

A LABORATORY STUDY OF LARVAL COMPETITION BETWEEN *Aedes aegypti* (L.) AND *Aedes triseriatus* (Say)¹

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The distribution of *Aedes aegypti* in the southeastern United States includes limited areas where this mosquito is apparently absent for varying periods even though such areas previously have been heavily infested and appear to remain ecologically suitable. Examples of this situation have been seen in Louisiana, where a widespread infestation had reportedly diminished to a single parish in 1964 (Hayes and Ritter, 1966), and in Savannah, Georgia, also formerly infested, where an intensive survey during the spring and summer of 1966 gave negative results (McCray *et al.*, 1967).

The possible role of competing mosquito species has figured prominently in speculations regarding such discontinuities in the distribution of *A. aegypti* but quantitative data on this subject are generally lacking. Eventual exclusion of a species from its ecological niche by a competitively superior species having nearly identical requirements is a firmly established principle in ecology (see Mayr, 1963, pp. 66-82). Competitive displacement of one mosquito species by another has been shown to occur. Service (1966) reported the recent replacement of *Culex nebulosus* by *Culex pipiens fatigans* in towns in Nigeria, apparently due to a competitive advantage afforded *C. p. fatigans* by its greater tolerance for DDT. Macdonald (1956) showed experimentally that many more *A. aegypti* than *Aedes albopictus* adults emerged when equal numbers of these two container breeders were reared together in earthenware jars and in tree-

holes; and according to Rudnick (1965), *A. aegypti* has almost completely replaced the indigenous *A. albopictus* in Bangkok, Thailand.

Aedes triseriatus (Say) is rated as the most domesticated of the North American tree-hole mosquitoes (Jenkins and Carpenter, 1946), and in the southeastern United States its larvae are often found in the same container as those of *A. aegypti*, particularly in used tires. Any interspecific competition which may take place between associated mosquito larvae should be most intense between species whose ecologies show marked areas of overlap. By virtue of its ecological similarity to *A. aegypti*, *A. triseriatus* is a likely competitor in the larval stage. A number of rearings were set up under controlled conditions to investigate the effects of different initial species proportions and varying larval food supply on the relative survival and competitive abilities of these two mosquitoes.

PROCEDURES AND MATERIALS. Eggs of *A. aegypti* and *A. triseriatus* deposited on paper toweling strips were hatched by immersion in tap water. Nitrogen was bubbled through the water to provide a hatching stimulus by displacing oxygen. As soon as a sufficient hatch was obtained, 50 larvae were transferred to each of five 1-pint plastic cups in the following proportions of *aegypti* to *triseriatus*: 50:0, 37:13, 25:25, 13:37, and 0:50. The initial larval density in each cup was one per square centimeter of water surface. Water depth was 5 cm. and evaporation loss was replaced daily. The larvae were reared in an environmental chamber providing constant conditions of $80^{\circ} \pm 1^{\circ}$ F., 80 percent ± 2 percent relative humidity, and a photoperiod of 14 hours.

At the Technical Development Laboratories, larvae of both species are

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routinely reared on ground dog chow passed through a 40-mesh screen and fed at the rate of 0.15 mg. per larva on the first day, 0.30 mg. per larva on the second day, and 0.60 mg. per larva each day thereafter until pupation. This feeding schedule was adopted as the standard ration in the present experiment. The standard ration was added to one set of five containers. Other sets received double, half, and quarter rations, respectively. Three replicates were used. When pupation or evident larval mortality occurred, the amount of food added to each container was reduced accordingly so that the daily ration per larva was kept constant. At the same time each day, pupae were transferred by means of a wide-mouth pipette to netting-covered 1-pint ice-cream cartons and returned to the rearing chamber until emergence. Adults were aspirated from the cartons and chloroformed. The emergence was tallied daily by species and sex.

RESULTS AND DISCUSSION. Restriction of the larval food supply resulted in a marked increase in development time for both species but the responses were not identical. Table 1 shows the number of days

TABLE 1.—Days required to obtain 90 percent or more of the adults produced by *A. aegypti* and *A. triseriatus* when reared together in different proportions at four food levels.

| | Proportion | Ration | | | |
|--------------------------|------------|--------|------|----|----|
| | | 2X | Std. | ½ | ¼ |
| <i>Aedes aegypti</i> | 100% | 9 | 10 | 12 | 18 |
| | 75% | 9 | 10 | 11 | 16 |
| | 50% | 8 | 9 | 11 | 14 |
| | 25% | 8 | 9 | 10 | 11 |
| <i>Aedes triseriatus</i> | 100% | 13 | 13 | 14 | 23 |
| | 75% | 13 | 13 | 15 | 25 |
| | 50% | 12 | 13 | 15 | 26 |
| | 25% | 13 | 13 | 15 | 23 |

after hatching required by each species to produce 90 percent or more of the adults obtained at the various food levels. On the standard ration, *A. aegypti* attained its 90 percent emergence mark in 9 to 10 days

while *A. triseriatus* required 13 days. When the daily ration was doubled, *aegypti* gained a day but the development time of *triseriatus* appeared unaffected. Reduction of the food supply to half the standard ration slowed the development of both species alike by 1 to 2 days. In pure culture, *A. aegypti* required 8 days longer on quarter ration than it did on standard ration to produce 90 percent of the adults obtained. The comparable increase for *A. triseriatus* was 10 days. Keirans and Fay (1968) noted the same 2-day difference in the responses of these two species to larval food restriction in terms of the time required for 90 percent pupation at 80° F. In mixed cultures the quarter-food level produced a differential effect. In the absence of *A. triseriatus*, *A. aegypti* took 18 days to develop 90 percent of the adults produced; but as the initial proportion of *A. triseriatus* larvae in the container was increased, the retarding effect of restricted food supply was progressively lessened. When three-quarters of all larvae initially in a container were *A. triseriatus*, the *A. aegypti* emergence from that container reached the 90 percent parameter in only 11 days. Except for a reversal which occurred when *A. triseriatus* made up 25 percent of the population, an opposite, though less pronounced tendency for *A. aegypti* larvae to retard development of *A. triseriatus* in the same quarter-ration container was evident.

In contrast to the normal 1-day difference in emergence of male and female *A. aegypti* adults, a 3-day lag occurred at the quarter-food level in the absence of *A. triseriatus*. The lag decreased to less than 1 day, however, when *A. triseriatus* larvae were present in a 3:1 proportion. No consistent change in the emergence pattern of male and female *A. triseriatus* was observed as the species ratio changed. Its speeded development in response to a double ration and the advantage it obtained at quarter ration from increasing proportions of *A. triseriatus* larvae clearly indicate that *A. aegypti* is the more efficient species, both at utilizing larval food

when it is unusually abundant and at obtaining it under conditions of scarcity.

Pre-adult mortalities varied greatly (Table 2). The high mortalities sustained

TABLE 2.—Percent mortalities sustained by *A. aegypti* and *A. triseriatus* reared together in different proportions at four food levels.

| | Proportion | Ration | | | |
|--------------------------|------------|--------|------|----|----|
| | | 2X | Std. | ½ | ¼ |
| <i>Aedes aegypti</i> | 100% | 6 | 0 | 5 | 5 |
| | 75% | 4 | 6 | 5 | 31 |
| | 50% | 16 | 0 | 0 | 11 |
| | 25% | 15 | 5 | 10 | 18 |
| <i>Aedes triseriatus</i> | 100% | 42 | 3 | 5 | 35 |
| | 75% | 53 | 13 | 9 | 31 |
| | 50% | 18 | 1 | 13 | 19 |
| | 25% | 10 | 10 | 8 | 15 |

by *A. triseriatus* on double ration when it constituted 75 percent and 100 percent of the container population were very likely caused by pollution. Bacterial surface films were observed in these containers. The low mortalities which characterized *A. aegypti* at the double food level and the higher population ratios are in marked contrast. Surface films did not appear in these containers and the mortality figures attest not to a greater tolerance by *aegypti* for water pollution but rather to its more efficient use of large quantities of food as a result of a faster rate of development. Incomplete emergence of weak adults contributed heavily to the mortalities recorded at the quarter-ration level, especially for *A. triseriatus*. This species appeared somewhat more severely affected by the intensified larval competition resulting from food shortage than did *A. aegypti*.

Its shorter development time under all experimental conditions, its greater efficiency in utilizing abundant larval food, and its ability to take advantage of the slower growth rate of its competitor when food was scarce all have shown *A. aegypti* to be superior to *A. triseriatus* in the container habitat. In terms of larval competition in mixed populations, no com-

bination of food level and species ratio was found or indicated in which *triseriatus* had any competitive advantage.

SUMMARY. The competitive abilities of *A. aegypti* and *A. triseriatus* larvae in mixed populations were compared by rearing them together under controlled conditions at four food levels and in five species proportions. Double, standard, half, and quarter daily rations of ground dog chow were added to containers holding 50 larvae in the following *aegypti* to *triseriatus* proportions: 50:0, 37:13, 25:25, 13:37, and 0:50. Adjustments for pupation and larval mortality kept the daily ration per larva constant at each food level.

A restricted food supply increased the development time of both species in pure culture, the effect on *A. triseriatus* being the more pronounced. In mixed cultures the effect of food restriction on the growth of each species was influenced by the presence of the other. The development time of *A. aegypti* was lessened by increasing proportions of *A. triseriatus* larvae, while the presence of *A. aegypti* had an opposite, though much less pronounced, effect on *A. triseriatus*.

When larval food was abundant, *A. aegypti* was the more efficient at utilizing it and was thus less subject to pollution of the water. Larval mortality of *A. triseriatus* was higher than that of *A. aegypti* in nearly all rearing containers.

In terms of larval competition *A. aegypti* proved to be the superior species under all the combinations of species proportions and food levels tested.

Literature Cited

- HAYES, G. R., JR., and RITTER, A. B. 1966. The diminution of *Aedes aegypti* infestations in Louisiana. Mosq. News 26(3):381-383.
- JENKINS, D. W., and CARPENTER, S. J. 1946. Ecology of the tree hole breeding mosquitoes of nearctic North America. Ecol. Mono. 16(1):31-47.
- KEIRANS, J. E., and FAY, R. W. 1968. Effect of food and temperature on *Aedes aegypti* (L.) and *Aedes triseriatus* (Say) larval development. Mosq. News 28(3):338-341.
- MCCRAY, E. M., JR., WILTON, D. P., and

SCHOOFF, H. F. 1967. Preliminary observations concerning the absence of *Aedes aegypti* in Savannah, Georgia, and nearby areas. Proc. 54th Ann. Mtg. New Jersey Mosq. Exterm. Assoc. pp. 152-158.

MACDONALD, W. W. 1956. *Aedes aegypti* in Malaya. II. Larval and adult biology. Ann. Trop. Med. Parasit. 50(4):399-414.

MAYR, E. 1963. Animal species and evolution.

Belknap Press, Harvard University, Cambridge, Mass. 797 pp.

RUDNICK, A. 1965. Studies of the ecology of dengue in Malaysia: a preliminary report. J. Med. Ent. 2(2):203-208.

SERVICE, M. W. 1966. The replacement of *Culex nebulosus* Theo. by *Culex pipiens fatigans* Wied. (Diptera, Culicidae) in towns in Nigeria. Bull. Ent. Res. 56(3):407-415.