THE DISPERSAL OF *CULICOIDES MISSISSIPPIENSIS* (DIPTERA: CERATOPOGONIDAE) IN A SALT MARSH NEAR YANKEETOWN, FLORIDA[1]

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ABSTRACT. Of the estimated 40,000 *Culicoides mississipiensis* 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 information 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 periodically 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 CO_2 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 several 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. 1981).

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 CO_2 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 CO_2 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 positioned on land or in shallow water only. The entire procedure was repeated for a second release 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 individuals were counted and the recapture location recorded. The number and sex of un-

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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-

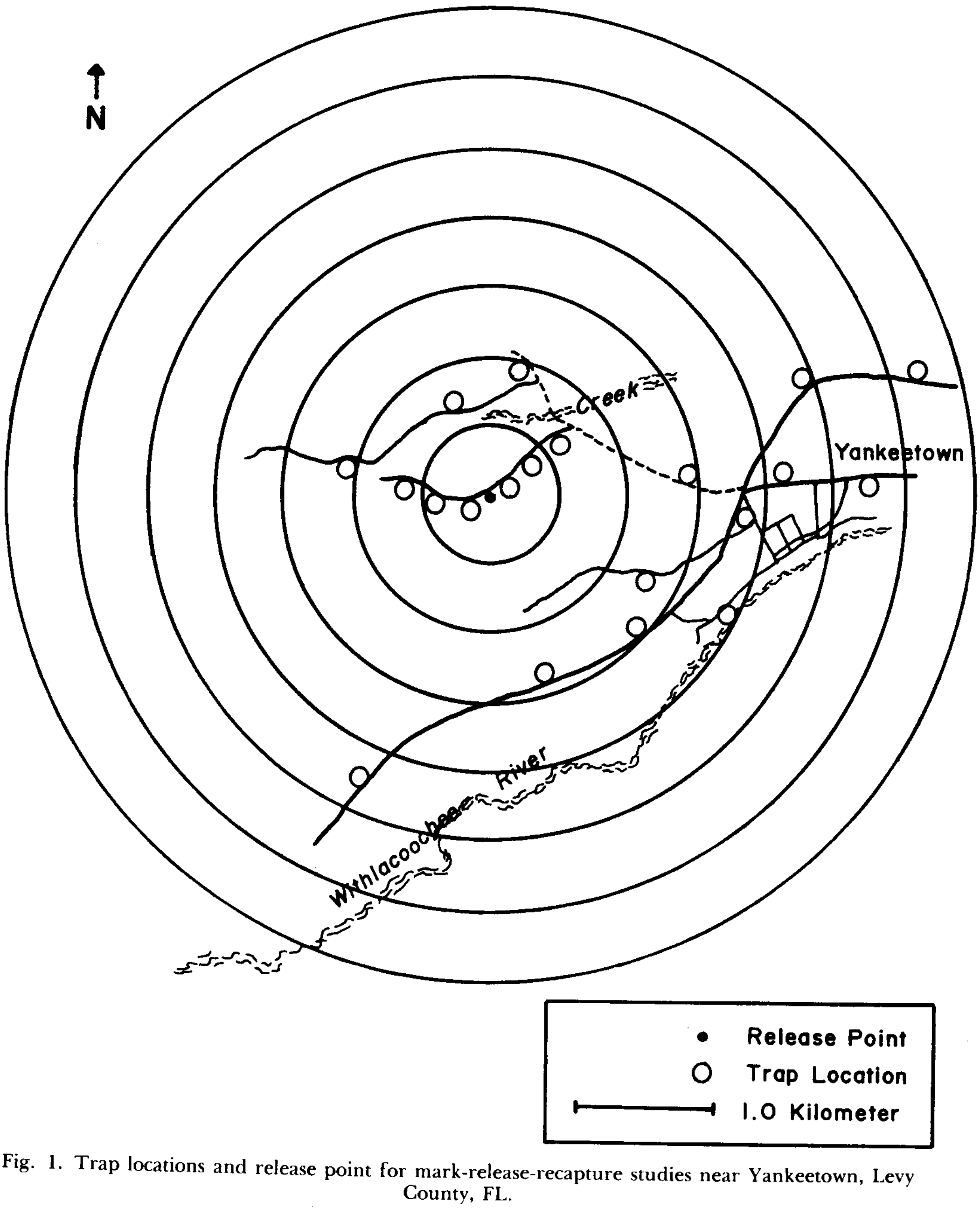

Fig. 1. Trap locations and release point for mark-release-recapture studies near Yankeetown, Levy County, FL.

Table 1. Data used to calculate correction factors.

Trapping subunit (km)	Number of traps	Area (km^2)	Correction factor
0.5	4	0.8	0.42
1.0	4	2.3	1.19
1.5	5	4.0	2.08
2.0	2	5.5	2.86
2.5	3	7.0	3.64
3.0	1	8.6	4.47
3.5	1	10.3	5.38
TOTAL	20	38.5	20

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

$$CF = A_s/A_t \times 20$$

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:

$$MDT = \frac{\Sigma\,(\text{Expected no. recovered} \times \text{Distance})}{\Sigma\ \text{Expected no. recovered}}$$

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 2. Number of specimens recaptured, transformed data, and mean distance traveled by *Culicoides mississippiensis* released on April 2, 1984.

	Day postrelease					Day postrelease				
	0	1	2*	3		0	1	2*	3	
Trapping subunit (km)	Number recaptured				Total by distance	Transformed data				Total by distance
0.5	29	14		3	46	4	2		1	7
1.0	5	11		1	17	2	4		1	7
1.5	27	123		5	155	12	52		2	66
2.0	0	11		0	11	0	16		0	16
2.5	0	257		0	257	0	312		0	312
3.0	0	12		0	12	0	54		0	54
3.5	0	0		0	0	0	0		0	0
Total by day	61	428		9	498	18	440		4	462
Mean distance traveled (km)						1.2	2.0		1.1	2.0

* 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.

Trapping subunit (km)	Day postrelease 0	1	2	3	Total by distance	Day postrelease 0	1	2	3	Total by distance
	Number recaptured					Transformed data				
0.5	0	5	5	2	12	0	1	1	1	3
1.0	0	7	6	0	13	0	2	2	0	4
1.5	21	3	6	3	33	9	2	4	2	17
2.0	0	0	1	2	3	0	0	2	3	5
2.5	1	1	1	1	4	2	2	2	2	8
3.0	0	3	0	0	3	0	14	0	0	14
3.5	1	0	0	0	1	6	0	0	0	6
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 (Breeland 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 CO_2 and therefore would not be trapped because of behavioral changes. Females were more likely to search for an oviposition site rather than a CO_2 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 CO_2 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 CO_2 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 CO_2-baited light trap data, the probability of this type of gynandromorph forming in a *C. mississippiensis* population is 1×10^{-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 km^2 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.

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