SEASONAL VARIATION IN AUTOGENY IN *CULEX TARSALIS* COQ. IN NORTHERN CALIFORNIA [1]

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The process of autogeny (i.e., ovarian development without the usual protein-rich food source) [3] has long been known in mosquitoes, and more recently in other biting Diptera (Theobald, 1901; Smith, 1904; Roubaud, 1929; Detinova and Butenko, 1955; Bellamy and Kardos, 1958; Downes, 1958; Lea and Lum, 1959; Davies, 1961; Johnson, 1961, Williams, 1961; Chapman, 1962).

Since the introduction of the term *autogene* by Roubaud (1929), a number of workers have investigated various aspects of this process (Ball and Clark, 1953; Deduit and Callot, 1955; Möllring, 1956; Spielman, 1957; Twohy and Rozeboom, 1957; Chen, 1959; Larsen and Bodenstein, 1959; Kardos, 1959; Chaniotis, 1960). Most of the investigations in this area have dealt with members of the *Culex pipiens* complex of mosquitoes. Much work remains to be done in determining the exact factors (internal and external) which permit the expression of autogeny, and whether these elements vary among the different groups of flies which possess this capability.

Observations on *Culex tarsalis* in relation to autogenous egg production were made as part of a larger study of the biology and flight range of this species in the Sacramento Valley of California. Initially, the aim of this particular phase of the work was to determine the percentage of autogeny in local populations of *C. tarsalis,* and such experiments were begun in the late summer of 1960. In the spring of 1961 a similar test was made, but with very different data resulting. It was this difference in results which prompted a continuation of the work.

Materials and Methods. Samples of pupae were taken from May through October, 1961, from a number of locations (Fig. 1). The sites near Knights

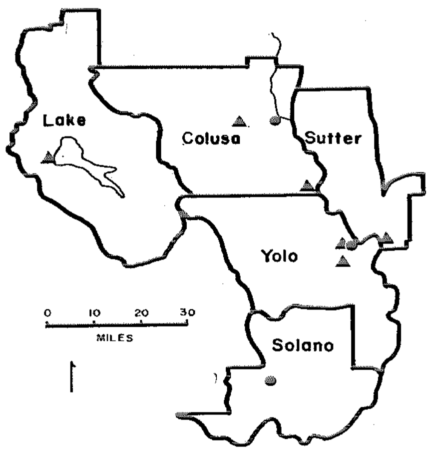

Fig. 1.—Locations of nine collection sites for *C. tarsalis* in northern California. Localities sampled in 1961 marked by triangles, 1962 by circles.

Landing (Yolo County and Sutter County) were the main localities under observation, since this area was already the center for the other *tarsalis* project studies. However, a continuous source of *C. tarsalis* was not always available at most of the locations due to local control operations.

From May to October, 1962, samples were taken from three localities: (1) rice field drainage ditch, 1 mi. S.W. of Colusa County; (2) rice field seepage, 1 mi. W. of Knights Landing, Yolo County; (3) spring seepage, alkali pasture, 1 mi. N.E. of Fairfield, Solano County. These sites

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[3] Or, ". . . the absence of a developmental diapause condition of the ovary" (Spielman, 1957).

were in a north-south direction, covering a distance of about 65 miles. Larvae at each site were reared in screened enclosures (3 ft. x 3 ft. wide x 1 ft. high) anchored in the mud bottom, with the upper 6 to 8 inches above the water level. The purpose of these "pens" was to facilitate observation and collection of the larvae. Water temperature records were kept by means of recording thermometers (Marshalltown Model 1000) at each of the three locations. The sensitive bulbs of the recorders were located 1 to 3 inches below the water surface. Specimens for the study were taken from the pens, and from surrounding water when available.

In both years, samples consisted only of specimens in the pupal stage, as larvae reared in the laboratory were observed to produce fewer eggs. The collected pupae were allowed to emerge in small containers (one-pint ice cream carton attached to a one-pint Kerr wide mouth Mason jar) at room temperature (70° ± 5° F.). Food for the caged adult females consisted of raisins, 10 percent (by weight) sucrose solution, or both. After approximately 10 days the ovaries of these females were dissected out and examined for development. Eggs in stages IV or V of Christophers (1911) were regarded as having been produced autogenously. These eggs and any rafts which had been laid were totaled to obtain the number of eggs produced by each specimen. The bodies of all females examined during 1962 were mounted and labeled for future study.

In the two seasons reported upon, about 400 female *C. tarsalis* were examined.

RESULTS. Collection data for samples taken from May through October, 1961 and 1962, are shown in Figure 2. Auto-

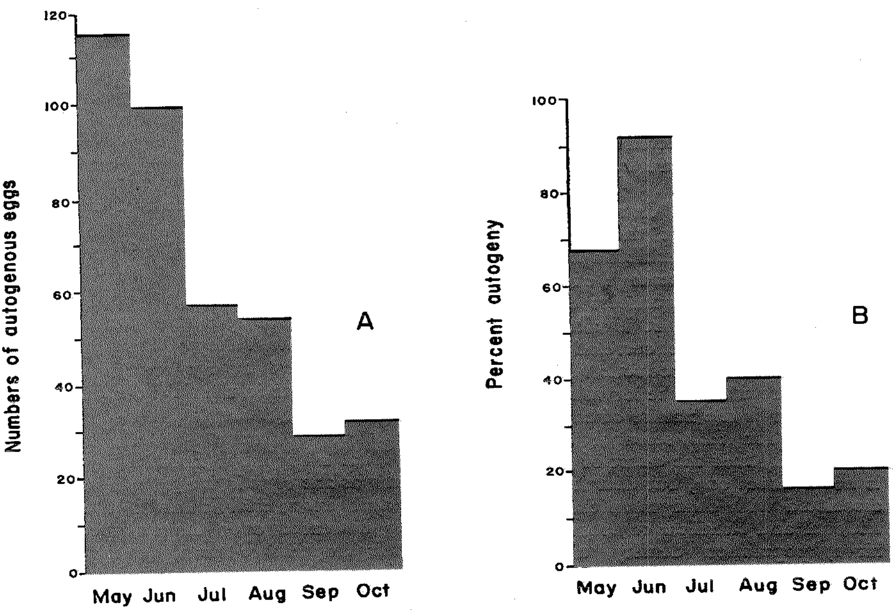

FIG. 2.—Autogeny in *C. tarsalis* during 1961 and 1962, summarized for nine localities by months. (A) Average numbers of eggs produced by autogenous females. (B) Percent autogenous females in the samples.

genous females taken in the spring and early summer of both years produced an average of 116 (May) to 100 (June) eggs, with individual specimens forming as many as 220 eggs.[4] The percentage of autogenous females in the samples during this period was high (67 percent in May, 92 percent in June). Egg production by autogenous females decreased during the mid-summer months to averages of 56 (July) and 54 (August) eggs per female. The percentage of autogenous females in the samples also decreased (35 percent in July, 40 percent in August). During September and October, the number of autogenous eggs produced and the percentage of autogenous females in the samples were further reduced.

During 1962, there was only a moderate correlation between high temperature and high egg production. Average daily water temperature during the larval period was compared with number of eggs produced by autogenous females. Calculation of the correlation coefficient ($r = \frac{\Sigma z_x z_y}{N}$) between these two factors gave the value $r=0.61$. Additional investigations are being conducted in this area using controlled temperature cycles in the laboratory.

Discussion. The data presented here clearly indicate that the *Culex tarsalis* populations studied exhibit a wide seasonal change in both percentage of autogenous individuals and in numbers of eggs produced per female. It is also seen that there is a moderate correlation between autogenous egg production and water temperature during the larval stage. What is not clear is the nature of the factors responsible for this seasonal change. It seems likely that the effect of temperature is not a direct one, but that it is probably associated with changes in the whole nutritional and chemical environment of the larva, population density, and possibly other factors. Future work is being planned to find answers to some of these problems.

Another matter, which should be of interest to taxonomists, is the question of whether the mechanisms of autogeny differ from one taxonomic group to another. Much of the confusion found in this area may be semantic in nature. The condition of "anautogeny" is the unusual state if one looks at the overall picture of the Diptera, though as Downes (1958) points out, the autogenous forms within the Nematocera are widely scattered among the different families. In view of the increasing numbers of autogenous groups which have been found in recent years, it may be that this supposed uneven occurrence has been due to lack of observation or inadequate techniques. Much of the answer to this question may come from the investigations of various workers on the mechanisms of autogeny in different species. If the basic mechanisms responsible for the expression of autogeny differ from species to species, then the case for autogeny as a secondary development will be fairly well established. Conversely, if the mechanisms are the same in all groups (which seems doubtful at present), then *anautogeny* must be given more consideration as the secondary form of ovarian development.

Summary. The level of autogeny in field populations of *Culex tarsalis* Coq. was measured during the spring and summer of 1961 and 1962 at eight locations in the Sacramento Valley of California. Egg production by autogenous females collected as pupae in the field decreased from an average of 116 eggs per female in May to 27 eggs per female in September. Individual autogenous females produced as many as 220 eggs in May. The percentage of autogenous individuals in the samples also decreased over the summer. High water temperature during the larval period showed a moderate correlation with increased egg development ($r=0.61$). The seasonal change and the relation of autogeny to the phylogeny of the Nematocera are discussed briefly.

[4] During the study a total of 34 specimens were observed to produce 125 or more autogenous eggs (about 8.6 percent of all females examined).

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