STUDIES OF THE MALARIA PROBLEM IN PORTO RICO

RELATION BETWEEN NUMBER OF TEMPORARY WATER DEPOSITS AND INTENSITY OF ANOPHELINE BREEDING

Paper XII

Table XXX shows the number and percent of temporary water deposits found with albimanus, grabhamii and vestitipennis larvae during the various months of the year.

TABLE XXX

BREEDING OBSERVATIONS IN TEMPORARY WATER DEPOSITS

Month	Visits to temporary water deposit stations at which they were found				Percentage with larvæ		
	With water	With larvæ			Alb.	Grab.	Vest.
		Alb.	Grab.	Vest.			
May	15	10	.....	.....	67	.....	.....
June	11	3	.....	.....	27	.....	.....
July	18	3	.....	.....	17	.....	.....
August	14	2	.....	.....	14	.....	.....
September	22	5	2	.....	23	9	.....
October	40	34	6	.....	85	15	.....
November	24	21	8	1	87	33	4.0
December	49	34	19	6	69	39	12.0
January	35	26	19	6	74	54	17.0
February	8	5	3	.....	62	37	.....
March	9	3	3	2	33	22	22.0
April	40	10	10	3	42	25	7.0

It seems quite evident that during the active season of all three, mosquito breeding was observed in a fairly high percentage of temporary water deposits. Some of the heaviest breeding of vestitipennis was found in temporary water deposits in ditches about Caño San José. The percentage with larvae is small because some of the temporary deposit stations were located in regions where vestitipennis were never found.

Of further interest is the seasonal variations in breeding in these temporary water deposits, at least, as shown by presence or absence of larvae. In general the per cent found with breeding varied in the same direction as the changes in potential breeding ground. There was a high per cent encountered with breeding in May and a rapid decline in August. Then a rapid increase to the maximum in October and November, which latter period corresponds with the active period of albimanus, as shown by larva catches in all stations.

From then on there was a decrease (with slight rise in January) to a low point in March. A slight rise was again observable in April. It would thus seem that the changes in amount of breeding in temporary water deposits, at least from September on, followed in general that in permanent water deposits, and that the same factors that increased or decreased the area of temporary water deposits possibly tend to increase or decrease the anopheline activity.

The increase alone in the areas of water produced by increase in temporary water deposits does not seem to be the determining factor in increasing anopheline production in this region for albimanus production dropped off before this area had been materially reduced and grabhamii production reached its maximum when the area of these water deposits was its smallest. It would seem that if the maximum area of water deposits is reached in the season that is most favorable otherwise for anopheline production, the increase in density of adult mosquitoes ought to be enormous. Apparently in this region the two do not often entirely coincide. The relation between amount of temporary deposits, rainfall and per cent of deposits found with albimanus is also shown in monthly average of each for the four-month periods, May–August, September–December, and January–April. The relation between water deposits and per cent with breeding seems so definite as to be of some significance. Rainfall, temperature, and wind velocity probably determine in a general way the amount of standing surface water. It would seem likely that these factors, while not necessarily being the only ones are important factors in determining the seasonal variations in activity of albimanus.

TABLE XXXI

RELATION BETWEEN ALBIMANUS BREEDING; AREA OF TEMPORARY WATER DEPOSITS, AND RAINFALL

Months	Average monthly rainfall	Average monthly frequency of finding water in temporary water deposit	Percent found with larvæ
May-August	4.45	5.8	31
September-December	6.85	10.7	70
January-April	4.90	7.3	55

SUMMARY OF SEASONAL VARIATIONS IN ACTIVITY OF ANOPHELES IN RELATION TO CLIMATIC CHANGES

It would seem probable that the season of lowest albimanus production is in February and March. There is an early spring rise but to what extent is not definitely known. It probably does not

reach the proportion of fall rise because of occurrence of rains when temperatures are still comparatively low, and as they rise, winds become much stronger and the area of water deposits smaller. The diurnal variations in temperatures are also greatest at this time. After the warmest month of August, but while temperatures are comparatively high, albimanus reaches its maximum production. During October and November wind velocities are lowest.

Thus we found *albimanus* at its height of activity when temperatures were still relatively high, rainfall high and wind velocity lowest. Its activity is lowest during the months of lowest temperatures and rainfall and with relatively high wind velocity.

Grabhamii does not seem to thrive well during the warm months and is most active during the coldest and driest months of the year: January and February.

Vestitipennis would seem to be intermediate between the two but is apparently more sensitive to heat than the other two. It was most active when temporary water deposits were the most numerous.

RELATION OF CANE CULTIVATION TO ANOPHELINE BREEDING

The Cutting Season.

It is in January after the peak of albimanus production has passed that the cane-cutting season usually begins. In the first part of this season shade produced by cane is generally at its maximum as is the production of grabhamii.

Cane is all cut by hand and leaves are left lying everywhere so that ditches are often completely filled. The two most important results of cutting cane would seem to be reduction of shade and filling of water deposits by debris.

Effect on Albimanus.

The relation of shade and increase in debris probably favor albimanus production and often albimanus breeding increased rapidly in ditches about which the cane had recently been cut. As a rule however this effect did not seem to be general, and as the cane leaves decayed and water often became foul, anopheles breeding soon reduced markedly. It would not seem that the cutting of cane immediately increases albimanus production to any great extent.

Effect on Grabhamii.

It is possible that in this region the cutting of cane and exposure of breeding places to sun, taking place as it does at the height of grabhamii breeding, would tend to reduce that breeding. It does not seem to do it immediately, and in fact in one ditch a marked

increase was found for two weeks after cutting. It was common to find grabhamii continue breeding several weeks after cutting had taken place and a reduction was noticed in many ditches after February where cane was not cut. The effect of cutting on grabhamii breeding is not definite.

Breeding of vestitipennis was already rather sporadic and little can be said as to what influence the cutting might have.

The cutting season generally lasts till June or July. Toward the end of this period, the amount of shade produced by cane is probably the lowest.

The Growth Period.

Following the cutting of cane, the leaves are removed from new plants that are coming up and are left in piles between rows of cane where they gradually decay. Every four or five years land is plowed, new ditches constructed and a new plant of cane made.

Ditch-cleaning Operation.

The cane leaves are removed from the important ditches following the cutting of cane, and vegetation cleaned out. Grasses grow very rapidly, however, and within at least a month are generally back to former conditions. These operations are repeated in the more important ditches for the sake of maintaining drainage in the course of cultivation, on the average of three or four times a year. In important drainage channels it may be done more often while in others the vegetation may not be disturbed.

In a ditch with grass on edges and heavy albimanus breeding the immediate effect of cleaning is to reduce the breeding markedly. As a rule, however, unless there is much current in the ditch, enough debris is left to enable breeding to quickly return to its former state. This was especially noticed in a small stream arising from seepage in which hornwort was abundant.

In numerous other instances, however, in which heavy dense vegetation covers a ditch so that there is practically no breeding the effect of cleaning is to increase the amount of breeding.

This is at times very marked and was noted by Mr. Johnson in an area in which he was observing especially. Ditches with considerable vegetation and not disturbed seemed to show rather constant light breeding throughout the year.

Breeding in Early Part of Year.

During early summer, cane is low in most fields, and majority of ditches are moderately clean and sun exposed. Breeding was quite general and widespread. By August the cane cut in the first

part of year is almost head high and is already producing some shade. In October, November and December and first part of year there is probably the most shade from this plant.

Breeding in Latter Part of Year.

As noted by Mr. Johnson in an area in which he was especially observing, and also noted in general in the course of the study, as cane becomes high and leaves extend over and into smaller ditches, breeding of albimanus is reduced markedly in the smaller ditches in the center of cane fields. Grasses do not grow well in these ditches. The tendency is for breeding to be restricted to ditches surrounding the fields and in places more open and with other vegetation. In these low lands especially it is doubtful how much influence the shading by cane has on reducing albimanus breeding for the following reasons:

(*a*) The period needed for cane to reach maturity is more than a year so that at any one time in any cane area there are always a number of fields with low cane.

(*b*) Cane plantations are divided up into small fields by intersecting roads, and in the low lands there are ditches with water alongside of all roads. These are only partially shaded.

(*c*) In low areas there are always large numbers of large ditches not shaded by cane.

(*d*) In low lands cane growth is poor and often the cane does not extend high enough to shade ditches.

(*e*) In center of many fields in high lands there are often open ditches with no shade and if it had not been for the fact that some of these were found with breeding before cane was cut, it would have been said that the cutting of cane increased breeding.

It is thus seen that in the low lands, at least, there are always sufficient exposed ditches for enormous albimanus production.

SUMMARY OF RELATION BETWEEN CANE CULTIVATION, ANOPHELINE BREEDING AND MALARIA

The main point would seem to be that—

(1) Cane is mainly grown in the coast regions where potential breeding areas in low lands are naturally very great.

(2) Ditching operations increase the potential breeding grounds.

(3) Drainage ditches seem to be particularly favorable breeding grounds of anopheles mosquitoes.

(4) Ditch-cleaning operations, as they are not done often nor completely, result in conditions favorable for anopheline breeding.

(5) High cane, producing much shade, reduces amount of breed-

ing in small ditches but there are always large numbers of ditches not so shaded.

(6) Cutting of cane seems to temporarily increase albimanus breeding in many cases.

(7) From the standpoint of malaria, the cultivation of cane draws a large population near to breeding grounds.

SEASONAL VARIATION IN MALARIA

Beginning July 14 an inspector put his entire time to weekly visits to the majority of houses in the area attempting to localize cases of malaria. A blood smear was taken from any patient with fever the cause of which was not obvious, as, for instance, when due to upper respiratory infections or common communicable diseases. In many cases fever continued after subsidence of these obvious symptoms and in these cases blood smears were taken.

An attempt was made to see the majority of cases to make a clinical diagnosis, but so much of short survey work required that I be absent from Barceloneta part of the time that very few cases were actually seen. For that reason it was felt best to rely only on the results of the blood smears taken by inspector doing this work, hoping that, while it would not show total amount of clinical malaria, it would show any seasonal variations that might take place.

The work was made more difficult by the unusual prevalence of numerous communicable diseases. Almost everyone seemed to have suffered from grippe or colds with fever, and as malaria parasites were found in many of these patients it was difficult to say which was of primary importance. The acute respiratory infections are unusually common in the Island and often travel through communities every few months. One notices it especially in the servants who at frequent intervals are sick and often in bed with fever.

There was an epidemic of whooping cough followed by measles and chicken pox, so that one can readily appreciate some of the difficulties especially since at times the characteristic symptoms of each disease or its complications were not pronounced and the question of whether a smear should be taken or not had to be often left to an inspector. During November and December the record was interrupted by numerous holidays and by the fact that the inspector was absent for a short time to aid in a short survey.

Monthly Malaria Rates.

The monthly rates show considerable variation, but it seemed that there was considerable malaria when the work started in July and that through August a large amount of sickness was seen but with

few positive smears. During November and December there was more malaria considering the number of days which inspector was in the work. Dividing the nine-month period from August to April, inclusive, into three equal parts and totaling the cases for those periods, one finds that throughout almost any season there are patients suffering from some of the acute manifestations of the disease but that during November, December and January there seemed to be more cases of malaria. Since each case could not be seen personally and a careful investigation made to determine from past history the probability of the present attack being a relapse or new infection, and due to the further fact that in this region there is no season in which adult anopheles albimanus are not flying about at night, the determination of relapse or new infection is made more difficult.

TABLE XXXII

CASES OF MALARIA IN THE STUDY AREA DURING THE YEAR

Month	Cases of malaria	Total
July	19	19 (*)
August	15	.....
September	36	.....
October	16	67
November	25	.....
December	26	.....
January	31	82
February	15	.....
March	18	.....
April	17	40 (**)
Total	.....	208

* Last two weeks of July.
** First ten days of April.