MOSQUITOES ASSOCIATED WITH WATER LETTUCE
(PISTIA STRATIOTES) IN SOUTHEASTERN FLORIDA

L. P. LOUNIBOS AND R. L. ESCHER
U. of Florida, IFAS, Florida Medical Entomology Laboratory
200 9th St. SE, Vero Beach, FL 32962 USA

ABSTRACT

Emergence traps monitored weekly for three years were used to describe the mosquito fauna associated with water lettuce and their abundances and phenology in a drainage canal and a borrow pit in St. Lucie County, Florida. *Mansonia dyari*, *M. titillans*, and *Culex erraticus* accounted for, respectively, 89.7%, 6.2%, and 1.5% of 45,932 adult specimens identified. Eleven other mosquito species were regarded as incidental. Spring emergences of *M. dyari* and *M. titillans* were followed by several overlapping generations between May and December. A decrease in emergence of these species during January and February was associated with colder water temperatures and plant mortality. The proportions of *M. dyari* and *M. titillans* emerging in traps and occurring as larvae on water lettuce roots were similar, but females of the latter species were captured relatively more often at a blood source.

RESUMEN

Trampas de salida, inspeccionadas semanalmente por tres años, se usaron para describir la fauna de mosquitos asociados con la lechuga de agua y su abundancia y fenología en un canal de drenaje y en un foso en St. Lucie County, Florida. *Mansonia dyari*, *M. titillans*, y *Culex erraticus* componen el 89.7%, 6.2%, y 1.5% respectivamente de las 45,932 muestras de adultos identificados. Otras once especies de mosquitos fueron consideradas como incidentales. Las salidas primaverales de *M. dyari* y *M. titillans* fueron seguidas por varias generaciones solapadas entre mayo y diciembre. Una reducción en la salida de estas especies durante enero y febrero se asoció con temperaturas de agua más fría y con la mortalidad de plantas. Las proporciones de *M. dyari* y *M. titillans* obtenidas en las trampas eran similares a las de sus larvas en las raíces de lechuga de agua, pero hembras de la segunda especie se capturaron relativamente con más frecuencia en una fuente de sangre.

Water lettuce (Pistia stratiotes) is abundant in the tropics and subtropics where it may overgrow lakes and slow-moving waterways (Tarver et al. 1978) and concomitantly provide substrate for a diverse fauna of aquatic invertebrates (Dunn 1984). The growth and reproduction of this aquatic macrophyte in the Afrotropical region has been investigated by Chadwick and Obeid (1966), Hall and Okali (1974), and Okali and Hall (1974). In subtropical Florida, growth of water lettuce is seasonal, declining in late autumn and winter and increasing in the spring (Odum 1957).

Diptera were the most abundant of aquatic invertebrates associated with *P. stratiotes* in West Africa (Petr 1968). Some of the Diptera, including several species of mosquitoes, seem to be specifically associated with this host plant (Macfie and Ingram 1923). Larvae and pupae of the mosquito
genera Aedevomyia, Ficalbia, and Mansonia attach themselves to the prolific root systems of P. striatiotes. Mansonia (Mansonioidea) vectors of human filariasis in India are stated to prefer water lettuce for attachment (Tyengar 1938).

Two species of Mansonia (Mansonioidea) are abundant near freshwater in southern Florida. Although major pests and potential transmitters of human pathogens, M. dyari and M. titillans have been subjects of only limited light trap surveys and a few larval samples from P. striatiotes (Bidlingmayer 1968, Provost 1976). No data are available to describe the abundances and seasonality of Mansonia emergence. The present study was undertaken to remedy this deficiency and subsequently was extended to describe all culicid fauna emerging from a water lettuce habitat.

SITE AND METHODS

Two man-made freshwater habitats in St. Lucie County, Florida were chosen for their accessibility and overgrowth with a relatively pure culture of P. striatiotes. A drainage canal, approximately 15 meters X 428 meters, near Indrio (27.5° N, 80.5° W) was studied from Jan. 1981-Dec. 1983. Adult mosquitoes emerging from a 7.4 ha borrow pit 4 km SW of Indrio were sampled between April and December 1983. At both sites, occasional cattails (Typha), primrose willows (Ludwigia), and water ferns (Azolla) occurred, but these aquatic plants were excluded from the emergence traps.

Two pyramidal emergence traps each covering a surface area of 4 m² were maintained 50-100 m apart at each site. Traps sampled ca 0.1% and 0.01% of the surface areas of the drainage canal and borrow pit, respectively. The trap design and concentrating devices conformed to model WEEK of LeSage and Harrison (1979). Collection bottles were changed weekly whereupon traps were cleared of observable aerial and terrestrial predators, mainly odonates and arachnids.

At 6- to 8-week intervals, traps were repositioned over different water lettuce plants to compensate for the possible depletion of insect fauna under the enclosure and the insulating effects of the trap on plant growth. This time interval was selected because Mansonia mosquitoes required at least six weeks to complete larval and pupal development in laboratory conditions that most closely resembled the temperatures and densities experienced in Florida (Laurence 1960). Although the screened enclosures protected P. striatiotes from full solar radiation in the summer and from cold during the winter, there were no indications that this affected mosquito attachment.

On several occasions Mansonia larvae and pupae were dislodged from uprooted P. striatiotes by shaking plants vigorously five times in a 20-liter bucket containing tap water. Detached larvae and pupae were separated visually in the laboratory from detritus and identified by species and instar in enamels pans under strong light.

Blood-seeking adult mosquitoes were captured in cylindrical ‘lard-can’ traps (Service 1976) hung in vegetation on the periphery of the drainage canal. Traps were suspended overnight with young chickens as bait. Adult mosquitoes from bait traps and immature stages from roots were identified with conventional keys (Carpenter et al. 1946).
RESULTS

Fourteen species of mosquitoes were identified from 45,982 specimens captured in emergence traps placed over water lettuce (Table 1). Three species, *Mansonia dyari*, *Mansonia titillans*, and *Culex erraticus* accounted for, respectively, 89.7%, 6.2%, and 1.5% of all identifications, and the remaining eleven species were regarded as relatively incidental. There were no departures between years or sites in the rank order of abundance of the three commonest species, with the exception that *Culex nigripalpus* replaced *C. erraticus* in third place at the borrow pit.

The seasonal pattern of emergence of *M. dyari* consisted of a spring brood in March or April, a brief respite, followed by nearly continuous emergence between May and December (Fig. 1 and 2). Emergence was most depressed during January and February when water temperatures were coldest and some *P. stratiotes* died. Surface water temperatures (range: 10.5°-27° C), measured mid-afternoons when the trap was inspected, and the weekly numbers of *M. dyari* adults captured in trap one were positively correlated in both 1981 (r_s=0.4913, p<0.001) and 1982 (r_s=0.0496, p<0.01).

The pattern of *M. dyari* emergence was consistent between traps (Fig. 1 and 2), suggesting that the results describe the average phenology at the canal. The peak spring emergence occurred in March in both 1981 and 1983 but was delayed until April in 1982.

An abrupt conclusion of emergence in August 1983 (Fig. 1 and 2) was associated with prominent mortality of *P. stratiotes* in the study canal. Water salinity measured with a hand-held refractometer was 5 ppt (Fig. 1), far in excess of the tolerance level for *P. stratiotes* (Haller et al. 1974); previous measurements in this same canal had not exceeded 1 ppt. Ap-

<table>
<thead>
<tr>
<th>TABLE 1. MOSQUITO SPECIES AND NUMBERS OF ADULTS IDENTIFIED FROM EMERGENCE TRAPS ON WATER LETTUCE IN ST. LUCIE COUNTY, FLORIDA, 1981-1983.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage Canal¹</td>
</tr>
<tr>
<td>1981</td>
</tr>
<tr>
<td><strong>Mansonia dyari</strong></td>
</tr>
<tr>
<td><em>Mansonia titillans</em></td>
</tr>
<tr>
<td><em>Culex erraticus</em></td>
</tr>
<tr>
<td><em>Culex nigripalpus</em></td>
</tr>
<tr>
<td>Anopheles crucians</td>
</tr>
<tr>
<td>Coquillettidia</td>
</tr>
<tr>
<td>perturbans</td>
</tr>
<tr>
<td>Uranotaenia lowii</td>
</tr>
<tr>
<td>Uranotaenia</td>
</tr>
<tr>
<td>sapphirina</td>
</tr>
<tr>
<td>other species⁴</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
</tr>
</tbody>
</table>

²Few mosquitoes recorded after August 1983 due to extensive *P. stratiotes* mortality.
³Sums from two traps April-Dec. 1983.
Fig. 1. The seasonality of emergence of *M. dyari* in one trap placed on water lettuce in the drainage canal Jan. 1981-Dec. 1983. Asterisk marking 5 ppt identifies a salinity reading in August 1983.
Fig. 2. The seasonality of emergence of *M. dyari* in a second trap on water lettuce in the drainage canal May 1981-Dec. 1983.
parently leakage had occurred through the dike separating this canal from the brackish Indian River.

In a nearby borrow pit, mosquito emergence from water lettuce persisted during this period (Fig. 3), confirming that the sudden disappearance of water lettuce and *M. dyari* from the drainage canal in August 1983 was a local event. Emergence of *M. dyari* was relatively uninterrupted between April and Dec. 1983 at the borrow pit. As at the drainage canal, traps differed in absolute numbers of *M. dyari* captured, but the peaks and valleys in the pattern were congruent between traps.

The phenology of emergence of *M. titillans* at the drainage canal did not differ appreciably from the more abundant *M. dyari* (Fig. 4). Peak spring emergence of both species occurred in March 1981 and 1983. The autumnal emergence of both species persisted later into 1982 than in the previous year.

Three methods of collection of *Mansonia* were compared at the drainage canal. Ten *Pistia* plants, each with 13 to 21 leaves, the longest leaves 20.3 to 25.4 cm from base to tip, were uprooted and all larvae and pupae dislodged by shaking. A mean of 205.4 ± 110.6 (SD) *Mansonia* larvae and pupae were extracted per plant. An aliquot (range 19-61) of fourth instar larvae from each plant was identified to species. Of 428 larvae, 97.4% were *M. dyari* and 2.6% *M. titillans*, quite similar to frequencies of the two species in emergence traps during the same time period (Table 2). Thus, adults

![Graph showing the seasonality of emergence of *M. dyari* in two traps on water lettuce in a borrow pit, April-December 1983.](image-url)
Fig. 4. The seasonality of emergence of *M. titillans* in two traps on water lettuce in the drainage canal Jan. 1981-Dec. 1983. Trap 2 was not operative until May 1981.

Identified from emergence traps provide a relatively unbiased indicator of the relative abundances of their immature stages developing below.

Chicken-baited lard-can traps, set overnight on 8 occasions along the periphery of the drainage canal, captured 3998 *Mansonio* females, of which 78.3% were *M. dyari* and 21.7% *M. titillans* (Table 2). The difference in relative incidence of the two species at a blood source compared to frequencies on nearby water lettuce might indicate that either *M. titillans* is more strongly attracted than *M. dyari* to the chicken bait, or that the bait lured *M. titillans* from a source other than the drainage canal.

<table>
<thead>
<tr>
<th></th>
<th>Number identified</th>
<th><em>M. dyari</em></th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fourth instar larvae from 10 <em>P. stratiotes</em></td>
<td>428</td>
<td>97.4</td>
<td>2.6</td>
</tr>
<tr>
<td>Adults from 2 emergence traps</td>
<td>2,143</td>
<td>99.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Adults from 4 &quot;lard-can&quot; bait traps</td>
<td>3,993</td>
<td>78.3</td>
<td>21.7</td>
</tr>
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</table>

**DISCUSSION**

The observed depression in emergence of *M. dyari* and *M. titillans* in January and February agrees with the observations of Bidlingmayer (1968) and Provost (1976) who likewise associated the hibernal decline with colder water temperatures and die-off of *P. stratiotes*. The dependence of these species on a floating macrophyte subject to seasonal mortality distinguishes them from the third *Mansonia* (s.l.) in Florida, *Coquillettidia perturbans*, whose larvae, protected by the roots of submerged macrophytes, undergo an obligate winter diapause (Lounibos and Escher 1983).

Earlier studies concluded, and the present investigation confirms, that *M. dyari* is multivoltine in Florida. However, the evidence presented here does not corroborate a small spring brood and a depression in emergence in July, as indicated by Bidlingmayer's (1968) observations in Leesburg, Florida.

Light trap data previously suggested, as confirmed here, that the phenology of *M. titillans* resembles that of *M. dyari*. Other observers also recorded *M. titillans* as less abundant than *M. dyari* in trap collections, although the former species occurred in some localities where *P. stratiotes* was scarce (Provost 1976, Carpenter and LaCasse 1955).

The third commonest mosquito, *C. erraticus*, emerging from water lettuce is known to prefer vegetated aquatic habitats (Carpenter and LaCasse 1955). Several related species of *Culex (Melanoconion)* from the neotropics are known for their close association with *P. stratiotes* (Gorgas Memorial Laboratory Annual Report 1978).

During peak emergence periods at the borrow pit, 641 to 1128 *M. dyari* trap/week were recorded (Fig. 3). If these densities are representative over the 7.4 ha pit uniformly covered by *P. stratiotes*, then 1.2 to 2.1 X 10^7 *M. dyari* adults were emerging from this habitat during weeks of maximum productivity. Collection data from the drainage canal (Figs. 1 and 2) demonstrate that these high densities of emerging *M. dyari* are not unique. In fact, emergence traps may underestimate true mosquito densities due to predation within enclosures.

Although *M. dyari* is not noted for questing human blood, the sheer abundance of this species in association with water lettuce increases its potential as a human pest and disease vector. In Bayano Lake, Panama,
M. dyari became a primary link in the transmission of St. Louis Encephalitis (SLE) virus in an impoundment with proliferating P. stratiotes (Gorgas Memorial Laboratory Annual Report 1978). SLE is the commonest arbovirus affecting humans in Florida, where C. nigrripalpus is regarded as its principal vector to man (Provost 1969). Where water lettuce is abundant, it is not unlikely that M. dyari could play a role in enzootic cycles of SLE transmission.

ACKNOWLEDGEMENTS

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REFERENCES CITED


Okali, D. U. U., and J. B. Hall. 1974. Dieback of Pistia stratiotes on
SUSCEPTIBILITY OF THE FALL ARMYWORM, SPODOPTERA FRUGIPERDA, TO THE FUNGAL PATHOGENS PAECILOMYCES FUMOSO-ROSEUS AND NOMURAEA RILEYI

N. K. MANANIA AND J. FARGUES
Station de Recherches de Lutte Biologique, I.N.R.A.,
La Minière 78280 Guyancourt, France

ABSTRACT

Laboratory bioassays determined the susceptibility of the fall armyworm Spodoptera frugiperda Smith to 6 isolates of Nomuraea rileyi (F.) Samson and to 10 isolates of Paecilomyces fumoso-roseus (Wize) Brown and Smith. Significant differences in first-instar mortality and in time-mortality response were found to exist between the different strains of the 2 fungi. Calculated LT 50 values varied between 2 and 3.7 days for 7 P. fumoso-roseus isolates as compared to 5 and 10 days for the N. rileyi isolates. S. frugiperda caterpillars were highly susceptible to 4 strains of P. fumoso-roseus. The most active pathotype, P. fumoso-roseus nº 32 had a LT 50 value of 2.6 days at the concentration of 3000 conidia/mm² of leaf surface and its LD 50 was 40 conidia/mm² of leaf surface (mortality recorded at 6 days post-exposure). In contrast, the best N. rileyi isolate (nº 5) had a LD 50 value of 400 conidia/mm² of leaf surface. This study demonstrated that P. fumoso-roseus might also have potential as microbial control agent against the fall armyworm.

RESUMEN

La susceptibilidad del gusano cogollero Spodoptera frugiperda hacia 6 aislados de Nomuraea rileyi (F.) Samson y 10 aislados de Paecilomyces fumoso-roseus (Wize) Brown and Smith, fueron determinados por ensayos biológicos en el laboratorio. Se encontró que existían diferencias significativas en mortalidad del primer estadio y en mortalidad a través del tiempo entre las diferentes razas de los 2 hongos. Los valores calculados de LT 50 variaron entre 2 y 3.7 días en 7 aislados de P. fumoso-roseus comparados con 5 y 10 días en aislados de N. rileyi. Las orugas de S. frugiperda fueron muy susceptibles a 4 aislados de P. fumoso-roseus. El patótipo más activo, P. fumoso-roseus no. 32, tuvo un valor de LT 50 de 2.6 días a una concen-