PROGRESS REPORT OF AN INVESTIGATION OF THE RELATIONSHIP OF WATER TABLE LEVEL FLUCTUATION TO MOSQUITO DEVELOPMENT AND POPULATION DENSITY, 1954-1956[1]

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SUMMARY OF WATER TABLE LEVEL STUDIES, 1954–1955

TECHNIQUES. It is believed that one of the principal keys to successful mosquito control ultimately lies in a study and understanding of mosquito ecology. Hence, in January 1954, three 24 x 1 x 4 inch wood stakes (Nos. 1, 2 and 3) were placed at various locations on the U. S. Naval Air Station, Jacksonville, Florida, to determine the ground water table level fluctuation. These stakes proved to be unsatisfactory because the water table level was usually below the stakes and could not be recorded. They were discontinued.

In March 1954 at the south end of the station, a 60-inch diameter stump hole was deepened to about 50 inches and stake No. 3 was driven into the center. The elevation of the stake top was 23 feet 6¾ inches above mean sea level. It is from this stake that all of the significant recordings herein reported have been made.

Within ten feet of stake No. 3, a 100-inch long, hollow pipe (inside diameter 2 inches) was driven into the ground 70 inches in order to determine water table level with minimum rate of evaporation. In the spring of 1955 the actual elevation above mean sea level of both stakes and pipe were determined by engineering survey in order to have standard reproducible reference points.

FINDINGS. During a sixteen month period, this investigation has shown that by observing the water table level fluctuation, the following questions could be answered with a reasonable degree of satisfaction:

(1) Is there a relationship between the reading on the stake and the surface water level of actual or potential mosquito production habitats?

Yes. It has been observed that when the water level reading on the stake is 42 ± 2 inches, surface water will be found in all stump holes, marshes, swamps and ditches, both standing and running, and that mosquito larvae will be present in many of these habitats provided there is insufficient surface run-off and percolation to interrupt development through drying. Furthermore, it has been observed that when the stake water level reading is no higher than 27 inches, all stump holes and approximately 50 per cent of the marsh and swamp areas are dry. When the water level reading falls below the 27 inch mark, the remaining areas will rapidly become dry (i.e., free of standing surface water).

(2) Can a rough estimate of the daily evaporation rate be made and if so, can this be correlated with the length of time surface water will remain in certain mosquito production areas? What is the advantage of this?

The answer is thought to be—yes. Although the daily mean evaporation rate has not yet been established, work up to this point indicates that a reasonable estimate may be in the order of one inch per day at this station, provided, of course,

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[1] The opinions or assertions contained herein are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

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there is no rainfall. The advantage of knowing this is obvious in that it will enable field workers to estimate how long water will remain in certain areas and predict mosquito development, and to time probable adult emergence. For example, when the stake water level reading is 33 inches, it has been possible to estimate that all the stump holes would be dry in about six days; and consequently, larval control measures were obviated, since very little, if any, emergence of mosquitoes could occur.

(3) How can the stake water level reading be used to advantage?

By noting the stake reading accurately and regularly it is possible, in most cases, to know where the existing surface water is located. It will permit an estimate of the length of time the water will remain standing in any given area in the absence of additional rainfall. This informs the investigator or field surveyor where larviciding or further field survey reconnaissance may be required, if at all. In short, this information makes possible a greater accuracy in forecasting mosquito development, emergence and need for control measures.

FUTURE PLANS. Some of the problems that remained to be worked out were:

(1) All ditches, marshes, swamps and stump holes would have to be more accurately recorded and determinations made of that stake reading at which each would be dry.

(2) Daily mean evaporation rate would have to be determined together with standard deviations. Evaporation pans are presently being evaluated and an attempt made to correlate the evaporation rates of these with those of the stake site.

(3) Because of the fact that during some rains there is an unequal distribution of rainfall over the controlled area other stakes may have to be located at other points on the station.

The pipe described above has not yet been fully evaluated.

CONCLUSIONS, 1954–1955. It is believed that fluctuation of water table level has a definite relationship to the population density and other mosquito bionomics, the regular recording and tabulation of which may be a useful aid in forecasting brood emergence and scheduling control operations if indicated.

SUMMARY OF WATER TABLE LEVEL STUDIES, 1955–1956

TECHNIQUES. Observations and readings of the water table level have been made during the current mosquito season with some modifications as follows:

(1) Evaporation pans were found to be an unreliable index to surface water evaporation and were discontinued.

(2) The daily reading of instruments, such as stake or pipe used to determine water table level, also indicates the rate of evaporation. These daily readings are laborious and to obviate them it is hoped that the following equation, which is used to determine the amount of evaporation over a large water surface at sea level, may be used to determine the daily rate of evaporation without reference to the instruments:

$$E = (18 + 39.2 \times v^{0.75})\ (e_m - e);$$

where E = Evaporation in cc. per square meter of surface; v = Wind force (Beaufort's scale); e_m = Maximum vapor pressure at prevailing temperature in mm.; e = Actual vapor pressure in mm.

(3) In an effort to improve the method by which the fluctuation of the ground water table level is measured and recorded, a modified procedure for determining variations in the exposed water table within the pipe has been developed as follows:

A 130-inch length of one-inch inside diameter pipe is driven into the ground to a depth of 100 inches. A fishing cork float with a nylon thread attached to the upper end is dropped down inside the pipe to the water surface. The free end of the thread is strung over a pulley that is secured to a stake driven into the ground parallel to the pipe. An arbitrary graduated scale in inches and fractions of an inch is made from two yard-sticks placed vertically end to end and attached to the stake. A pointer is attached to the thread along the scale so that changes in the water table level can be read in inches directly from the scale as the float moves up and down with the changing water level.

(4) Observation procedures for the water level readings in the pipe are still not entirely satisfactory. During the next year, two 4-inch inside diameter pipes located about 3½ miles apart will replace the smaller pipe. The addition of these should enable readings to be made with greater accuracy, using the float-pulley measuring device.

FINDINGS TO DATE. (1) It has been observed that when the water level reading on the stake is 42 ± 2 inches, surface water both standing and flowing will be found in all stump holes, marshes, swamps and ditches, and that mosquito larvae will be present in many of these habitats provided there is insufficient surface run-off and percolation to interrupt development through drying. Furthermore, it has been observed that when the water level reading on the stake is no higher than 27 inches all stump holes and approximately 50 percent of the marsh and swamp areas are found to be dry. When the water level reading falls below the 27-inch mark the remaining areas will rapidly become dry (i.e., free of standing surface water).

(2) Although the daily mean evaporation rate has not yet been established, work up to this point indicates that a reasonable daily average estimate may be in the order of one inch at this station, provided of course there is no rainfall. The advantage of knowing this, together with the water level, is obvious in that it will enable field workers to estimate how long water will remain in certain areas and predict mosquito development and probable adult emergence. For example, when the stake water level reading is 33 inches it has been possible to predict that all the stump holes would be dry in about six days. Consequently larval control measures were obviated since very little, if any, emergence occurred.

(3) By recording the stake reading accurately and regularly it is possible, in most cases, to know by and large where the existing surface water is located. This permits an estimate of the length of time water will remain standing in any given area in the absence of additional rainfall. This informs the inspector or field surveyor if and where larviciding or further field reconnaissance is required. In fine, this information makes possible a greater accuracy in forecasting mosquito development, emergence and need for control measures.

(4) A comparison of the water table level measurements and mosquito abundance for the past three years is given in Table 1. The measurements at stake No. 3 were taken at intervals during the nor-

TABLE 1.—A comparison of water table level recordings and overall mosquito prevalence during a three-year period, U. S. Naval Air Station, Jacksonville, Florida.

	Average Water Table Reading (Inches on stake)	Mosquitoes/Trap/Day [1] (Average number)
	1954	
April	18.3	0.8
May	3.0	3.4
June	3.6	3.2
July	7.9	7.4
August	5.7	4.7
September	40.5	4.4
October	39.7	1.9
	1955	
April	35.0	6.6
May	9.8	8.1
June	8.1	7.5
July	18.8	13.7
August	12.4	11.1
September	39.8	32.5
October	49.5	27.7
	1956	
April	21.5	4.4
May	32.8	5.1
June	17.5	3.5
July	30.1	10.1
August	25.4	7.7
September	22.1	3.8
October	40.0	6.2

[1] Based on 8, 10, and 9 mosquito light traps for 1954, 1955 and 1956 respectively.

mal mosquito season (April–October). The average water level reading was computed for each month as well as the average number of mosquitoes per trap per day. These averages were computed statistically using rank correlation.

Unfortunately, analysis showed no correlation or negative correlation between the observed water level and the mosquito abundance for any of the years compared. Although these data appear to be in direct contrast to previously mentioned observations, many important factors which cannot be analyzed statistically must be taken into consideration. Some of these factors are: wind, unequal distribution of rainfall over the observed area, adulticiding by ground and air, larviciding and permanent control measures. Taking these factors into account, field observations reasonably show that there is a correlation between the water level and prevalence of mosquitoes during April through October when temperature and rainfall are most ideal for their aquatic development.

FUTURE PLANS AND PROBLEMS TO SOLVE. Some of the problems which remain to be worked out are:

(1) Several years' additional data will be needed to make accurate comparisons between the stake readings (water table) and the surface water level in ditches, marshes, swamps and stump holes. This will be accomplished by simultaneously observing the stake readings and water level in ditches, marshes, swamps, and stump holes within a given area.

(2) At present it is difficult to obtain fine readings from the stake to determine water level fluctuations of less than one-half inch. It is expected that readings obtained from the 4-inch pipes will produce greater accuracy.

(3) Lack of additional pipes has prevented sufficient observations on the effect of unequal distribution of rainfall over the station. The addition of two 4-inch pipes, located about 3½ miles apart will partially overcome this deficiency.

(4) A field sampling method has not yet been developed which can be used to establish the relationship between larval indices and the water table level over an exact observation area.

SUMMARY. Progress is reported on an investigation to determine the relationship of the water table level to the production and density of larval and adult mosquitoes at the Naval Air Station, Jacksonville, Florida. The development and refinement of techniques used to measure the water table level and evaporation rates are described. Use is made of the readings of water level from stakes and pipes in an attempt to correlate this with mosquito population abundance based on light trap indices. A working relationship is established between these readings and actual or potential mosquito production capacity of certain habitat sources. It is concluded that the techniques when properly developed may have value in prognosticating brood emergence and scheduling of control operations if indicated.