THE INFLUENCE OF THE AQUATIC FERN *SALVINIA AURICULATA* ON THE BREEDING OF *ANOPHELES ALBIMANUS* IN COASTAL GUATEMALA

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ABSTRACT. A field trial was carried out to quantify the observation that the presence of the aquatic fern *Salvinia auriculata* is detrimental to the production of *Anopheles albimanus* by transplanting the fern to natural ponds and sampling larval populations on a weekly basis. Intact mats of *Salvinia* had a marked inhibitory effect on anopheline breeding. Cage tests in the laboratory indicated that the plant can be an oviposition barrier to gravid *An. albimanus*. The suggestion is made that the plant might be considered as a naturalistic vector control measure in certain types of breeding places.

INTRODUCTION

The influence of aquatic plants on mosquito breeding has been observed and studied for many years. It has long been known that the production of *Anopheles quadrimaculatus* (Say) is in most cases limited to waters containing vegetation and flotage. One ecological factor associated with aquatic and semi-aquatic plants which affects mosquito production has been called the "intersection line" by Hess and Hall (1943). They define the intersection line as "the line of intersection between three interfaces, water-air, water-plant and plant-air." These authors found a positive correlation between the amount of intersection line and the number of *Anopheles* larvae per unit of water surface area.

Some aquatic plants are thought to be of value in eliminating mosquito breeding (King et al. 1960). One species of *Chara (C. fragilis)* appears to exert a deterrent effect, although this has not been found with other species of this genus. The bladderworts (*Utricularia*) capture and destroy small aquatic animals, including mosquito larvae. Duckweed *(Lemna)* and similar floating plants *(Azolla* and *Wolffia)* may form such dense mats on the water surface that they act as mechanical barriers to mosquito breeding, although *Anopheles* and *Culex* larvae may be found in abundance when the growth is scattered.

Various explanations have been offered for the deterrent effect of floating aquatic plants on mosquito breeding. Bradley (1932) suggested that floating plants do not provide effective protection for anopheline larvae because their leaves lie on top of the water surface and therefore do not hide the larvae from their enemies in the water. Another factor may be that some floating plants when closely packed together may interfere with the pre-oviposition flight necessary to some mosquito species (Russell et al. 1963). A review of the earlier literature on utilization of aquatic plants as aids in mosquito control may be found in Matheson (1930), and a more recent discussion of plant communities and mosquito production is given by Hall (1972).

In Guatemala, field workers of the National Malaria Eradication Service (SNEM) have observed for many years that the aquatic stages of *Anopheles albimanus* (Wiedemann), the principal malaria vector of the country, are rarely found in otherwise suitable breeding places when the water surface is covered with the aquatic fern *Salvinia auriculata* (Aublet). The growth form of the plant is that of floating rosettes with sessile leaves and roots pendant in the water. Members of this fern genus are widely distributed in the warmer parts of the world, are opportunistic colonizers, and are often considered pests when introduced (Hutchenson 1975).

The field part of this study was done to verify the observations that *Salvinia* growths are detrimental to the production of *An. albimanus* by planting the fern in two natural ponds and measuring larval densities in the ponds during the rainy season of 1980. In the laboratory, cage tests were done with gravid *An. albimanus* females and oviposition containers with and without the fern to see if colonies of the plant could provide an oviposition barrier.

MATERIALS AND METHODS

Two ponds at Finca San Bernardo, Department of Escuintla, were chosen for these trials. This locality is situated in the Pacific coastal plain of Guatemala, near the city of Escuintla. Both natural ponds were known to be prolific breeding places of *An. albimanus*. One pond, named La Montanita, had a surface area of 7,500 m^2, and the other, El Cuchin, had a

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surface area of 612 m². Both ponds were cleared of emergent vegetation by hand labor, and divided approximately in half by the construction of a floating bamboo barrier or fence. One half of each pond was to be a test area and the other half was left as a control. *Salvinia* was transplanted from a nearby natural site by moving 25 m² of the plant to the larger pond, and 15 m² of the plant to the smaller pond. To determine growth rate, weekly measurements were made of the advancing mat of vegetation.

Starting from the time when the test plots were covered by *Salvinia,* weekly larval surveys were carried out for 18 weeks. The survey consisted of 12 dips taken in the part of the pond covered by the plant and 12 dips taken in the section free of the plant. The galvanized metal dipper used had a capacity of 870 ml and was flattened on one side. Two fine mesh screens in opposite sides of the dipper allowed water to drain out without losing the larvae. All third and fourth stage anopheline larvae were collected and identified. The sampling was done by the same person and in the same parts of the ponds each week.

The cage oviposition tests were done in the insectary of the Central American Research Station in San Salvador, El Salvador, with colonized mosquitoes. In each of two tests 200 gravid female *An. albimanus* were placed in a cage 51 × 42 × 75 cm. Two enamelware pans, 33 × 23 × 5.7 cm, were placed in the cage as oviposition sites, one pan with water and *Salvinia,* the other with water alone. Many of the females in all the tests laid eggs. The eggs were easy to see and count in the pan with water alone, but to count the eggs in the plant-covered pan, it was necessary to remove each individual plant and wash it off well before making the count.

RESULTS AND DISCUSSION

Salvinia proved to be a rapid colonizer of the unobstructed surface of the test ponds. Table 1 shows the growth rate of the plant, expressed in terms of percentage of available water surface covered by week after the planting. We found that after the surface was completely covered, the mat could be kept healthy and intact by harvesting or raking out approximately 5 m² of the plant each week. Otherwise, the plants tended to pile up around the edges and die in small patches, leaving open water.

Figure 1 shows the results of the weekly larval sampling in the two ponds with their respective controls. Although the presence of *Salvinia* did not completely suppress *An. albimanus* breeding, there was a marked difference in anopheline production in the fern-covered and fern-free portions of both ponds. This suppression of breeding did not hold for culicine species, since high larval densities of culicine mosquitoes, mostly *Aedomyia squamipennis* (Lynch Arribálzaga) were found among the *Salvinia* colonies every week of the trial. This finding also indicates the absence of toxin or metabolic by-product produced by the fern which would be harmful to mosquito larvae in general.

Table 1. Growth rate of *Salvinia auriculata* in two experimental ponds in coastal Guatemala.

Weeks after planting	Percent of pond surface covered	
	Pond El Cuchin	Pond La Montania
1	7.3	3.6
2	15.3	10.7
3	36.5	13.7
4	93.0	26.1
5	100.0	53.6
6	—	66.6
7	—	92.6
8	—	100.0

Table 2 gives the results of cage oviposition trials. When gravid female *An. albimanus* were placed in a cage with two types of oviposition containers, one with and one without *Salvinia,* most of the eggs were deposited in the plant-free container. Studies of the normal oviposition behavior of *An. albimanus* were made by Earle (1932), who observed that females oviposit at night on the surface of the water while standing on it. *Salvinia* plants when present in a dense colony do cover much of the water surface, and simple mechanical obstruction could interfere with egg laying. This phenomenon has been reported in studies of other anopheline species. Cage tests with *An. darlingi* (de Zulueta and Bates 1948) showed that females respond to certain surface features in selecting sites for deposition of eggs. When the water in a pan was barricaded by glass tubes that had been placed vertically, in a manner similar to emergent vegetation, females tended to avoid the pan and chose an unobstructed one. A similar reaction was displayed when the surface was

Table 2. Cage oviposition tests with colonized *Anopheles albimanus* using containers with and without *Salvinia auriculata.*

Test no.	No. Gravid females	Eggs deposited	
		Plant-covered water	Plant-free water
1	200	0	1000+
2	200	0	1000+
3	200	45	800

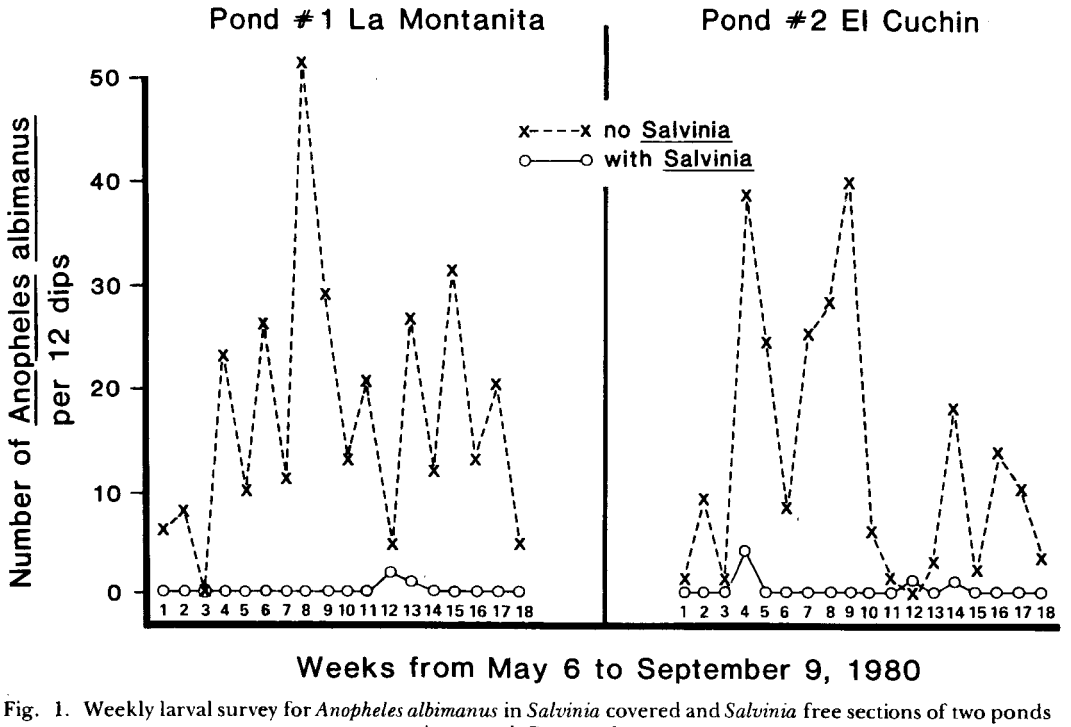

Fig. 1. Weekly larval survey for *Anopheles albimanus* in *Salvinia* covered and *Salvinia* free sections of two ponds in coastal Guatemala.

broken by flat strips of floating wood. In studies of *An. gambiae,* Muirhead-Thomson (1946) found that mechanical obstruction, as represented by emergent vegetation, deterred oviposition in proportion to the density of the vegetation. Russell and Rao (1942) observed the oviposition behavior of *An. culicifacies* in India and found that mechanical obstruction interfered with the oviposition dance of the adult.

In this study we did not examine the other environmental characteristics of water covered by *Salvinia* which could also contribute to the inhibition of anopheline breeding. Other factors might include a diminished intersection line, chemical changes in the water, larger predator populations in plant-covered water, and reduced phytoplankton populations caused by the shading effect of the plant. Our primary objective was to test the efficacy of the plant as a naturalistic anopheline control measure in the field. We believe that the detrimental effect of *Salvinia* on anopheline production could be taken advantage of in some integrated malaria control programs, in areas where the plant grows naturally, by transplanting the fern to selected permanent breeding places that cannot be dealt with by drainage or filling, and where the use of larvicides is not practical. Intact mats of *Salvinia* inhibit the growth of other aquatic plants, and in our experience, *Salvinia* by itself does not provide a good oviposition substrate for *Mansonia* species.

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