–99%) by Haile et al. (1984) and Breidenbaugh and de Szalay (2010). In fact, similar positive results have been found after other nighttime sprays not included in this study period and location, underscoring the effectiveness of postsunset sprays for many mosquito species, as well. Consequently, nighttime aerial spray operations are currently used by the AFASU for the control of adult mosquitoes in nearly all situations (Haagsma et al. 2015, Qualls and Breidenbaugh 2020). Were there an outbreak of disease transmitted by these crepuscular biting midges, a nighttime application of pesticides could be useful in breaking transmission by greatly reducing the population of active *Culicoides* spp. as was proposed for epidemic vesicular stomatitis, an insect-transmitted exotic animal disease (Peck et al. 2020).

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