NOCTURNAL DISTRIBUTION OF LOUISIANA RICELAND MOSQUITO ADULTS [1, 2]

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ABSTRACT. Nocturnal riceland mosquito populations in southern Louisiana were monitored using nonbaited CDC miniature light traps. A mixed population of *Anopheles quadrimaculatus*, *An. crucians*, *Psorophora columbiae* and *Culex salinarius* adults was collected in a livestock occupied barn. Highly variable numbers of all 4 species were trapped in areas away from the barns. Species density at any given trap location was not related to trap location, type of habitat surrounding the trap or brush density near the trap. Captures of anophelines were not affected by moonlight, whereas trap collections of culicines were lower on moonlit nights. Mean numbers of anophelines captured at night in traps exhibited a linear function of trap distance from the barn, with higher catches at locations farther from the barn. No such function was observed for culicines.

INTRODUCTION

The Louisiana rice-cattle agroecosystem provides an ideal environment for the maintenance of abundant mosquito populations (Andis and Meek 1984, Williams and Meek 1984). Species of particular importance include *Psorophora columbiae* (Dyar and Knab), *Anopheles quadrimaculatus* Say, *An. crucians* Wied. and *Culex salinarius* Coq.

There is little information on the short range (≤1.61 km) distribution, dispersion and resting habitats of adult mosquitoes from the previously mentioned species that occupy the riceland habitat. McAllister and Meek (1991) indicated that the initial dispersal of emergent *Ps. columbiae* adults from fallow rice field habitats in south Louisiana was multidirectional. Horsfall (1942) reported the flight range of *Ps. columbiae* in Arkansas to be as much as 10 km. Weathersbee and Meisch (1990) determined that Arkansas populations of *An. quadrimaculatus* males and females dispersed mean distances of 1.05 and 1.84 km, respectively, from the release point during a 2-day period. Eyles and Bishop (1943) showed that the flight range of *An. quadrimaculatus* in Tennessee can be up to 2.5 miles (4.02 km) over 6 days and noted that flights over 1 km of open water have been reported.

Only a few studies have been conducted to determine adult mosquito resting sites within the riceland agroecosystem. Gahan et al. (1969) observed that adults of *An. quadrimaculatus* in the rice growing region near Stuttgart, AR, were usually found in buildings that housed livestock or had livestock nearby. Holck and Meek (unpublished data) also demonstrated in Louisiana ricelands that during daylight hours *Anopheles* adults were concentrated in buildings frequented by livestock. The same study demonstrated that during daylight periods *Ps. columbiae* adults in pastures were primarily distributed in the immediate vicinity of grazing livestock.

Mosquito species occupying the Louisiana ricelands are primarily nocturnal or crepuscular fliers and feeders. There is insufficient information concerning the nocturnal distribution of these species in relation to blood hosts, adult resting sites (e.g., artificial shelters and vegetation) and larval habitats in Louisiana ricelands. Such information would be useful to organized mosquito control agencies by targeting specific habitats where high densities of mosquito populations exist. This study helps clarify the short range nocturnal dispersion of mosquito adults. It focuses on the relationship of population densities of selected riceland mosquito species to the locations of blood hosts (i.e., primarily cattle) within proximal agricultural lands (i.e., pastures and rice fields) and associated resting habitats (i.e., vegetation and a barn).

MATERIALS AND METHODS

The study was conducted in commercial fields located 10 km south of Kaplan, LA. The study

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site consisted of a 50 ha section of land, bordered on 2 sides by gravel roads and by 4 m wide irrigation canals on the other 2 sides (Fig. 1). A plurality of the land (21.9 ha) was devoted to rice production, with flooded crawfish fields (20.3 ha), fallow fields (1.6 ha) and livestock pastures (6.3 ha) also present. Nearby livestock included sheep (ca. 50), cattle (ca. 5) and poultry (ca. 50). Natural populations of rodents and rabbits were also observed in the study area and were available as blood hosts. An open barn was near the middle of one pasture, as was one machinery shed with no livestock occupants. Two sodium-vapor lamps were exterior to the machinery shed, and one sodium vapor lamp was exterior to a house in the northeast corner of the study site. No other artificial light sources were present. The area immediately adjacent to the study area proper consisted primarily of crawfish fields, rice fields and fallow land. Only the area to the northeast of the study site contained pastures inhabited with livestock.

On each sampling night, 15 CDC miniature light traps (not baited with CO_2), were placed at 250 m intervals on a 3 × 5 grid over the study area (Fig. 1). In addition, 3 traps were placed along the pasture/crawfish/rice interface. Finally, one light trap was placed in the rafters of each of the outbuildings mentioned previously. Sampling occurred over 5 nights in June and August 1988. No rain was noted during the nocturnal sampling periods; however, on one occasion, rainfall occurred shortly after sunrise. Table 1 lists the meteorological conditions for each sampling date. On the morning following each trapping night, the collection bags were

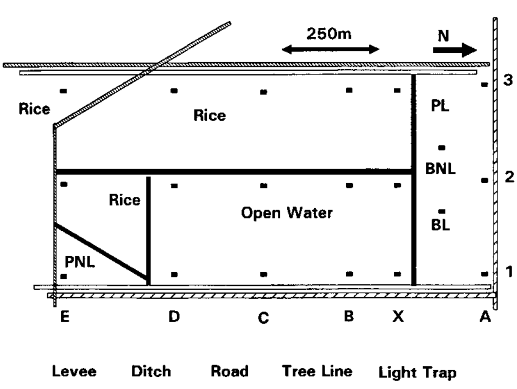

Fig. 1. Schematic map of study site near Kaplan, LA. PL = pasture with livestock; PNL = pasture without livestock; BL = barn with livestock; BNL = barn without livestock.

placed on dry ice and returned to the laboratory. The total number of adult mosquitoes captured in each trap was identified and counted.

Mean catch for each species in each trap was calculated, along with an associated standard deviation. The SAS general linear models (GLM) procedure (SAS 1987) determined the relationship of trap catch to the proximity of blood meal sources and ovipositional substrate for each species. A regression analysis determined the relationship of mean trap catch as a function of distance from any particular location.

RESULTS AND DISCUSSION

Populations of all riceland mosquito species mentioned previously were collected during the course of the experiment. Mean numbers of female *An. quadrimaculatus*, *An. crucians*, *Ps. columbiae* and *Cx. salinarius* and their respective standard deviations are given in Table 2. For each species, trap catches from within the livestock barn were 10 to 100 times higher than from traps exterior to it. The observed standard deviations obtained were very large, indicating much variability exists in the nocturnal distribution of these species.

The largest mean number of trapped females was taken from the livestock barn. However, direct comparison is not valid between light trap catches in the barn to those outside the barn because the barn traps were knowingly in close proximity to a concentrated CO_2 source (i.e., cattle). Carbon dioxide excites mosquitoes and changes the trapping efficiency of a light trap when it is present (Bidlingmayer 1985). Therefore, trap catches from within the barn were deleted from the data set for further analysis. The remaining data were subjected to a SAS general linear models procedure (SAS 1987) to determine the effect of individual trap location, week sampled, habitat surrounding the trap (rice, water, etc.) and nearby presence or absence of dense brush-type vegetation on the number of female mosquitoes captured in any given trap (Table 3). Individual trap location, habitat type surrounding the trap nor brush density were significant ($P < 0.05$) for any of the mosquito species. In addition, no significant ($P < 0.05$) two- or three-way interactions were observed.

When trap catches for female mosquitoes were compared by species among weeks, there were some significant differences. *Psorophora columbiae* and *Cx. salinarius* catch rates were significantly ($P < 0.01$ for both species) higher on the 3 nights with either a <1/4 moon or

Table 1. Meterological parameters applicable to the study site in southern Vermilion Parish, LA, recorded by a field station of the National Oceanic and Atmospheric Administration.

Date	Moon phase	Cloud cover (%)	Sunset[1]	Sunrise
Jun. 9–10	1/4	50	1901	0459
Jun. 16–17	3/4	75	1905	0500
Jun. 23–24	Full	40	1905	0502
Aug. 2–3	Full	0	1854	0519
Aug. 15–16	New	0	1842	0528

[1] All times in eastern daylight savings time.

Table 2. Mean catches ±SD from CDC miniature light traps for *Anopheles quadrimaculatus* (*An. quad.*), *An. crucians* (*An. cruc.*), *Psorophora columbiae* (*Ps. col.*) and *Culex salinarius* (*Cx. sal.*) females.

Trap	*n*	*An. quad.*	*An. cruc.*	*Ps. col.*	*Cx. sal.*
A1	5	0.6 ± 0.9	1.0 ± 1.2	1.3 ± 1.0	1.4 ± 0.9
A2	4	0.3 ± 0.5	0.8 ± 0.5	2.0 ± 2.3	0.4 ± 0.5
A3	5	0.8 ± 0.8	0.6 ± 0.9	1.0 ± 1.2	0.4 ± 0.5
B1	4	0.2 ± 0.4	0.5 ± 0.6	1.0 ± 1.4	2.3 ± 3.9
B2	4	1.3 ± 0.6	0.8 ± 1.0	1.5 ± 0.7	2.0 ± 2.4
B3	5	0.8 ± 1.0	1.8 ± 1.5	5.2 ± 8.4	0.0 ± 0.0
C1	4	0.8 ± 1.0	1.0 ± 1.2	1.3 ± 1.5	1.3 ± 1.9
C2	5	1.0 ± 1.7	1.5 ± 1.7	2.3 ± 2.6	6.8 ± 9.0
C3	5	0.4 ± 0.5	0.8 ± 0.8	1.0 ± 0.8	0.4 ± 0.5
D1	4	1.0 ± 1.4	1.0 ± 0.8	0.5 ± 0.6	2.2 ± 2.9
D2	5	0.7 ± 1.2	1.2 ± 1.3	1.3 ± 1.3	0.4 ± 0.5
D3	4	1.3 ± 0.5	0.7 ± 1.2	4.6 ± 3.3	3.0 ± 3.0
E1	2	0.4 ± 0.4	0.7 ± 0.5	1.4 ± 0.9	0.0 ± 0.0
E2	2	2.5 ± 3.5	2.0 ± 1.4	0.5 ± 0.7	0.0 ± 0.0
E3	4	1.5 ± 1.0	1.8 ± 1.0	1.3 ± 1.9	0.0 ± 0.0
X1	5	0.5 ± 0.6	0.4 ± 0.5	6.3 ± 7.4	7.2 ± 12.3
X2	4	0.0 ± 0.0	0.5 ± 1.0	0.5 ± 0.6	1.0 ± 1.7
X3	3	1.0 ± 1.0	1.0 ± 1.4	3.7 ± 6.4	3.3 ± 4.2
BL	4	95.8 ± 41.2	137.0 ± 67.8	803.0 ± 613.0	67.0 ± 28.8
BNL	4	1.3 ± 1.0	1.7 ± 0.9	3.3 ± 0.9	0.0 ± 0.0

Table 3. Mean square error (MSE), F values and *P* values obtained for *Anopheles quadrimaculatus, An. crucians, Psorophora columbiae* and *Culex salinarius* regarding trap location, type of surrounding habitat and brush density.

	Trap location (61 df)	Habitat type (77 df)	Brush density (79 df)
An. quadrimaculatus			
MSE	1.01	0.14	1.07
F	1.02	1.08	0.73
P	0.45	0.36	0.40
An. crucians			
MSE	1.10	0.08	1.10
F	0.69	0.73	0.61
P	0.79	0.52	0.44
Ps. columbiae			
MSE	10.98	0.67	12.61
F	1.47	0.97	1.18
P	0.15	0.52	0.19
Cx. salinarius			
MSE	15.85	0.14	20.54
F	1.33	1.30	1.85
P	0.22	0.28	0.18

>70% cloud cover than on the others with nearly full moon and <50% cloud cover. Mean catches of either *Anopheles* species were not related to moon phase (*An. quadrimaculatus* $P > 0.15$; *An. crucians* $P > 0.12$).

To test if trap catch was a function of distance from the livestock-occupied barn, a weighted linear regression with weight equal to the number of nights/trap location was performed on the mean female catch data for each species. Once again, trap means from within the barn were deleted. For *An. quadrimaculatus*, a highly significant ($P < 0.01$) linear relationship was observed. Mean catch was found to equal 0.274 plus 0.0011 times the distance (meters) of the trap from the barn. The r^2 value obtained was 0.40. Trap means of *An. crucians* females were also significant ($P \leq 0.03$). Mean catch was determined to equal 0.18 plus 0.0008 times the distance (meters) from the barn. A r^2 value of 0.31 was also noted. Although not particularly large, these r^2 values, in conjunction with the *P* values obtained, indicated that some portion of the variability observed was a function of trap distance from the barn. Neither *Ps. columbiae* ($r^2 = 0.02$) nor *Cx. salinarius* ($r^2 = 0.02$) exhibited significant regressions.

The sampling method employed (i.e., CDC miniature light traps with no CO_2 attractant) served as a satisfactory indicator of overall mosquito population density in the area. Service (1976) reports that the range of attraction for non-CO_2 baited CDC traps is quite short, possibly as low as 5 m. Therefore, it is highly unlikely that any interference among traps was encountered. Bidlingmayer (1985) also notes that catches made with these traps are affected by various meteorological factors. Fortunately, with the exception of moon phase, the selected meteorological factors monitored during this study were reasonably similar during the trapping nights (U. S. Department of Commerce 1988).

The lack of anopheline response in this study to moon phase is interesting. Bidlingmayer (1985) reports on several studies conducted using light traps in which catch effectiveness was lower during full moon periods for *Culex* and *Aedes* populations in Florida. Ribbands (1945) noted that on moonlit nights *An. funestus* Giles tended to enter buildings at greater rates than on non-moonlit nights. These results concur with the observations of Bidlingmayer (1964) on *Ae. taeniorhynchus* (Weid.) populations, which were more active on moonlit nights. Horsfall (1943) observed that light trap catches of *An. quadrimaculatus* responded inversely to increasing moon phase in a 3-year study but made no mention of the presence of any mammalian blood sources in relation to the trap site. Our data indicated, however, that for Louisiana anopheline populations little or no increase or decrease in trap efficiency was attributable to moon phase. Populations of *Ps. columbiae* and *Cx. salinarius* were present and respondent to moon phase. It is possible that the anopheline response is less distinct than the culicine response and was not observed with the sample size utilized.

Nocturnal populations of Louisiana riceland mosquitoes appear to be somewhat variable in distribution. With the exception of large populations of all 4 species in livestock-occupied barns, few other predictable patterns concerning adult mosquito distribution were observed. This is in stark contrast to the results obtained by Holck and Meek (unpublished data) for diurnal distribution patterns of adult mosquito populations in the same study area. Diurnal populations of adult anophelines were endophilic, being concentrated inside livestock shelters. *Psorophora columbiae* and *Cx. salinarius* populations were predominantly exophilic, with populations of the former primarily in livestock-occupied pastures and the latter in rice fields and pastures. Apparently during nocturnal periods this natural habitat partitioning disappears and the distribution of each species largely overlaps. Note that *Ps. columbiae* and *Cx. salinarius* were collected in large numbers inside the livestock-occupied structure, a habitat they rarely employed during the diurnal period.

The observation of a significant linear function with distance from the barn as the dependent variable deserves further discussion. We assume that CO_2 and other livestock-produced odors from the building were responsible for attracting the large mosquito populations observed. Gillies (1980) notes that in still air, CO_2 tends to activate mosquito populations, but little orientation toward the source is possible without wind currents being present. Apparently, the variable 5–10 km/h winds observed were adequate for this purpose. Snow (1983) discussed the range that cattle are attractive to female mosquitoes. Range of attraction was presented as a function of host weight, with a maximum range in the data set analyzed of ca. 130 m. Theoretically, large mammalian blood sources may be detected at a range of a kilometer or more. The data presented previously lend credence to this theory, although it is unknown whether CO_2 concentration or some other emission is responsible for this long range orientation.

A substantial proportion of all 4 pest mosquito populations presumably entered the livestock-occupied building to obtain a blood meal. From a local pest management perspective, it seems that an adequate control approach toward these species might be to apply insecticide treatments to livestock-occupied structures. Several residual insecticides are currently registered and commercially available for this purpose. In addition, some self-treating methods for livestock insect control (i.e., back rubbers or dust bags) also might be useful. This might prove especially effective if a non-repellent insecticide was employed.

The current mosquito control strategy used in these rural areas of Louisiana involves aerial and truck mounted, cold aerosol, ULV insecticide applications over and around rice fields and pastures. The cost-effectiveness of treating a finite number of buildings versus a large open area deserves subsequent study. Coupled with these proposed studies, mosquito control personnel should monitor the susceptibility of localized mosquito populations to the incorporated residual insecticides.

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