STUDIES OF THE MALARIA PROBLEM IN PORTO RICO

PAPER VI

VEGETATION

In the regions in which malaria is the greatest problem in Porto Rico and in fact in the entire Island there are no jungles or regions with dense tall vegetation. The problem lies where land is already under cultivation or cultivation has been attempted and failed, and where the land is overgrown with reed and grasses. There are also extensive mangrove swamps.

Grasses.

It has already been stated in this report that the most favorable conditions were present in ditches with grassy margins or with debris. No attempt has been made to differentiate the grasses though it would seem at times as though heavier breeding was found more commonly with certain varieties. These grasses do not grow well in the region next to the ocean where salt concentration is high, nor in the mangrove swamps.

It is in the ditches and larger water courses as well as ponds that the grasses are abundant and apparently afford protection for anopheles larvæ. Where a ditch is left undisturbed the grasses soon fill it more or less completely, producing a thick mat over which one can often walk with safety. As soon as the ditch tends to approach this condition albimanus larvæ are not found in great abundance if at all.

Growth of all plants is very rapid and in three to four weeks after an average cleaning, vegetation has usually returned more or less to its former state unless cane has reached such a height that considerable shade is produced. The grasses present one of the biggest problems in controlling mosquitoes.

Ceratophyllum dermersum—Hornwort.

Next to the grasses this plant was probably more commonly associated with anopheline breeding than any other. In fact it was probably more commonly associated with breeding than the grasses but not having universal distribution of the grasses it was not of such great importance.

It was most commonly found in the large drainage ditches, bayous

and rivers where in a comparatively short time, if floods did not occur, extensive mats were formed at times to the extent of completely filling a water course. The plant apparently was capable of thriving in very deep (ten to fifteen feet) channels. The small spiny whorls stick up just above the surface of the water and the large mats provide extensive areas of comparatively stagnant water with protection from fish, etc., in the middle of streams which may have a comparatively strong current.

In the Manatí River, which is quite large with current and considerable wave action, breeding in any quantity was practically restricted to the mats of this plant. One can appreciate how the breeding area is increased by the extension of these mats across the surface of a stream or bayous when ordinarily breeding would only be found on the edges. The mats destroy wave action, the effect of tide and current, and afford protection from fish, even though at times the young of Dormitator masculatus are commonly found penetrating throughout it. It has also been suggested that there are other factors as the pronounced production of oxygen by this plant which may make conditions unusually favorable. The small spines just sticking above the water may form a more convenient support for mosquitoes during ovisposition.

Breeding in large channels, rivers, and bayous was more commonly found in association with this plant than under any other condition. As a rule only a few weeks are necessary after its removal for it to return to its former condition. In case of floods, however, apparently the plant as a whole is more often carried off and it is then a long time before the plant again appears in large numbers.

Algae.

Much has been written in a general way about the relation of algæ and anopheline breeding. One gains the impression in reading Greene's reports that as long as algæ were present anopheles larvæ were sure to be found. It was Johnson's observation in this study that algæ were not at all necessary for breeding to take place nor could it be stated that the presence of algæ prohibited the growth of larvæ.

There are so many varieties of algæ, and each one often exists in various states, that it is difficult to generalize on the subject. An attempt was made to identify a few of the more common forms but this was found to be difficult. Of the algæ, *Spyrogyra* seemed to be more commonly found with breeding than many of the others, but there were times when areas with this algæ presented an appearance

indicating death of the plant, as shown by brownish-yellow color, and in these areas breeding was generally quite light.

A large dark-green, almost black, alga—*Oscillatoria princeps*—was also found in abundance in certain regions. It would often be seen covering the bottom of a ditch and later extending to the surface. As small mats were formed they would break loose and pass down stream. Small streams would be partially covered by these floating masses, each mat varying from a few inches to a foot in diameter. This alga seemed to have periods of greater activity and would be found at times covering all vegetation in the water course. At times where water became stagnant a foul odor was produced and in these areas it was rare to find albimanus larvæ.

Of all the areas examined, it could be stated with certainty that anopheles larvae were not commonly found in water deposits with this alga, though anopheline were found here and there in association with it.

Certain forms of the spyrogyra and the oscillatoria seemed to be encountered more commonly alone and were therefore more easily studied. The others, however, were much more difficult to identify and were often found mixed together in gelatinous masses on debris or no other plants. This was noticed particularly in one bayou (Caño San José) where *Ceratophyllum demersum* became covered by a gelatinous coating of the algæ. The *Ceratophyllum demersum* did not look healthy, had a dark color and not the bright-green appearance of fresh plants. Breeding was much more spotted in character at this time up to the point where finally very few larvæ could be found. The appearance of this gelatinous coating of algæ was the most obvious change. Grass or debris of cane leaves and sticks were more often reported with heavy breeding than were algæ.

In contrast to these findings we have of course those in which deposits with nothing but spyrogyra, are found with enormous numbers of larvæ. It is hoped that the matter can be studied more thoroughly when more information is available concerning the varieties of algæ and their indentification.

Reed Swamps.

Opportunity of studying breeding in these swamps on a large scale was not presented. Where reed only were found it was not a common thing to find many anopheles larvæ.

Mangrove Swamps.

In this area no extensive swamps were present. As a rule in the swamps themselves there is very little other vegetation than the

mangrove trees, and when there is direct connection with the ocean the tide action probably keeps breeding from reaching large proportions as does also the high salt content of sea water.

These swamps exist under a variety of conditions, however, and conditions vary in the area bordering the swamps. The matter will be studied a little more throughly as opportunity presents itself. In those studied no breeding was found in the parts influenced greatly by the tide, but in some away from the ocean and in the parts bordering the swamp, breeding was encountered.

Other Water Plants.

Many of the bayous and large channels contained large numbers of plants belonging to genus Pistia, commonly called water lettuce. The roots may be loosely embedded in mud or the plants may float on the surface of the water and when present in large quantities the surface may be completely covered. Anopheles larvæ may be found when the plants are few, but when the surface is more or less completely covered no breeding takes place. If one could be assured of maintaining this latter condition the plant would be of great value. Flood disturbances make this impossible, however, at a time of year when it is most important.

Lemna.

This was also quite abundant but was never seen in such large quantities as to completely cover the surface of the water. Breeding was thus found among it. One form, probably that called Wolffiaarhiza (Howard, Dyar and Knab, Pa. 419, Vol. I) was found, however, covering completely certain small stock ponds. No anopheles larvæ were found here, but as these are not water deposits in which albimanus were often found anyway, no conclusions can be drawn.

Various forms of lily plants are also quite abundant and as a rule heavy breeding was not found among them, but no general rule could be made. One cannot be sure that these plants will competely cover the surface of the water deposits and even then they are only of value in a limited number of water deposits, many of which in Porto Rico can be handled more easily by other methods.

It would seem that the plants which favor breeding are of greater importance than those that tend to diminish breeding. One cannot be sure that the latter will be present in sufficient numbers to prevent breeding, but the former must be removed before any degree of control be assured.

Predatory Larvae.

Many water deposits seemed "alive" with larvæ of other insects and with other animal life. Larvæ of dragon flies and of a Dytiscid of genus Hydoxous, were seen on various occasions to catch and devour anopheles larvæ. It could not be shown, however, that they were of any importance in reducing greatly the amount of breeding.

FISH

Greene in his reports devotes considerable attention to the importance of fish, but came to the conclusion that while undoubtedly considerable larvæ were destroyed by this means, vegetation was so abundant that fish could not be depended upon. In two instances (Barceloneta) it seemed that fish possibly had destroyed large numbers of larvæ. In one case a cane-field ditch was breeding heavily but dropped off suddenly when a large number of fish (probably mullets) entered the ditch. In another case a small ditch was breeding quite heavily until numbers of very young *Dormitator maculatos* appeared and penetrated into the vegetation. In contrast to this were the large number of ditches containing large numbers of fish in which breeding went on rather heavily, especially in the mats of *Ceratophyllum dermesus.*

In this region the common fish were:

Dormitator maculatus.

The young were found in edges of ditches and small creeks and among the water plants. They are also found in very shallow ditches which contain running water from seepage. In the laboratory they eat larvae very rapidly and two to three placed in a barrel containing large numbers of culex larvae will devour them all in a short time. They are very hardy fish and stand handling well. In nature they do not seem to be able to control breeding constantly.

Philypnus dormitator Guavina.

They are very common in running water, brackish and fresh; are generally seen traveling in schools on surface of water when young. When in clear water they carefully avoid mud that may be stirred up and are easily frightened. They seem to feed extensively on the surface of water but seemed to be more or less always in mid stream and do not penetrate into vegetation. The small fish ate larvæ rapidly in the laboratory but their habits would indicate that they probably are not of any great importance in nature. They reach a large size and are caught for food.

Agonostoma monticola—Fresh-Water Mullets.

These are also very numerous in fresh-water ditches from seepage areas and are often found in schools traveling about often on the surface. They are often seen to feed there. In the laboratory they eat larvæ but not quickly, and only when larvæ are seen to move. It is not a hardy fish, does not stand transportation well, and soon dies in artificial containers. It probably is not of much importance in antimosquito work in nature.

Mugil curema—Jumping Mullet.

It well deserves its name for it is almost impossible to keep them in uncovered pails. They are very numerous in muddy ditches in brackish water. When very small they can be seen in schools on the surface of the water. They could not be made to eat larvæ in the laboratory and were easily killed by handling and transportation. It is probable that they are not of much assistance. Various species of Gobies were found also but seemed to be always on the bottom and never found to eat larvæ.

It would thus seem that *Dormitator maculatus* was the only one in this region that could be used at all, but this fish in nature did not seem to be very efficient. It was not very widely distributed in water deposits in the area. The most common fish was the mullet.

At Fajardo the most common fish was *Poecilia vivipara*. In the studies at Aguirre by Hingst working with Greene it was found that this minnow was a very active larva under laboratory and field conditions but that it was not very efficient when much vegetation was present. In any case it was considered that the fish was a great aid but that it could not be relied upon. It seemed to be most numerous in summer months up to October. None of these fish were found at Barceloneta. They are very abundant about Ponce in all irrigation and drainage ditches, often when only small amounts of water are present. Large numbers of larvæ were also often found in the same ditches. At Ponce the mullets were also numerous especially in rivers. *Dormitator maculatus* did not seem to be so abundant.

Exactly how much use can be made of fish in malaria campaigns here is difficult to say. They undoubtedly aid especially where *Poecilia vivapara* and *Dormitator maculatus* are abundant but these fish seem to be able to obtain plenty of food from other sources and do not need to rely upon larvæ to any extent. They probably are of great assistance in certain large tanks, small ponds, and surface wells which can be easily kept clean and which might breed in the absence of vegetation. They are also of great value in artificial containers for control of culex and ædes.

For the solution of the main problem in the numerous water courses they are probably of secondary importance.

Relative Importance of Above Factors.

All of the points mentioned above were carefully considered to try and explain presence of breeding in one deposit and absence in another nearby. Under the discussion of each point certain favoring points have been indicated as well as many disfavoring. There still remains a large number of deposits apparently identical but widely varying quantities of larvæ. In a region with such an extensive area of water deposits, for the present it is only possible to say that chance must enter in a great deal as to whether the mosquito shall lay its eggs in one or the other. There is also some evidence to show that certain regions are picked out as foci and that mosquitoes spread out from there. Naturally the farther away from these foci a water deposit is the less likely it is to have mosquito eggs deposited in it. This will be discussed a little more later on.