LARVAL DEVELOPMENT OF *MANSONIA* MOSQUITOES IN CENTRAL FLORIDA[1]

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In Central Florida *Mansonia* (*Coquillettidia*) *perturbans* (Walker) and *Mansonia* (*Mansonia*) *indubitans* Dyar and Shannon are widely distributed. The third species, *Mansonia* (*Mansonia*) *titillans* (Walker) is restricted to the southern part of the state. The work reported here was done in the vicinity of Leesburg and Gainesville, Florida from July (1949) to June of the following year.

Grossbeck (1907, 1908) and Smith (1908) describe the events leading to the discovery of the larvae and pupae of *M. perturbans* attached to the roots of aquatic plants. There is general agreement the type of marsh is more important than the plant species occupying it. McNeel (1932), Gerry (1953) and Hagmann (1953) have reported that marshes with relatively clean, hard bottoms are unfavorable. Adults emerge in early summer in the northern states with a single generation annually, but McNeel (1932) thought this species had two broods in Central Florida. In Central Florida New Jersey light traps may show a slight increase again in the autumn (Provost 1952).

There is little information regarding *M. indubitans* in Florida. Provost (1952), concluded there were broods every 3 months. This species is at its northern limit in Florida, and numbers decline drastically following inclement winters. The larva is attached almost exclusively to water-lettuce.

MATERIALS AND METHODS. The larvae were sampled by means of a trap previously described (Bidlingmayer 1954). Essentially, it consists of a sheet metal cylinder which may be thrust into the bottom of a marsh. The plants within are uprooted, washed, and then discarded. A cone-shaped catching basin is then inserted into the cylinder with the open tip of the cone just beneath the surface of the water. As *Mansonia* larvae rise to the surface for air, plants being lacking, they pass through the open tip of the cone and are retained in the basin. Properly set, the water is clean enough so that even the smaller instars are easily recovered. There is no reason

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to believe the trap does not sample all instars in representative numbers; therefore collections were determined to instar to follow the progress of larval development. The trap samples 1 square foot of marsh and thus is well suited to making population estimates.

Emergence cages were bottomless cages set over host plants with the lower edges submerged. The cages enclosed 4 square feet and were provided with sleeves for access. The concurrent New Jersey light trap data for the Leesburg area were furnished by the Florida State Board of Health from 3 traps operated nightly in Leesburg.

For each larval collection, the water temperature, color, pH and turbidity were recorded. The species and density of aquatic plants were noted while the marsh soil profile was determined with a soil auger.

RESULTS

Mansonia perturbans

1. *Marsh environment.* Larvae were recovered from 18 of 23 species of aquatic plants. The mean number of larvae collected per trap setting is shown, in the following list, for those species extensively sampled. Larvae were taken from *Bidens* spp., *Decodon verticillatus* (water-willow) 75, *Hydrochloa caroliniensis, Hydrocotyle* spp. (water pennywort), *Jussiaea* spp., *Jussiaea peruviana* (primrose willow), *Limnobium spongia* (frog-bit), *Mariscus jamaicensis* (saw-grass) 23, *Myriophyllum brasiliense* (parrot's feather), *Panicum hemitomum* (maiden cane), *Peltandra* spp. (arrow arum), *Pontederia cordata* (pickerel weed) 11, *Piaropus crassipes* (water hyacinth) 4, *Pistia stratiotes* (water lettuce) 7, *Sagittaria* spp. (arrowhead) 62, *Saururus cernuus* (lizard's tail) 51, *Typha angustifolia* and *Typha latifolia* (cattail).

No relationship was found between color, turbidity or pH of the water and density of *Mansonia* breeding within the ranges occurring. Nor was there any direct relationship between height or density of host plants with *Mansonia* numbers, other than where plants were sparse numbers were always low.

High larval numbers were most frequently associated with a marsh profile characterized by a 6–24 inch layer of noncompacted organic material overlying the bottom of the marsh. This layer was usually composed of partially decomposed leaves and stems but occasionally consisted of an organic ooze. The type of substrate, whether sand or peat, showed no influence upon larval numbers.

2. *Effect of temperature and light upon larval activity.* Traps were usually set for 24 hours, but a limited number of collections were made at hourly intervals in September and February to study effect of water temperatures upon the rate of arrival in the traps. The results are shown in Table 1.

During daylight in September (col. 1) larvae took 1 to 8 or more hours before rising to the surface of the water. In these collections 7 percent were 4th instar larvae. The mean and standard error of the mean (SE_M) number of hours the larvae remained submerged was $4.06 \pm .22$, $5.00 \pm .06$ and $3.59 \pm .18$ hours, respectively, for 2nd, 3rd, and 4th instars. The mean number of hours for 3rd instar larvae was significantly greater than for 2nd or 4th instar larvae ($P = < .001$).

Column 2 shows the results when collections were made at night. The mean and SE_M for 3rd instar larvae was $3.30 \pm .08$ hours, which is significantly less than the mean for 3rd instar daylight collections ($P = < .001$).

These tests were repeated in February (col. 3) when only 4th instar larvae were taken. Larvae began to appear in the traps during twilight and the median number of hours' submergence was 12. In the next test the traps were set at 0100, but the first collection was not made until 0900 (col. 4). Numbers were low during the day but began increasing during the afternoon. The largest collection was made during evening twilight. The median number of hours' submergence for larvae here was 18.

TABLE 1.—Number of larvae taken at hourly intervals after trap was set, showing influence of light and temperatures.

Month		September			February			
Water Temp. (°F)		77–78°	75–76°		54–56°	56–59°	54°	59°
Time Trap Set		0830	1830		0900	0100	0900	2000
Species		*M. perturbans*					*M. indubitans*	
Column		1	2		3	4	5	6
TIME 0800								
0900						*		
		4						
1000					0	4	11	
		19						
1100					0	2	16	
		65						
1200					0	3		
		150					11	
1300					0	3		
		176					1	
1400					0	4		
		107					2	
1500					1	6		
		61					1	
1600					0	15		
		42						
1700					0	14		
1800				Sun set	0	21		
	Sun set							
1900					11	93		
			0					
2000					37	53		
			9					
2100					16	12		66
			52					
2200					12			33
			29					
2300					12			2
	DARKNESS		10					
0000					6			1
			2	DARKNESS				
0100					11			0
0200					2			
0300								
0400								
0500								
0600	Sun rise							
0700				Sun rise				
0800						**		
Hours submerged (median)		5	3		12	18	2	1

* Collection at 0900, 8 hours after trap was set, contained 41 larvae.
** Collection at 0800, 11 hours after last collection, contained 4 larvae.
Note: Data in columns 1 and 2 are at hourly intervals on the half hour; in columns 3, 4, 5 and 6 are at hourly intervals on the hour.

3. *Seasonal development.* The number of larvae taken and the proportion of different instars present each month are shown in Fig. 1. Numbers of 1st instar larvae taken were usually small and have been combined here with 2nd instar. The percentage of the yearly catch of the New Jersey light traps is also shown to indicate those months adult numbers are greatest. In winter, low temperatures will reduce flight activity and result in smaller light trap collections.

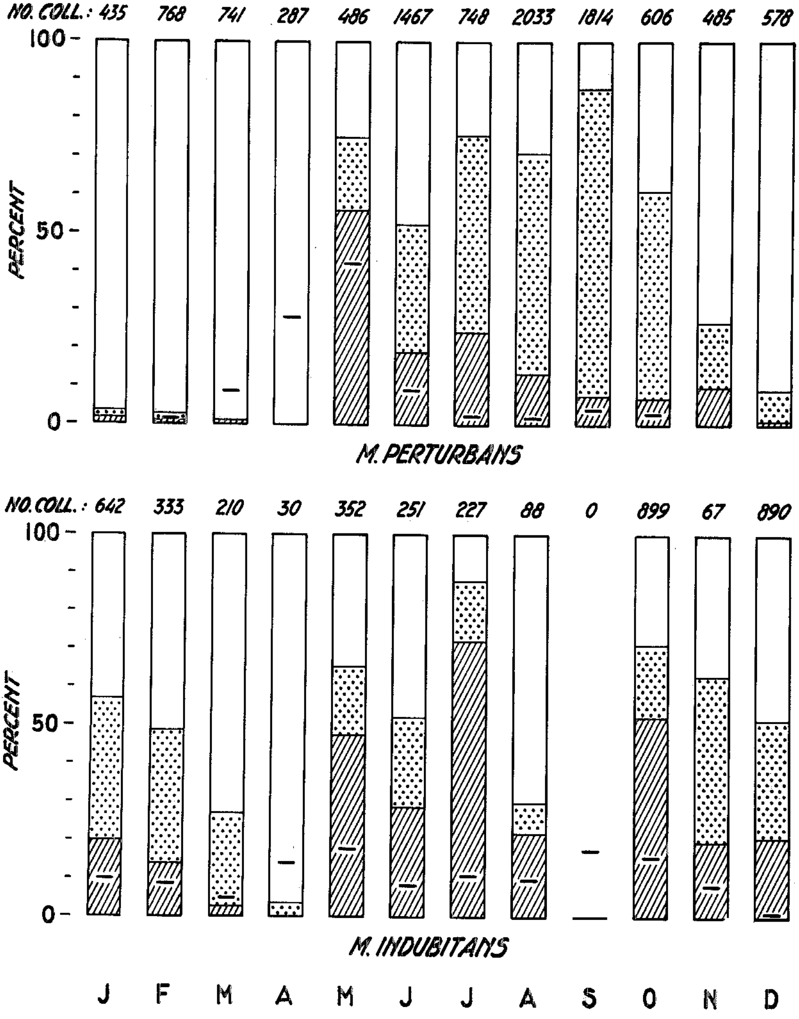

FIG. 1.—Number collected and percentage in different instars during the year for *M. perturbans* and *M. indubitans* (1st and 2nd instar cross-hatched, 3rd instar stippled and 4th instar clear). Also percentage of yearly catch of adults taken in 3 New Jersey light traps.

Adults of *M. perturbans* were virtually non-existent during winter (<1 percent) and larvae were principally 4th instar. The first adults appeared late in February and peak numbers occurred in May. During March and April the larval population was nearly 100 percent 4th instar. The first young larvae of the season appeared in May. Adult numbers declined after May until a slight increase occurred in September. During late summer and early autumn the larval population is predominantly 3rd instar.

Mansonia indubitans

1. *Marsh environment.* Larvae were recovered almost exclusively from water lettuce; two recoveries were from adjacent pickerel weed. Nearly all larvae were taken from two productive marshes, consequently no assessment as to the effect of water color, turbidity, pH or marsh profile with larval numbers can be made. Water lettuce has a bushy cluster of roots just beneath the water's surface and most larvae are attached here. This plant was observed to undergo a slow degeneration as winter progressed. Old leaves turned yellow and died while new leaves failed to attain full size. The root system also degenerated. This had an adverse effect upon larval numbers. The mean number of larvae per trap setting from October to June was 112, 67, 95, 107, 44, 1, 5, 6, and 16, respectively. With the advent of warm weather, plants were small with scanty root systems. Full size was not achieved again until midsummer.

2. *Effect of light upon larval activity.* Table 1 shows the results from larval traps set in February during daylight (col. 5) and after dark (col. 6). The average length of submergence was 2 hours during daylight and 1 hour at night. It is evident *M. indubitans* does not remain submerged nearly as long as *M. perturbans.*

3. *Seasonal development.* Adults of *M. indubitans* were found throughout the year (Fig. 1) with peak numbers in April-May, September-October, and possibly July. First and 2nd instar larvae made up a much greater proportion of the larval population than for *M. perturbans.* During the winter months the proportion of small instars declined with minimum numbers occurring in April. The large proportion of 4th instar larvae in April, June and August, followed by an increase of small larvae in succeeding months, indicate three broods annually. Emergence during the winter is probably dependent upon temperatures.

DISCUSSION

Mansonia perturbans

The roots of most species of marsh plants appear to be satisfactory for larval attachment, provided they are available. Most species have a large number of roots penetrating the detritus freely and loosely tying it together. In the absence of detritus, the plants were rooted in the firm substrate. Thus a plant may be a good host in one marsh but not in another. Arrow-arum and golden club (*Orontium aquaticum*) supported few or no larvae even when growing adjacent to other plants which supported numerous larvae. These two species tend to be deeply rooted with few or no roots in the detritus layer.

Water hyacinth and water lettuce are floating aquatics which possess a bushy mass of roots beneath a rosette of floating leaves. Only a few roots on the larger plants grow sufficiently long to penetrate the detritis layer, and this probably accounts for the small numbers of larvae taken. Occasionally, numbers of *M. perturbans* larvae were taken from dense mats of floating plants of other species. The layer of detritus was of no importance here, and in one area was absent.

Mansonia larvae within a trap cylinder are compelled to come to the surface when their oxygen reserves approach exhaustion. The data in Table 1 indicate these larvae seek the surface sooner during the hours of darkness. At low temperatures the length of time submerged is greatly extended; from 3–5 hours to 12–18 hours. In the first February test (col. 3) the larvae appeared after sunset over an extended period, while in the next test (col. 4), collections began to increase before sunset.

The rapid rate after sunset indicates they were near the end of their endurance. It is probable that at progressively lower temperatures longer times would be required, or even be no movement to the surface at all.

M. perturbans is seen to have a single large brood appearing in April and May. With the advent of autumn there is a very slight increase in adult numbers and subsequently in 1st and 2nd instar larvae (Fig. 1). McNeel (1932) reared *M. perturbans* to adulthood from eggs in an enclosure in a swamp in about 3 months.

It was noted that the proportion of 4th instar larvae shown for June appears too great; it is greater than for May or any of the 4 months following. It will be recalled that the study period embraced from July to June, and thus these months belong to different years. However, the only area sampled in June was an impoundment nearly covered by a luxuriant growth of a floating aquatic, frog-bit, which received sewage effluent. The water literally teemed with a variety of tiny invertebrates.

Earlier, during February and March, emergence cages had been placed in a pickerel weed marsh to establish the adult emergence rate prior to the main emergence. These cages gave an estimate of 9 *M. perturbans*/ft^2 while larval traps indicated a population of 19.6/ft^2. In June, the emergence cages over frog-bit in the impoundment indicated a population of .5/ft^2 while the larval trap showed 70.5/ft^2, nearly 50 percent being 4th instar. If these 4th instar larvae had overwintered, a high adult emergence rate would be expected, inasmuch as the peak of emergence was past. If these 4th instar larvae had developed from the spring oviposition, but were still too young to pupate and emerge, it must be concluded a very rapid rate of development was achieved. The larvae were close to the water's surface and therefore exposed to higher temperatures as well as an enriched medium. As it seems unreasonable to expect these young 4th instar larvae to remain in this stage until the following spring, these larvae probably emerge during the autumn.

In the more usual marsh, the proportion of *M. perturbans* larvae found near the surface of the water is small. However, conditions for growth here may be superior to those below, developmental time may be shortened, and result in a second brood.

Mansonia indubitans

The degeneration of water lettuce may not be due entirely to cool weather, as Dunn (1918) observed the same phenomenon in the Panama Canal Zone during the dry season. Although the light trap data presented do not show this, spring broods are usually smaller than fall broods. With few suitable host plants available, the progeny of the spring brood probably have slender chances of survival. The survivors produce the small July emergence and, as the host plant is now rapidly recovering, lay eggs resulting in the large fall emergence. Synchrony is lost during the winter, emergence and oviposition depending upon temperature. This species probably tends to be a continuous breeder but weather and its dependence upon water lettuce result in synchronizing production.

While Table 1 shows *M. indubitans* probably rose to the surface more rapidly at night than during the day, the higher water temperature may have contributed to this result. As this species lies close to the surface where light intensities are high, negative phototaxis would not be expected to be strongly developed. When transporting larvae in jars, it was noted this species drowns much more easily than *M. perturbans*.

Ths study was made in an area where *M. perturbans* is near the southern limit of its range and *M. indubitans* its northern limit. The larvae of these two species have extensive ecological and behavioral differences, which are even indicated by their appearance. The former is pale green or white, thick-bodied and sluggish, while the latter is brown, slender and active. *M. indubitans* occurs near the surface where the levels of dissolved oxygen, temperatures and light are high and phyto- and zooplankton abundant. *M. perturbans* is found primarily deep within the detritus layer where all these are low and thus occupies a comparatively impoverished environment. This environment may have contributed to the development of lethargic movements and an extended life cycle. The more rapid development of *M. perturbans* larvae when near the surface would support this view.

SUMMARY

The use of a trap for *Mansonia* larvae made it possible to collect smaller instars to follow the progression of broods and also make quantitative evaluations of larval densities in different marshes. Environmental factors were investigated and also the effect of temperature and light upon submergence time. The annual life cycle was studied by comparing light trap data with the proportion of different larval instars present each month. *M. perturbans* was found to have one large brood emerging in the spring and a partial brood emerging in the fall. It is suggested that larvae living near the surface develop more rapidly and produce a second brood. *M. indubitans* has large spring and fall emergences with a smaller one in July.

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