COMPARISON OF DIURNAL AND NOCTURNAL *MANSONIA* LARVAL POPULATIONS ON WATER LETTUCE PLANTS

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ABSTRACT. Observations were made in July and September of 1982 and in January of 1983 in Polk County, Florida, to determine differences in the relative abundance of *Mansonia dyari* and *Ma. titillans* larvae on water lettuce plants during day and night. The results showed that during certain times of the year the number of larvae attached to plants during the day was significantly higher than those attached at night. During July and September only *Ma. dyari* was collected, but during January, of 3541 larvae collected 89.5% were *Ma. dyari* and 10.5% were *Ma. titillans*. Members of both species appeared to detach at night in equal proportions. Although large numbers of larvae were detached at night, this study did not reveal their specific location during detachment.

INTRODUCTION

Larvae and pupae of the genus *Mansonia* attach to submerged roots, stems and leaves of aquatic plants by means of modified siphons or trumpets. It is generally believed that this attachment is for obtaining oxygen for respiration from air spaces inside the plant (McNeel 1931, Burton 1959, Laurence 1960, McDonald and Lu 1973). Although several papers have been published on the biology of the *Mansonia* group (including the genus *Coquillettidia*), little is known about the daily habits of the larvae. It is extremely difficult to study these mosquito larvae in their natural habitat because of their habit of attaching to plants below the surface of the water. Bidlingmayer (1968) stated that in the absence of plants *Mansonia* larvae will rise to the surface to obtain oxygen; however, they can remain submerged for several hours. He designed a trap for studying the time of day the larvae would come to the surface after all plant material had been removed from the trap. Under these conditions he found that *Coquillettidia perturbans* (Walker) (as *Mansonia perturbans*) remained submerged for about 5 hr during the day and about 3.6 hr at night. *Mansonia dyari* Belkin, Heinemann and Page (as *Mansonia indubitans* Dyar and Shannon) remained submerged for about 2 hr during the day and 1 hr at night. Although that study showed a difference in diurnal and noctural activity, it did not establish differences in daily activity in the presence of plants.

The present study was designed to determine if larval populations of *Mansonia* were different on water lettuce (*Pistia stratiotes* L.) plants during light and dark periods of the day.

METHODS AND MATERIALS

The study site consisted of an abandoned phosphate mining pit in Polk County near Bartow, Florida, approximately 0.5 ha, that was filled with water and completely overgrown with water lettuce. Each collection consisted of 10 plants collected individually at random from an area of about 2 sq. m extending 1 m from shore; depth of water was about 1 m. Although 10 plants were removed from the same location during each collection period, the space they occupied was filled by the ingression of other plants before the next collection. Collections were made about 2 hr after sunrise (daytime collection) and about 1 hr after sunset (nighttime collection) for 4 consecutive days during 3 periods of the year (July 1982, September 1982 and January 1983); *Mansonia* populations were too low during the spring to conduct a study. The plants were removed rapidly from the pit by hand and placed individually in 8-liter plastic buckets numbered from 1 to 10 in the order the plants were collected. Burton (1959) states that *Mansonia annulifera* (Theobald) rarely detach from water lettuce when collected in this manner. Lounibos and Escher (1983) found in laboratory tests that 95.7% (n = 141) of *Ma. dyari* remained attached to roots while being transferred from one beaker of water to another. To determine if there were larvae present at the water surface, after each plant was collected a one-liter sample of water was taken by partially submerging a jar which was filled with water from the surface. Each sample was numbered in the order collected.

The samples were then taken to the laboratory, the plants were washed over a fine screen that retained the larvae, and the plants were discarded. Larvae were counted and recorded as early (I- and II-), or late (III- and IV-) instars. They were then preserved in 70% ethanol and later identified.

The data were analyzed by 2 different methods. An analysis of variance (ANOVA) was used to determine if there were differences in population levels on the plants during day and

night. Also, a correlation analysis was performed to determine if there was a relationship between early- and late-instar larvae on individual plants. Correlation analysis was also used to determine if the sampling method had affected mosquito populations by causing the larvae to detach due to disturbance of the plants; this was conducted by analyzing the sequential effect of plant removal on larval numbers from each consecutive plant sampled and from each consecutive collection during the 4-day sampling period.

RESULTS AND DISCUSSION

The data from each sampling period reveal that the average number of *Mansonia* larvae found on the water lettuce plants was consistently higher during the day than during the night (Fig. 1; Table 2; the means for the daytime and evening collections, respectively, were 19.4 vs. 4.0 in July, 46.8 and 16.4 in September, and 71.2 and 50.7 in January). Analysis (ANOVA) of the data showed that during July 1982 the number of larvae on the plants during the day was significantly higher than those found at night for both early- ($F = 18.01$; $P \leq 0.0001$) and late-instar ($F = 21.55$; $P \leq 0.0001$) larvae. The ratio (day:night) was 5.0:1 and 4.6:1 for early- and late-instar larvae, respectively. The species composition during that period was 100% *Ma. dyari*.

By September 1982 the density of early-instar larvae on the plants had increased considerably, and again significantly higher numbers were found during the day ($F = 11.25$; $P \leq 0.001$); the ratio was 3.1:1. However, the population of late-instar larvae was about the same as it was during July, and although the same trend was observed, the differences in number of larvae collected from the plants during the day and night were not significant ($F = 2.68$; $P \leq 0.11$). The ratio for the late-instar larvae was 1.6:1. Again, all larvae collected during this period were *Ma. dyari*.

In January 1983 the number of early-instar larvae collected during the day was approximately the same as the daytime collections during September 1982, however, the nighttime collections were higher than in September. The ratio among the early instars during January was 1.3:1, and those differences were not significant ($F = 1.23$; $P \leq 0.27$). The population of late-instar larvae had increased considerably by January. There were 1.7 times more late-instar larvae collected during the day than at night, which was a significant difference ($F = 8.58$, $P \leq 0.005$).

In January a total of 2159 larvae in the daytime collections consisted of 89.5% *Ma. dyari* and 10.5% *Mansonia titillans* (Walker), and 1382 larvae in the nighttime collections contained 89.3% *Ma. dyari* and 10.7% *Ma. titillans*. This indicates that although the total nighttime collections of *Mansonia* larvae during January were 29% less than they were during the day, the 2 species appear to detach in equal proportion. The percentages of early- and late- instar larvae of *Ma. dyari* collected during the day ($n = 1932$) were 64.8 and 35.2%, respectively. The night collections contained 56.2% early- and 43.8% late-instar larvae ($n = 1234$). The only early-instar larvae of *Ma. titillans* collected in January were taken during the day (3.1% early- and 96.9% late-instars; $n = 227$). All *Ma. titillans* larvae collected at night (148) were late-instars.

The average number of *Mansonia* larvae per liter of water collected ranged from a minimum of 0.1 during July to a maximum of 2.0 in September. Data from the water samples were extremely variable, and an ANOVA showed no significant difference between daytime and nighttime collections during any period of the year. Although the data conclusively showed that a large proportion of the larvae were detached from the plants at night they were not collected in the surface water samples. Since the method of collecting water samples may have disturbed any larvae located at the surface, causing them to be missed, further studies are needed to determine the location of the larvae when detached from the plants.

Van den Assem (1958) found that in the absence of plants, selected predators consumed *Mansonia* and *Culex* larvae about equally in number when placed together. However, when water lettuce plants were present with the *Mansonia* and *Culex* larvae, and the *Mansonia*

Table 1. Results of correlation analysis of early- and late-instar *Mansonia* larvae on individual water lettuce plants during July and September 1982 and January 1983.

Date	Daytime collections		Nighttime collections	
	Correlation coefficients	P	Correlation coefficients	P
July 1982	0.767	0.0001	0.573	0.0001
September 1982	0.865	0.0001	0.438	0.005
January 1983	0.407	0.009	0.255	0.1

larvae were attached, the *Culex* were consumed at a much higher rate (6 to 35X, depending on the predator species). This suggests that there is a high degree of protection afforded the *Mansonia* larvae by being attached to plants and remaining motionless except for movement of the mouth brushes.

It is reasonable to assume that detachment of *Mansonia* larvae may be necessary for locating more suitable food sources, and/or for finding a

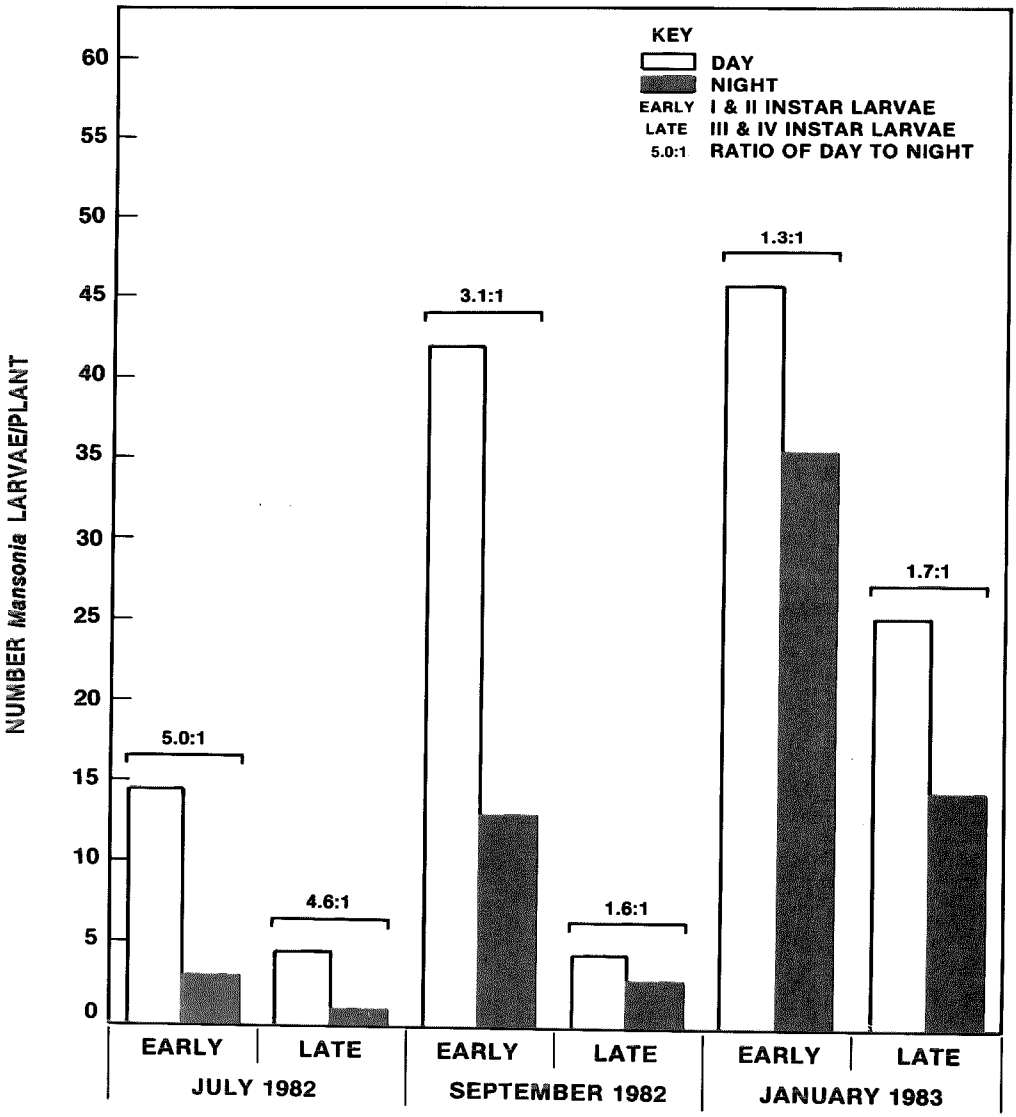

Fig. 1. Daytime and nighttime collections of *Mansonia* larvae on water lettuce plants during July and September 1982 and January 1983 (mean number of larvae per plant).

more favorable oxygen supply. Laurence (1960) observed that newly hatched larvae of both *Mansonia africana* (Theobald) and *Ma. uniformis* (Theobald) do not attach if food is scarce, however, when sufficient quantities of food were available they attached readily. It is possible that other species and other larval instars may behave similarly. The ability of *Mansonia* larvae to remain submerged for extended periods, even in the absence of plants, would allow them to be free-swimming at night in search of more favorable conditions.

Many predators of mosquito larvae detect and attack prey visually, usually in response to movement of the prey, and are correspondingly less efficient at night (van den Assem 1958, Service 1965, Oakley and Palka 1967). Therefore, attached *Mansonia* larvae, being virtually motionless, may not provide as ample a visual stimulus to potential predators as do free-swimming larvae. Also, because of the reduced visibility at night, *Mansonia* larvae may have a high degree of protection against detection by predators when they are detached and free-swimming. Wood (1956) demonstrated that *Chaoborus* larvae migrate from the bottom sediments of an Ontario lake to become free-swimming at night, which might also be an escape mechanism from predation.

A behavioral pattern of nighttime detachment possibly allows *Mansonia* larvae to move away from their previous point of attachment during darkness to seek alternate foraging locations or oxygen sources. The immediate area where they were attached during the day could possibly become depleted of food after dark, and also since plants use oxygen at night the roots possibly contain less oxygen at that time than they do during the day. The larvae may detach to follow daily vertical migrations of zoo- and phytoplankton that constitute their major food source (Dunn 1918, Laurence 1960). The difference in day/night population levels of *Mansonia* larvae on water lettuce were especially great during July for all instars and during September for early instars. Water temperatures (minimum-maximum) during the study were 26–27°C during July, 24–25°C during September and 7–15°C during January. One would expect the larvae to have a higher metabolic rate at those temperatures observed during July and September. The smaller differences that were evident in the day-night collections of late-instar larvae in September may have been due to reduced feeding activity of the larvae in preparation for overwintering.

There were no significant correlations between either the number of larvae per plant and the order in which the plants were collected, except for the late-instar larvae collected at night in January, or the numbers obtained from each of the eight sequential daytime and nighttime collections during the sampling periods. During January there was a significant negative correlation with the number of larvae and the sequential sample number; late-instar larvae decreased in number with subsequent samples. If this negative correlation is real, and not due to test variability, then possibly the true population of late-instar larvae on the plants at night during January was not different from the daytime populations, but only appeared different because some larvae detached during collection. If this is true, the smaller differences during day and night of all stages in January were probably due to the lower water temperatures resulting in lowered metabolic rates and feeding activity, and/or a change in availability of food organisms.

Table 1 shows the results of a correlation analysis of early- and late-instar *Mansonia* larvae on individual plants. A positive correlation existed for both daytime and nighttime collections; i.e., plants with high numbers of young larvae also had high numbers of older larvae. Those correlations were highly significant, except for the nighttime collections made in January, which could have been a result of the negative correlation that existed between the late-instar larvae with sample number.

It is unclear at this time why some plants of the same species seem to be much more attractive to *Mansonia* larvae than others. Table 2 shows the range and the mean number of larvae per plant found throughout the study. These data show the large variation of larvae found on individual plants. Some of the plants had no attached larvae, while others had very

Table 2. Range in number of early- and late-instar *Mansonia* larvae found on individual water lettuce plants (N = 40). Means are shown in parentheses.

Date	Early instars		Late instars	
	Day	Night	Day	Night
July 1982	0– 71 (14.8)	0– 21 (3.0)	0–19 (4.6)	0– 5 (1.0)
September 1982	1–207 (42.0)	0– 39 (13.5)	0–26 (4.8)	0–21 (2.9)
January 1983	3–187 (46.1)	0–180 (36.3)	5–79 (25.1)	0–72 (14.4)

high numbers. However, in general, those plants that had high numbers of one stage also had high numbers of both stages of larvae. This extensive variability is most likely a result of the relative ability of the plant to meet the needs of the attached larvae, i.e., age of plant and its effect on photosynthetic rate and oxygen release, thickness of epidermis and ease of penetration, and root mass as it affects detection of larvae by predators.

It is important that more information be obtained about the larval biology of *Mansonia* mosquitoes. Presently this group is difficult, if not impossible, to control with conventional larvicides because of the inaccessibility of the larvae under the vegetative mat of aquatic plants. However, if the larvae are free-swimming at times, it may be possible to develop techniques and to time applications in such a way as to bring the larvae into contact with larvicides or biological control agents.

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