THE EFFECTS OF SPECIES ON DENSITY OF MOSQUITO LARVAL POPULATIONS IN SALT LAKE COUNTY, UTAH [1]

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In 1956 the South Salt Lake County fosquito Abatement District began an itensive and detailed mosquito larval irvey to improve inspection procedures id obtain more accurate information out mosquito larval populations in the istrict. This survey has been continued each subsequent year. Inspectors for e district have generally been graduate udents in entomology from the Univer- ty of Utah and are trained to make curate observations. In addition, special asses and field demonstrations under the rection of a statistician were required fore inspectors began field work. The irpose of the classes and demonstrations as to develop, so far as possible, standard mpling procedures.

number per dip and some areas required many more. No effort was made to identify larvae in the field since they were later identified in the laboratory.

Data obtained from this survey and substantiated by light trap records and field observations have shown seasonal and annual fluctuations in the abundance of mosquitoes (Graham and Rees, 1961). In the case of *Culex tarsalis* some of the factors responsible for large increases have been reported (Graham, Bradley and Collett 1960). The greatest fluctuations in numbers of mosquitoes have been increases in *Culex tarsalis* in 1958 (Rees and others, 1959) and *Culiseta inornata* in 1960 (Graham and Rees *op. cit.*).

TABLE 1.—Percentages of times larvae of various species were found without other species of mosquito larvae being present, from 1956 through 1961

	1956	1957	1958	1959	1960	1961
des dorsalis	64.5	66.1	56.3	64.2	69.5	57.6
lex tarsalis	46.7	58.7	66.0	41.3	41.8	46.7
lex pipiens	36.0	25.5	18.5	20.4	20.3	32.2
liseta inornata	32.3	33.7	38.5	39.0	56.3	49.2

Each inspector was required to collect sample of larvae from each pool where ey were found and to make a record at included the date, location, size of the ea, source of the water, instar of the rvae and the average number per dip ken in a pint dipper. At least 10 dips ere required to determine the average

When these increases in abundance occurred there was not only an increase in the frequency with which pools contained larvae of these species but also an increase in the percentage of times the species increasing was found without larvae of other mosquito species being present. This is shown in Table 1.

The accompanying graphs also show this relationship.

A study of the density of mosquito larval populations based on the average number of larvae per dip showed interesting relationships. The average number of larvae per dip is a crude measurement

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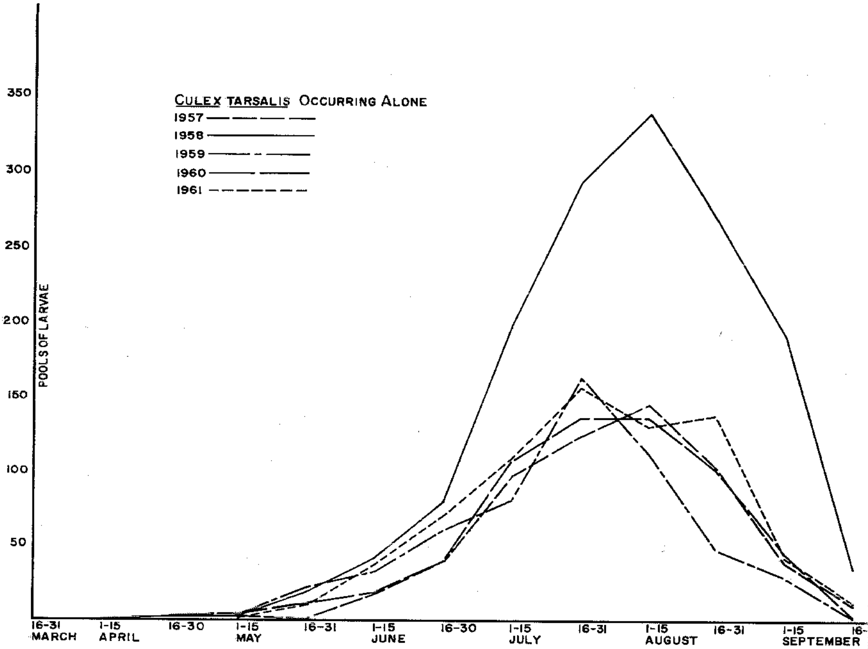

FIG. 1.—Pools with larvae of *Culex tarsalis* without other mosquito species being present.

even when taken under the careful conditions of this study and an average taken from a single pool or a few pools is not a reliable measure. Consistent patterns of larval density as determined by the average number per dip when data from many pools are aggregated are reliable. All observations made in this study regarding the average number of larvae per dip are based on aggregates of large numbers of average number of larvae per dip. More than 16,000 pools were sampled in the study.

Consistent seasonal patterns of average number of larvae per dip for species found alone were obtained for the four most abundant species of mosquitoes in Salt Lake County for the six years of study. Larval populations of *Culex pipiens* were densest followed by *Aedes dorsalis* and then by *Culex tarsalis* and *Culiseta inornata,* which were about the same. T relative density of larval populations not the same as relative abundance of t various mosquito species in Salt La County.

Graph 3 shows these relationships f 1959. Other years are similar.

In pools with two or more species mosquito larvae the average number p dip was between those of pools with o species. This relationship, illustrated Graph 4, has been consistent for each ye of the survey. Although some min deviations have occurred the average nu ber per dip for pools with more than o species is almost always between those pools with the various species alone.

In pools with more than one species mosquito larvae, at least one species, a probably each species, was less numero than in pools where the species we

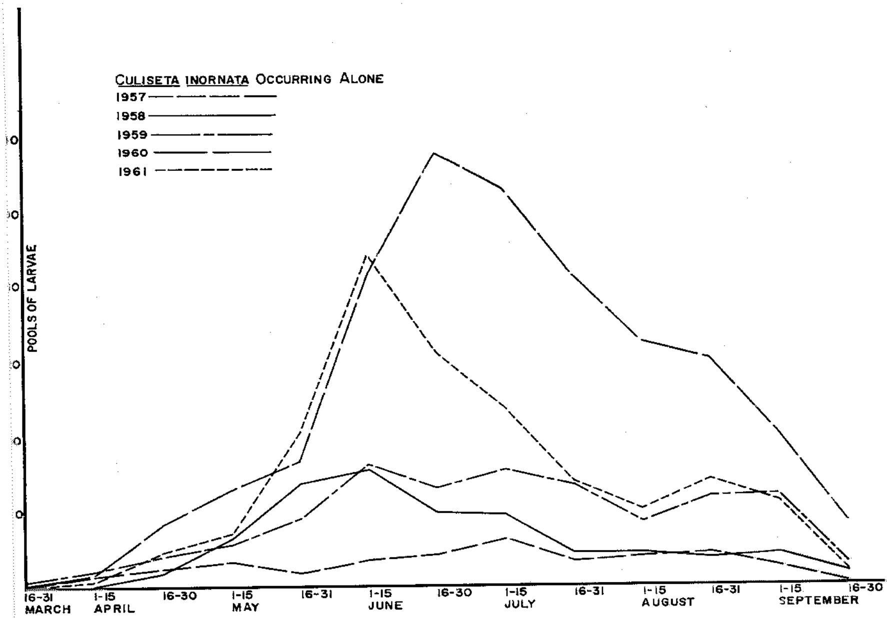

FIG. 2.—Pools with larvae of *Culiseta inornata* without other mosquito species being present.

und alone. In pools wth two species, ch species might be one-half as numer- is as when found alone and, in pools with ree species, each species might be one- ird as numerous as when found alone. order to test this hypothesis a model as constructed based on the assumption at it is true. The complexity of the data quired the development of a special for- ula that would take into consideration e interaction of seasonal fluctuations in val density and the number of pools ith larvae of one species and those with ore than one species. The formula is esented in Appendix A. The actual data ere compared with the results computed om the model and graphs were con- ucted to show this comparison. In pools th more than one species the actual av- age number per dip was usually higher an the calculated number per dip. Fig- e 5 shows the typical result. Occasionally the actual average number per dip was very close to the hypothetical result. This atypical relationship is illustrated by *C. pipiens* with other species in 1959 (Figure 6).

SUMMARY AND CONCLUSIONS. Since 1956 the South Salt Lake County Mosquito Abatement District has conducted intensive and detailed mosquito larval surveys. Carefully trained inspectors have sampled every mosquito producing area found and recorded pertinent information. The following conclusions are drawn from a study of these data. (1) Each of the four most abundant species of mosquitoes in Salt Lake County has consistent seasonal patterns of larval density. Larval density is relatively low early in the year, increases in the summer months to a peak, generally in August and then declines in September. (2) Larval populations of *Culex pipiens* are densest followed by

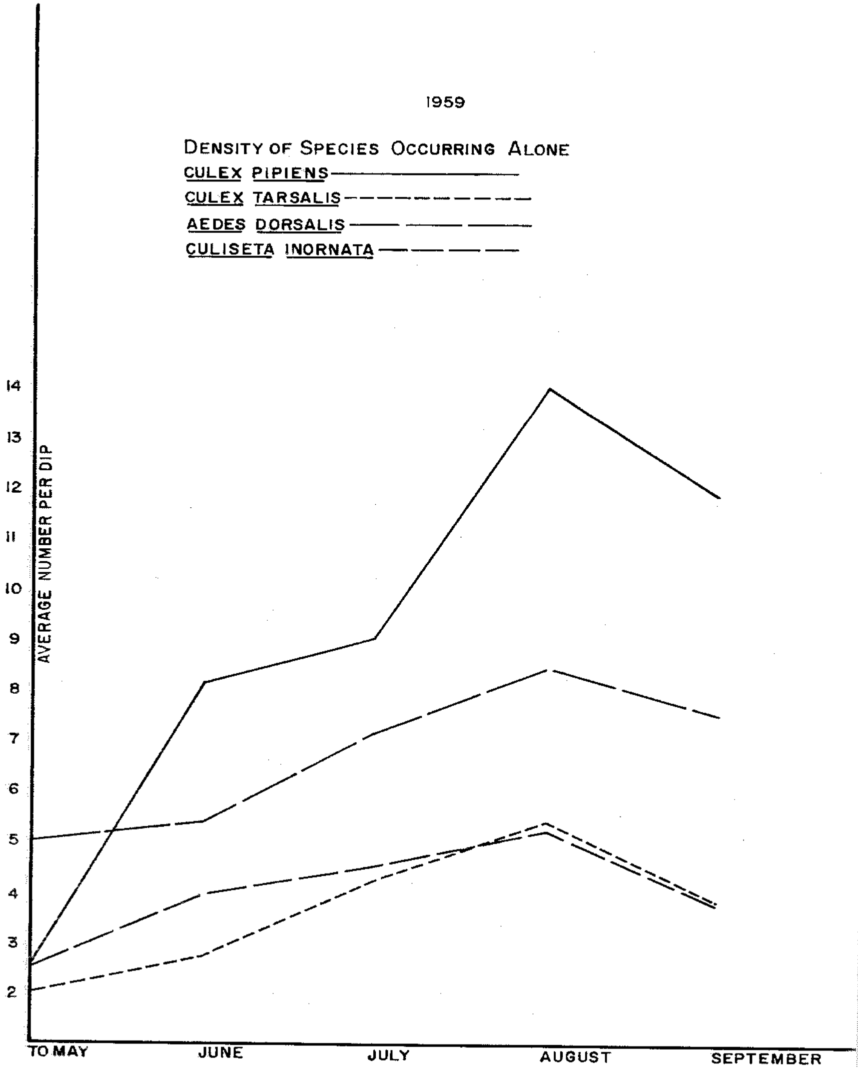

FIG. 3.—Density of larval populations of common mosquito species in Salt Lake County, U in 1959.

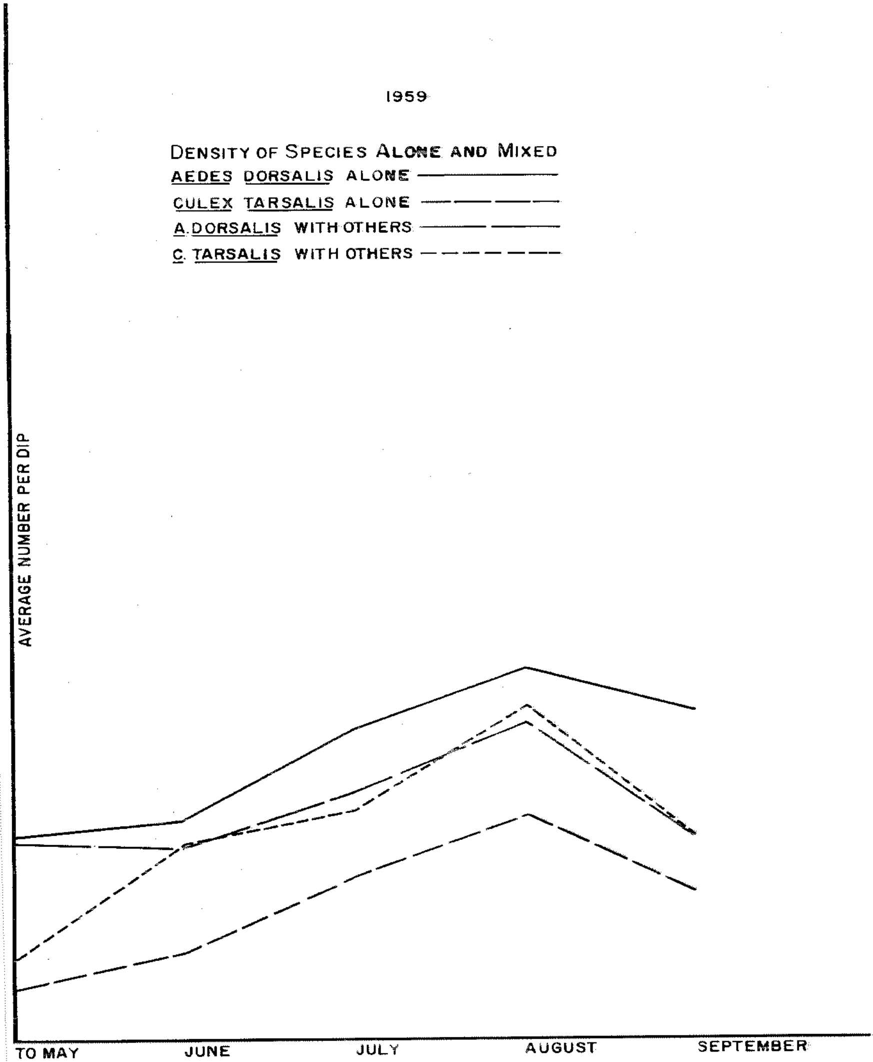

Fig. 4.—Densities of larval populations of *Aedes dorsalis* and *Culex tarsalis* in pools with one mosquito species and more than one mosquito species.

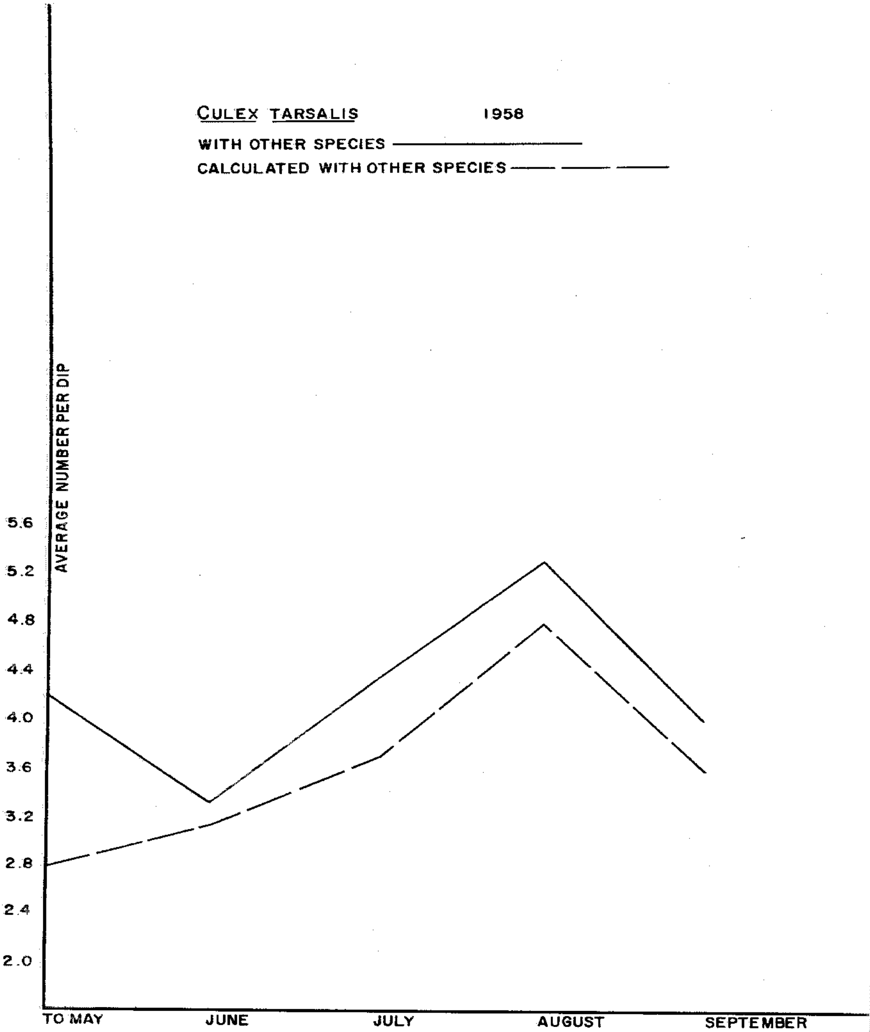

FIG. 5.—Actual and calculated numbers per dip for all pools with *Culex tarsalis* and other spec in 1958.

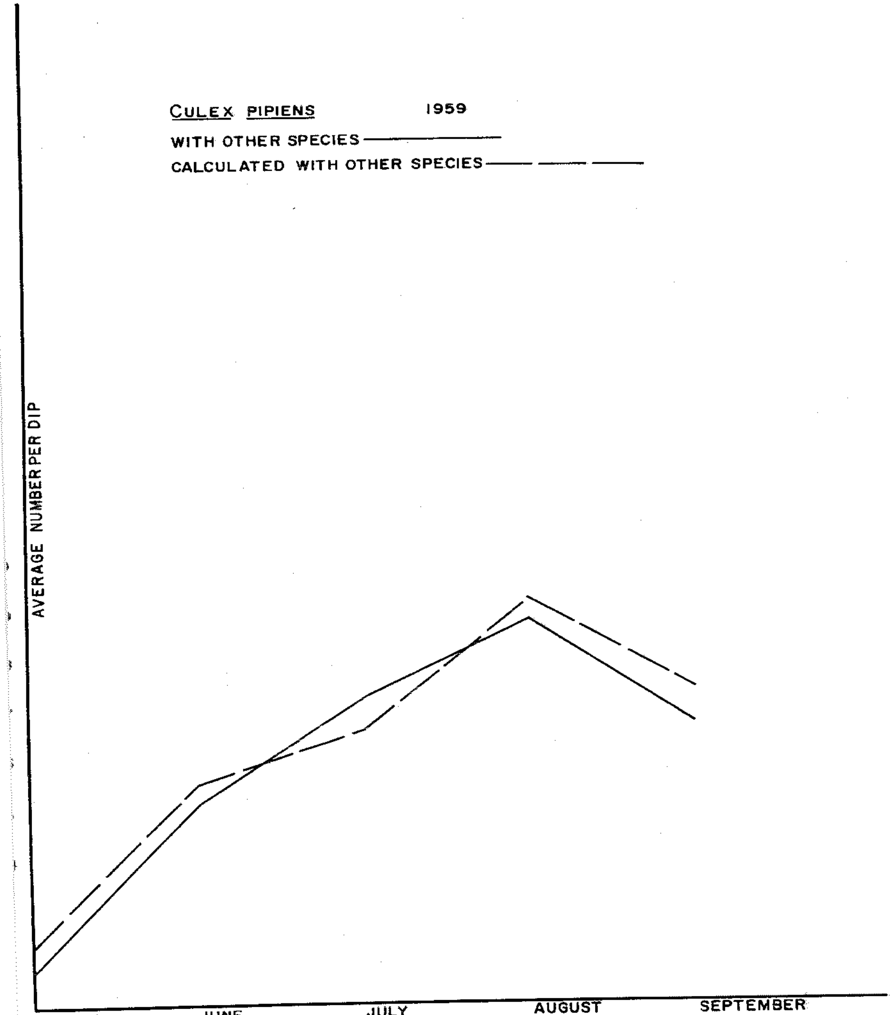

FIG. 6.—Actual and calculated numbers per dip for all pools with *Culex pipiens* and other species 1959.

Aedes dorsalis, Culex tarsalis and *Culiseta inornata.* Density of larval populations of *Culex tarsalis* and *Culiseta inornata* are essentially the same. (3) For pools with 2 or more species of mosquito larvae the average number per dip is between those of pools in which various species are found alone and is slightly greater than would be expected if each species were ½ as numerous in pools with 2 species and ⅓ as numerous in pools with 3 species as when found alone. Competition in some form limits larval density, but in pools with more than one species larvae of the different species occupy different niches in the same general larval habitat and competition is reduced. (4) Mosquito populations in Salt Lake County, Utah are determined, in part, by the number of times a particular species can occupy a larval habitat without other mosquito species being present and this is variable from year to year for some species. (5) The complex of variable factors, mostly unknown, which determines the species and numbers of mosquito larvae in various larval habitats is largely responsible for fluctuations of mosquito populations in Salt Lake County, Utah.

APPENDIX A

DEVELOPMENT OF FORMULA FOR CALCULATED NUMBER OF LARVAE PER DIP IN POOLS WITH MORE THAN ONE SPECIES. On the basis of a monthly aggregations of the average number of larvae per dip, the model is developed on the following assumptions: In pools with two species each species would be one-half as numerous as in pools where they were found alone; in pools with three species, each would be one-third as numerous as when they are found alone, etc.

The four species, *Aedes dorsalis, Culex tarsalis, Culiseta inornata* and *Culex pipiens* are designated by S_1, S_2, S_3, and S_4. The variable t is the average number of larvae per dip in an individual pool and T is the average of the t's over a given period of time. T_1, T_2, T_3 and T_4 will be the T value for each of the major speci when larvae occur without other mosquit larvae being present. These are dete mined from field data.

The formula will be developed for H hypothetical average number of larvae pe dip for S_1 in pools with one or more (the other species. H_2, H_3 and H_4 can b computed from the formula by simpl permuting the subscripts.

Let N equal the number of pools wit S_1 and only one other species and M equal the number of pools with S_1 an two or more species. Let $P=N/M+N$ and $Q=M/M+N$. Note that $P+Q=$ and that, of the total number of pools wit S_1 and other species, P is the fraction (those with only one other species and Q the fraction of those with two or mo other species. Let P_1, P_2 and P_3 be th fraction of N that S_1 is found with S S_3 and S_4 respectively. Note that P_2- $P_3+P_4=1$. Let M_2 be the number (spots with S_1, S_2 and other species, an define M_3 and M_4 similarly. Note th $M_2+M_3+M_4$ does not equal M, but wi be between 2M and 3M. For most of th data, the sum of the M_1 is approximatel 2M indicative of the fact, few pools hav all four species. Let $q_2=M_2/M_2+M_3-$ M_4 and q_3 and q_4 similarly. Note th $q_1+q_2+q_3=1$.

From the assumptions it follows that:

$$H_1=P\left[P_2\left(\frac{T_1+T_2}{2}\right)+P_3\left(\frac{T_1+T_3}{2}\right.\right.$$

$$\left.+P_4\left(\frac{T_1+T_4}{2}\right)\right]+Q\left[\frac{T_1}{3}+\frac{2}{3}(q_2T\right.$$

$$\left.+q_3T_3+q_4T_4)\right];$$

rearranging terms,

$$H_1=T_1\left(\frac{P}{2}+\frac{Q}{3}\right)+T_2\left(\frac{Pp_2}{2}+\frac{2Qq_2}{3}\right.$$

$$+T_3\left(\frac{Pp_3}{2}+\frac{2Qq_3}{3}\right)+T_4\left(\frac{Pp_4}{2}+\frac{2Qq_4}{3}\right.$$

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IE ROLE OF THE SUBSTRATE MOISTURE CONTENT IN THE SELECTION OF OVIPOSITION SITES BY *AEDES TAENIORHYNCHUS* (WIED.) AND *A. SOLLICITANS* (WALK.)[1]

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NTRODUCTION. In common with other dwater mosquitoes, *Aedes* (*Ochlero-s*) *sollicitans* (Walk.) and *A.* (*O.*) *iorhynchus* (Wied.) lay their eggs on st soil between the level of maximum ıdation and the prevailing water line. ond this, no precise information is ilable about the relationship between substrate moisture content and the se-on of an oviposition site by these two quito species.

nowledge of this subject is essential full understanding of the problem of osition-site selection and to any effort le towards controlling these mosquito ies through destruction of the egg e. The present study was carried out the purpose of determining under lab-ory conditions the substrate moisture ent occurring in sites utilized by *solli-ns* and *taeniorhynchus* for oviposition.

IATERIALS AND METHODS. Under cage litions, both *sollicitans* and *taeniorhyn-s* readily lay eggs on moist gauze. By ing available to ovipositing females ndomized series of gauze pads, differ-from one another only in the amount of water contained, and by subsequently counting the number of eggs laid on each pad, this capability was used to investigate the relationship between substrate moisture content and the choice of oviposition sites by these two mosquito species.

The strain of *taeniorhynchus* used in this study was obtained from the colony maintained at the Communicable Disease Center's Technical Laboratories, Savannah, Georgia. Since a colonized strain of *sollicitans* is not available, wild females of this species were collected, placed in laboratory cages, given a blood meal, and provided with moist gauze wicks for oviposition sites. After several thousand eggs accumulated, they were washed out of the gauze onto a filter paper and stored in petri dishes over water in a closed desiccator jar. Whenever a cage of *sollicitans* was required for testing, eggs from this supply were hatched and the larvae reared to adults.

To reduce the rate of evaporation of water from the gauze pads during exposure periods, mosquitoes were maintained in cages (20x20x20 inches) of the type described by Chao (1959). The sides of this cage consist of clear sheet acetate attached to the wooden frame with rubber cement. The cage is made addi-

[1] The opinions and assertions contained herein those of the authors and are not to be con-d as official or reflecting the views of the y Department or the naval service at large.