THE DISPERAL OF CULICOIDES MISSISSIPPIENSIS
(DIPTERA: CERATOPOGONIDAE) IN A SALT MARSH
NEAR YANKEETOWN, FLORIDA

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ABSTRACT. Of the estimated 40,000 Culicoides mississippiensis adults released, 567 (≈1.5%) were recovered
over two, 4-day periods. Individuals traveled a mean distance of 2 km following the first release and 2.2 km
after the second release. Their movement did not appear to be aided by wind. One specimen was recovered 3.2
km from the release point in 24-h.

INTRODUCTION

The dispersal and flight range of adult ceratopogonids have been evaluated by collecting unmarked adults in the vicinity of an
isolated breeding site or by releasing and recapturing marked specimens. Most studies are
based on the former procedure which is much easier to conduct. The mark and release
method is more time consuming because adults must be obtained by live-trapping or rearing
from the immature stage. They are then marked by using radioisotopes (Davies 1965),
fluorescent dusts (Lillie et al. 1981a), paints (Gillies 1961) or dyes (Dalmat 1950).

Mark, release, and recapture techniques have never been used to study the dispersal of salt
marsh Culicoides spp. We evaluated the dispersal of C. mississippiensis Hoffman in this manner
near Yankeetown, Levy County, Florida. The objectives of our study were to determine the
mean distance traveled (MDT) by C. mississippiensis females and whether the females are
capable of dispersing from the salt marsh to a nearby residential community. Dispersal infor-
mation is useful when planning a pest management program.

MATERIALS AND METHODS

We conducted this study in a salt marsh near Yankeetown, Levy County, FL. Juncus
roemerianus Scheele and Spartina alterniflora Loiseleur were dominant plants in areas per-
odically flooded by tides. Juniperus silicicola (Small) and Ilex vomitoria Aiton were common on
higher ground. Specimens for marking were live-trapped in 6 CDC portable light traps. Each
trap was baited with 2.2 kg of solid CO₂ and operated for 24-hr. Specimens were marked at
1030 hr on April 2, 1984 by inserting the needle of a 5 ml syringe through the screen adaptor on
the lower portion of a CDC trap. Approximately 0.4 ml of micronized fluorescent dust
(U.S. Radium Color 1953, green) was injected into the collection bag. A plastic bag with sev-
eral small holes in the bottom was held around the bag of specimens and the fan on the trap
was operated during the marking process to circulate the dust. Preliminary tests indicated
that 100% of the specimens in the collection bag could be marked by using this technique. In a
previous study of C. variipennis (Coq.) the dust remained on marked adults their entire life and
was not transferred from marked to unmarked individuals during copulation (Lillie et al.

An estimated 25,000 marked specimens were released at 1200 hr on April 2. This estimate
was based on the mean number of C. mississippiensis collected over a 4-day period at
the trapping sites used to obtain specimens for marking. Twenty traps were positioned within a
3.2 km radius of the release point to recapture marked individuals (Fig. 1). Each trap was
baited with 2.2 kg of solid CO₂ and equipped with a 1 liter jar of 70% ethanol as a collection
receptacle. The marking material did not wash off in ethanol during a prior experiment (Lillie
et al. 1981a). Every 24-hr for 4 days following the release, collection jars were changed and a
new supply of solid CO₂ was added to each trap. Most of the traps were located to the east of the
release point because salt marsh, tidal creeks and the Gulf of Mexico were to the west.
Equipment was available for servicing traps position-
on land or in shallow water only. The
entire procedure was repeated for a second re-
lease on April 16. Approximately 15,000 flies
were marked and released at that time.

Collections were examined using a dissecting
microscope (X12 magnification) and a Black
Ray® model UVL 56 longwave ultraviolet lamp
to detect marked specimens. All marked indi-
viduals were counted and the recapture loca-
tion recorded. The number and sex of un-
marked *C. mississippiensis* were also determined by removing and counting the individuals in a subsample. A petri dish with a grid system was used for the subsample procedure.

The number and location of recaptured specimens were used to determine the mean distance traveled (MDT) by *C. mississippiensis* females. Data transformation prior to determining the MDT was necessary to account for an uneven number of traps/unit area. This method was used previously by Lillie et al. (1981b) and Brenner et al. (1984). The recapture site was divided into subunits to calculate correction factors (CF) for transforming the data. There were 7 subunits radiating out in concentric rings every 0.5 km from the release point to 3.5 km (Fig. 1). The proportion of the total area occupied by each subunit was calculated and the number of traps, based on a total of 20, required for equal trap density through-

Fig. 1. Trap locations and release point for mark-release-recapture studies near Yankeetown, Levy County, FL.
Table 1. Data used to calculate correction factors.

<table>
<thead>
<tr>
<th>Trapping subunit (km)</th>
<th>Number of traps</th>
<th>Area (km²)</th>
<th>Correction factor</th>
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<td><strong>TOTAL</strong></td>
<td><strong>20</strong></td>
<td><strong>38.5</strong></td>
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</table>

out the recapture area was determined. A correction factor for each subunit was obtained in this manner which is summarized in the following formula:

$$\text{CF} = \frac{A_s}{A_t} \times 20$$

where $A_s$ = subunit area and $A_t$ = total trapping area (Table 1).

The number of specimens recaptured/trap in each subunit was multiplied by the corresponding correction factor to derive the number of individuals we would have expected to recover if equal trap density was employed. Transformed data were used to calculate the MDT for the release day and each day postrelease by using the following formula:

$$\text{MDT} = \sum (\text{Expected no. recovered} \times \text{Distance})$$

RESULTS AND DISCUSSION

Of the estimated 25,000 specimens released on April 2, 498 females (=2%) were recaptured (Table 2). A lower percentage (=0.5%) of the 15,000 biting midges released on April 16 were recovered (Table 3). Approximately 1.5% (567) of the marked individuals were recaptured during the entire study. The percentage of flies recovered was less than that observed in a study of C. mojave Wirth (13%) in southern California (Brenner et al. 1984) and more than the percentage of C. variipennis (0.5%) recaptured in Colorado (Lillie et al. 1981b). Usually less than 1% of the number of insects released in a mark-release-recapture study are recovered (Johnson 1969). Culicoides mojave was an exception to this generality because of the desert environment in which it occurs (Brenner et al. 1984). Vegetation and other material that may obscure traps in most areas are lacking in the desert; thus, a high recapture for C. mojave was not unusual.

Movement of C. mississippiensis was neither unidirectional nor limited to a specific distance. Most individuals were taken within 1.5 km of the release point during the first 24-hr, but a single specimen traveled 3.2 km over that period (Tables 2 and 3). The number of individuals recovered beyond 1.5 km increased during the second 24-hr period (i.e., one day postrelease) and they were scattered throughout the recapture area. Heavy rainfall on April 4 (2 days postrelease) prevented trapping on that day and most likely influenced recapture on the following day. Also, data from one trap had to be deleted after the first release because it was contaminated with marking material during preliminary tests and inadvertently placed at a trapping site. Problems relating to weather or equipment were not encountered for the second release.

The dispersal of C. mississippiensis did not appear to be aided by wind. The wind was blowing

<table>
<thead>
<tr>
<th>Trapping subunit (km)</th>
<th>Number recaptured</th>
<th>Total by distance</th>
<th>Transformed data</th>
<th>Total by day</th>
<th>Mean distance traveled (km)</th>
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</tbody>
</table>

* Inclement weather prevented trapping on 2 days postrelease.
Table 3. Number of specimens recaptured, transformed data, and mean distance traveled by *Culicoides mississippiensis* released on April 16, 1984.

<table>
<thead>
<tr>
<th>Trapping subunit (km)</th>
<th>Number recaptured</th>
<th>Total by distance</th>
<th>Transformed data</th>
<th>Total by distance</th>
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</thead>
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<td>6 0 0 0</td>
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</table>

Total by day 23 19 19 8 69 17 21 11 8 57
Mean distance traveled (km) 2.3 2.5 1.6 1.8 2.2

towards the east for about 6-hr following the release on April 2 and gradually shifted to the south. Twenty-five of 61 individuals were obtained in traps located to the west. Wind speed during that time did not exceed 2 m/sec. A single individual travelling 3.2 km to the east in a 24-hr period did so while the wind was blowing south. Brenner et al. (1984) recaptured most marked *C. mojave* in the direction of the prevailing wind; however, one individual dispersed 6 km against the wind in 30-hr. The movement of *C. furens* (Poey) in Panama (Breedland and Smith 1962) and the Virgin Islands (Williams 1962) was also aided by wind.

Observed data for *C. mississippiensis* females were transformed to account for unequal trap density and used to calculate an MDT of 2 km following the first release and 2.2 km for the second release. These distances are comparable to an MDT of 1.94 km for *C. mojave* (Brenner et al. 1984) and 1.89 km for *C. variipennis* (Lillie et al. 1981b). Yankeetown, FL was 2 – 2.5 km east of the release point (Fig. 1). Data obtained from both releases indicate that a sufficient number of biting midges could travel from breeding sites in the salt marsh to cause a nuisance in the residential area. Alternate breeding sites closer to Yankeetown are not a prerequisite for adult activity in that area.

A change in the rate of dispersal was noted as the time postrelease increased. The MDT for the first 24-hr after the release on April 2 was 1.2 km (Table 2). In the second 24-hr, the MDT increased by 0.8 km. The change was even less following the release on April 16 (Table 3); the MDT declined on 2 days postrelease and changed little after that time. This pattern of behavior was most likely the result of omnidirectional flight habits and/or physiological changes.

At the time of their release, individuals could either remain at the release point or move away from it. Some traveled over 2 km on the release night but if subsequent movement was always away from the release point the MDT would have continued to increase. Individuals were more likely to move towards or tangential to the release point as time elapsed. Such movement contributed little towards increasing the MDT. Also, as time elapsed the requirement for a bloodmeal was satisfied. Individuals were no longer attracted to CO₂ and therefore would not be trapped because of behavioral changes. Females were more likely to search for an oviposition site rather than a CO₂ source after ingesting a bloodmeal.

A few marked individuals other than *C. mississippiensis* females were also recaptured. Two males of that species were obtained 0.5 km west of the release point within 24-hr of the release on April 2. No other males were recovered. Male recapture was also rare in prior studies of *Culicoides* spp. The maximum distance traveled by male *C. variipennis* in Colorado was 0.8 km (Lillie et al. 1981b). Males of *C. mojave* were not recaptured in a dispersal study in southern California (Brenner et al. 1984). Poor attraction of males to CO₂ and light traps in general explain these results.

Other marked species represented in the recapture data included 1 *Chrysops fuliginosus* Wied., 4 *Anopheles quadrimaculatus* Say, 2 *Aedes sollicitans* (Walker), 1 *Ae. triseriatus* (Say), and 1 *Culex* spp. All were females. They were available for recapture because no attempt was made to separate *C. mississippiensis* from other species collected in the live-trapping operation prior to marking and release. *Chrysops fuliginosus* was recaptured approximately 0.8 km northwest of the release point following the first release. The mosquitoes were obtained after both releases and traveled 0.5 to 2 km.
from the release point. These species were not collected in sufficient numbers to calculate MDT values.

Unmarked *C. mississippiensis* collected throughout the study were counted and the sexes were separated. A total of 627,560 females and 7,379 males were trapped. The trap index for this species in 140 trap nights (a trap night is equal to 1 trap operated for 1 night) was 4,535. A single trap located in Yankeetown collected approximately 31,565 females during a 24-hr period on April 19. Another trap located adjacent to a breeding site also collected over 30,000 females on the same day. In addition to these specimens, 7 gynandromorphs were attracted to light traps. Such a genetic condition can produce individuals with male genitalia and a female head. They are attracted to CO2 because of female sense organs anteriorly. This type of antero-posterior dimorphism was also observed by Khalaf (1965) for specimens collected in Louisiana and identified as *C. hollensis* (Melander and Brues) but later found to be *C. mississippiensis*. Based on CO2-baited light trap data, the probability of this type of gynandromorph forming in a *C. mississippiensis* population is $1 \times 10^{-5}$. Other gynandromorphs such as those with male sense organs anteriorly were not encountered and were not considered in the above probability estimate.

The MDT for individuals of a pest population can be used to determine the area that must be treated with insecticide to suppress the adult population. Hocking (1953) recommended treating an area equivalent to the square of the MDT for effective control following a single application. Treatment of 4 km² surrounding each breeding site would be needed for *C. mississippiensis*. Large expanses of salt marsh available for larval development near Yankeetown make such an undertaking costly. Therefore, attempting to control the adult population by broadcasting pesticide over a large area should not be performed unless disease transmission is imminent or the quality of human life is deteriorating because of the pest's habits. Alternative methods such as personal protection or scheduling outdoor activities so as to avoid peak periods of biting midge activity are recommended.

**ACKNOWLEDGMENTS**

We thank K. F. Baldwin and N. Pierce, USDA, ARS, for their technical assistance. The residents of Granny's Footprint Island and Allen's Hickory Island are also acknowledged for their friendship during the field project. Dr. G. B. Fairchild identified the *Chrysops fuliginosus*.

**References Cited**


