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THE ACTIVITY AND PHYSIOLOGICAL STATUS OF PRE- AND POSTHIBERNATING *CULEX SALINARIUS* (DIPTERA: CULICIDAE) POPULATIONS[1,2]

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Abstract. *Culex salinarius* populations were monitored in New Jersey, USA, to define the seasonal distribution and host-seeking behavior of the species during the fall and spring. Data from a light trap operated year-round from July 1975 through June 1979 showed that *Cx. salinarius* adults remained active until late November or early December. Results of collections made with CO_2-baited CDC traps indicated that the species continued to seek a host throughout the fall. Ovarian dissections revealed that nearly all of the mosquitoes sampled in the fall were nulliparous, although over 90% of the first mosquitoes collected during the spring were parous. These data suggest that *Cx. salinarius* accepted a blood meal very late in the season and completed a gonotrophic cycle before leaving hibernation. Such behavior could allow the species to function as a reservoir for arboviruses throughout the winter.

According to the classification of mosquito seasonal cycles described by Bates (1949), *Culex* mosquitoes usually survive winter conditions as inseminated adult females. In general, these insects show a reduction in host-seeking activity during the fall, feeding almost exclusively on nectar sources to accumulate fat reserves for hibernation (Bellamy & Reeves 1963, Burdick & Kardos 1963, Clements 1963, Spielman & Wong 1973a).

Laboratory studies with a colonized strain of *Culex salinarius* Coq. however, indicate that unlike most members of the genus, the species cannot develop fat bodies for overwintering and will continue to seek a host at low temperatures and short photoperiods (Eldridge et al. 1976). Behavior of this sort in natural populations of *Cx. salinarius* might enable the species to ingest and maintain encephalitis viruses during the winter. The present study was undertaken to determine the likelihood of such an occurrence.

MATERIALS AND METHODS

The research was conducted at a coastal site in Barnegat, New Jersey, USA, where large populations of *Cx. salinarius* were produced from a series of freshwater impoundments. A New Jersey light trap was operated continuously from 1975–1979 to determine the extent of *Cx. salinarius* activity in all seasons. The trap was emptied daily from May until October and biweekly from November through April.

CDC light traps baited with CO_2 were used to study the autumnal host-seeking behavior of the species more closely. During the fall of 1977, 3 of the traps were operated biweekly from September until specimens were no longer collected. The live catches were transported to the laboratory and frozen at −70 °C until the samples could be processed. The entire collection was later identified and counted. When sufficient numbers were captured, at least 20 *Cx. salinarius* from each trap were dissected to determine the parous rate of the population by ovarian tracheation (Detinova 1962).

Collections with the CDC traps were resumed in the spring of 1978 and 1979, approximately 1 month before light trap data from previous years indicated the emergence of *Cx. salinarius* from hibernation. In addition, 12 modified Berlese funnels were inverted over the openings of assorted animal burrows in the early spring to capture adult mosquitoes that would be leaving hibernation from these natural shelters. Larval sampling was also conducted at 4 stations during 1978 to detect the earliest oviposition after hibernation.

RESULTS

Light trap data listed in TABLE 1 show that *Cx. salinarius* were present in large numbers at the study site from 1975 to 1979. Although the majority of specimens were captured during June, July and August, the data indicate that *Cx. salinarius* were often collected late into the fall. This behavior was most apparent during 1975, when al-

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TABLE 1. Monthly totals of ♀ *Culex salinarius* collected by light trap in Barnegat, New Jersey from July 1975–June 1979 compared with mean temperatures for the area.*

	1975–76		1976–77		1977–78		1978–79	
MONTH	No. mosq.	Mean temp °C	No. mosq.	Mean temp °C	No. mosq	Mean temp °C	No. mosq	Mean temp °C
July	61,276	23.6	1023	23.4	15,842	24.8	22,838	22.8
August	30,629	24.2	2898	22.5	14,136	23.8	21,472	24.7
September	4428	18.4	1046	19.1	10,669	20.8	5034	19.0
October	1641	15.7	498	11.2	1176	12.8	432	13.3
November	9880	10.6	10	5.0	92	9.2	701	9.0
December	1003	3.3	0	−0.2	30	1.9	916	3.4
January	0	−1.7	0	−5.2	0	−1.1	1	0.8
February	4	5.1	0	1.1	0	−3.8	0	−4.3
March	6	6.9	0	7.9	0	3.9	1	6.9
April	2	12.0	4	11.8	0	10.0	8	10.1
May	93	15.4	314	17.6	560	13.8	737	16.4
June	522	22.4	7371	20.6	10,239	20.5	12,166	19.2

* Compiled and analyzed by the authors from Ocean County Mosquito Extermination Commission records.

most 10,000 adult females of the species were trapped in November and over 1000 were caught during December. Small numbers were even collected throughout most of the winter months in 1976. TABLE 1 also provides a comparison of the winter catch of *Cx. salinarius* with temperature data for the area.

The CO_2-baited CDC traps revealed important information on the host-seeking activity of *Cx. salinarius* prior to hibernation (FIG. 1). Large numbers of the species were attracted to the traps from September through early November. Ovarian dissections showed that relatively few parous mosquitoes sought a host during September and October, and by November only nulliparous specimens were collected.

No mosquitoes were caught in the animal burrow traps. Large numbers of Calliphoridae, Tipulidae, and Chironomidae were captured, however, which demonstrated the ability of these units to catch insects leaving the habitat.

The spring CDC trapping yielded indirect evidence of blood feeding and subsequent oviposition or egg resorption by *Cx. salinarius* during the fall or winter. The first mosquitoes collected during early May revealed a 90% parous rate. No larvae were found until after this time, enhancing the probability that the adults collected were part of the overwintering generation and had not recently emerged. As the larvae developed into adults later in the month, the parous rate of the population decreased rapidly over a 2-week period. This pattern was evident in the spring of both 1978 and 1979.

DISCUSSION

During the autumn, members of the genus *Culex* usually cease blood feeding and enter a period of facultative diapause (Bellamy & Reeves 1963, Blackmore & Dow 1962, Clements 1963, Hayes 1973). In addition, these mosquitoes generally build up fat body reserves to survive the winter (Buxton 1935, Clements 1963, Schaefer & Washino 1969).

Data from both the light trap (TABLE 1) and the CO_2-baited CDC traps (FIG. 1) show that *Cx. salinarius* remains active and continues host-seeking during the fall, long after other *Culex* mosquitoes in the region have entered diapause. In addition, virtually all of the *Cx. salinarius* sampled by the CDC traps in the fall were nulliparous, though the first collections made in the spring exhibited a parous rate of over 90%. These results offer circumstantial evidence of actual blood feeding and ovarian development by the species during the fall or winter months and suggest that *Cx. salinarius* exits hibernation seeking a 2nd blood meal.

This information is supported by the laboratory work of Eldridge et al. (1972, 1976), who indicated that *Cx. salinarius* enters a period of facultative hibernation classified as oligopause (Mansingh 1971, Thiele 1973). Under simulated fall conditions that triggered diapause in *Culex pipiens* L. and *Culex restuans* Theo., *Cx. salinarius* females were shown to be capable of blood feeding. Once engorged, the species could not utilize this protein source to develop fat reserves and instead completed the gonotrophic cycle, although cold temperatures retarded the process substantially. Mosquito over-

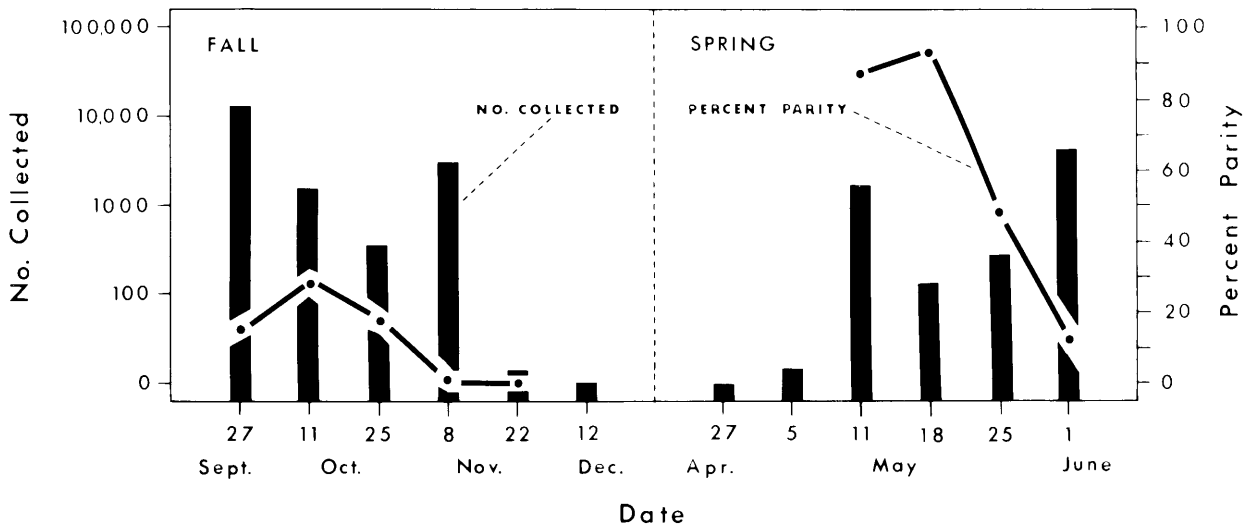

FIG. 1. The number and physiological status of *Culex salinarius* collected in CO_2-baited CDC traps in New Jersey during the fall and spring of 1977 and 1978.

wintering mechanisms remain a controversial subject, however, and some workers might feel that based on the description of Lees (1955), *Cx. salinarius* enters a state of quiescence rather than diapause.

The fate of eggs that might be developed over the winter is not clear. The ovarian cycle might be completed during hibernation, and the eggs oviposited in the spring might initiate the summer population. *Cx. salinarius* might also resorb the developing embryos, a phenomenon observed in *Culex pipiens* under laboratory conditions (Spielman & Wong 1973b).

The actual overwintering site of *Cx. salinarius* remains uncertain. Related species, such as *Cx. tarsalis* and *Cx. pipiens*, have been collected in large numbers from both artificial and natural shelters (Bennington et al. 1958, Bellamy & Reeves 1963, Nelson 1964, Hayes 1973, Bailey et al. 1978). Accounts of finding hibernating *Cx. salinarius*, however, are infrequent. Although Wallis et al. (1958) gathered 910 overwintering specimens from the basement of an abandoned farmhouse in southern Connecticut, other researchers have had little success in locating the species within artificial shelters, despite intensive searching (Lomax 1970, Eldridge et al. 1976). Even though *Cx. salinarius* was not found in animal burrows during the present study, Murphey (1961) trapped 25 females exiting woodchuck burrows during the spring in Delaware and speculated that the species may hibernate primarily in natural shelters.

The results of the current field research demonstrate the ability of *Cx. salinarius* to seek hosts and possibly to blood feed at a time when other *Culex* are entering diapause. Combined with evidence of St. Louis encephalitis transmission by the species (Chamberlain et al. 1959, Clark et al. 1977), the behavior exhibited by *Cx. salinarius* may allow this mosquito to function as an overwintering reservoir of certain arboviruses.

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