THE BIO-ECOLOGY OF *CULEX ERYTHROTHORAX* DYAR

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Not much has been published on the biology and ecology of *Culex erythrothorax*. The lack of interest in this species is probably due in part to its limited distribution in the West, an incomplete knowledge of its habits, and the absence of available knowledge as to its potential as a vector of diseases, especially Western encephalitis virus. Chapman (1959) reported large overwintering larval populations of *erythrothorax* in Nevada, which is probably the first record of any *Culex* overwintering as larvae in this country. The writer has made many observations on the biology and ecology of this species from 1958–61 and much of the pertinent information is included herein.

C. erythrothorax is known from Mexico, Arizona, California, Idaho, Nevada, Texas, and Utah. The writer has collected it in Nevada from Churchill, Douglas, Lyon, Mineral, Nye, Ormsby, and Washoe Counties. It has not been collected in the eastern part of the State.

FIELD STUDIES. Ecology.—Breeding sites in Nevada were slightly alkaline seep ponds, fresh-water impoundments and springs, irrigation seep areas and ditches, and overflow areas adjacent to hot springs. Vegetation present in these breeding sites was usually the common tule (*Scirpus acutus* Muhl.), cattail (*Typha angustifolia* L.), and three-square (*Scirpus americanus* Pers.), especially the last plant. The largest larval numbers were invariably dipped in the vicinity of three-square, especially where the plant had fallen over and touched the water surface. Larvae are very easily disturbed and quick to sound, and without a realization of this habit, dipping results can be very unfruitful and unreliable. This micro-habitat appears to provide excellen[t] protection for the aquatic stages of *eryth-rothorax* from its many predators. Som[e] potential predators often observed in-cluded nymphs and adults of Notonectida[e] and Belostomatidae, larvae and adults o[f] Hydrophilidae and Dytiscidae, caddisfl[y] larvae, dragon and damselfly naiad[s], planaria, and fish. Breeding sites wer[e] generally open, sunlit areas but occasion[al] collections were made in semi-shade[d] habitats.

A study of the water from 46 breedin[g] sites of *erythrothorax* in 1960–61 fro[m] the seven Nevada Counties indicated th[e] pH ranged from 6.8–9.1 with a mea[n] of 7.6 and the total soluble salts range[d] from 237–7,320 p.p.m. with an average o[f] 1,780 p.p.m. *C. erythrothorax* breedin[g] is evidently excluded from areas of highe[r] alkalinity since breeding was absent i[n] many adjacent water bodies possessin[g] higher pH readings. Three-square ap-peared to be an excellent indicator of th[e] possible presence of *erythrothorax*. Bot[h] three-square and *erythrothorax* were gen-erally absent in areas possessing a hig[h] alkalinity; desert salt-grass (*Distichl[is] stricta* (Torr.)) was usually the domina[nt] plant species in these situations.

Associated mosquito species in the f[ield] were *Culex tarsalis* Coq. and *Culise[ta] inornata* (Will.), both of which were al[so] found in areas with a much high[er] alkalinity. Initial breeding of *Anophel[es] freeborni* Aitken was often observed [in] the spring with *erythrothorax*. Seama[n] (1945) and Freeborn and Bohart (195[1]) in California listed marshes, tule pon[ds] and tule swamps as breeding sites [of] *erythrothorax* where it was associated wi[th] *Culex thriambus* Dyar, *Culex restua[ns]* Theob., *C. tarsalis*, and *Anopheles fre[e]borni*. Rees (1943) in Utah observ[ed] *erythrothorax* in shallow pools with abu[n]dant vegetation. In a later study in Ut[ah]

[1] In cooperation with the Nevada Agricultural Experiment Station, Reno, Nevada; approved for publication by Dr. Ray E. Ely, Associate Director.

Beck (1961) reported the aquatic stages rom a great variety of habitats which ncluded permanent and intermittent roadide pools, marshland pools, streams, irriation ditches, gravel pits, street gutters, nd city park and residential ornamental ools. It was the fourth most common nosquito found breeding during that urvey.

Biology.—The life history of *erythrohorax* apparently varies between Nevada nd at least the adjacent State of Utah. The typical life cycle in our six northern nd central counties is similar. Egg rafts re laid in September to early November. Most of these overwinter as second to ourth instar larvae and adult emergence akes place from March to early May. All f our records over a 3-year span indicate nly one principal brood each year. Small umbers of larvae pupate and adults merge in late October and early November and it is possible that some of hese adults hibernate. Some biting has een observed from these late fall females. Light breeding of *erythrothorax* has been oted in May and early June with no reeding observed from then until Sepember. Seven different broods were lipped weekly from fall until spring from 958–61 and pupae were never collected fter November 3 and prior to February 4. First, second, and third instar larvae vere noted as late as December 19, March 3, and April 14, respectively. These overvintering larval broods of *erythrothorax* ometimes averaged as high as 40 per dip or 55 dips and single dips often possessed nore than 125 larvae.

Overwintering in the aquatic stages is raught with many dangers. Only three f the above-mentioned seven broods sucessfully overwintered. Two broods were ompletely eliminated and two were decinated. Reductions were caused by drainng of breeding sites following the hunting season, by "eat-outs" from ducks and eese, which eliminated all emergent vegeation, and by the formation of thick ice vhich remained for long periods of time. The detrimental effect of long-standing, hick ice against *erythrothorax* was not especially noticeable in breeding sites that contained an abundance of emergent vegetation. Populations were often depleted or eliminated in those breeding sites that possessed only shore-line vegetation. These reductions were thought to be due in part to the mechanical action of freezing the larvae within the ice but mostly to forcing the larvae away from the protection of the vegetation along the shore into the open water and predators.

Only a few observations were made in the southern part of the State (Nye County) and these indicated a different time schedule undoubtedly due to warmer temperatures. There pupae and biting adults were prevalent in early February.

Biting adults have been noticed only in February–June and from September–November. The absence of adults and the lack of larvae in the warmest summer months may be indicative of aestivation. Evidence in support of this theory was observed in some fresh-water springs in the Amargosa Desert (Nye County) in July. Several times the writer parted matted bunches of three-square lying parallel to and above the water surface, and large numbers of *erythrothorax* females flew up. Suitable breeding habitats were plentiful but only a few larvae were collected.

Discussion. Pratt (1959) proposed a classification of life histories of North American mosquitoes. The life-history type of *erythrothorax* as it occurs in Nevada, is difficult to categorize since it appears to be dissimilar in some respects to all eleven of Pratt's proposed types. These differences are not unexpected since this species is the only *Culex* known to overwinter in the larval stage. *C. erythrothorax* appears to be closest to the "*Culiseta melanura* type" (larvae overwinter, eggs laid on water surface, and several generations a year). As mentioned above, *erythrothorax* differs from this type as it has only one principal generation each year.

Beck (1961) reported an entirely different life history for *erythrothorax* in Utah. Peak larval breeding occurred in early

August and the largest numbers of adults were attracted to light traps in July–September. This species was observed to to overwinter there as gravid females, principally in potato and fruit cellars. Small larval populations were observed covered with ice in the winter. Since the climate of Utah County and our Nevada areas is not too different, the reasons for such a dissimilar life history are not known. Nevada has been in the throes of a 3-year drought and many of our areas which normally produce *erythrothorax* broods have not contained water until fall. However, sufficient breeding sites were available for summer breeding but were not utilized.

Importance.—To date *erythrothorax* is only considered a distinct pest of man because of its biting habits (Rees, 1943; Carpenter and LaCasse, 1955; Beck, 1961). Since its breeding sites in Nevada are not abundant and are often located away from humans, it is not considered an important species. It does not hesitate to attack throughout the day when its haunts are invaded. If more people and breeding sites were available, it could become a serious pest. *C. erythrothorax* was also observed to feed on chickens, mice, rats, squirrels, and lizards (Henderson and Senior, 1961).

It is very surprising that no attempted isolations of western encephalitis virus have ever been reported from *erythrothorax* even though it is an active day- and night-time feeder on humans, birds, and miscellaneous hosts. It frequents swamps and marshes inhabited by blackbirds and other migratory birds, and it is a fairly abundant species in California and Utah. It is equally amazing that no direct or indirect transmission of virus has been attempted in the laboratory with this mosquito. The sole record of its relationship to a disease was an experimental laboratory infection with the filaria *Wuchereria bancrofti* (Scott *et al.*, 1945).

LABORATORY STUDIES. Biology.—Chapman (1959), in reporting on observations of *erythrothorax* larvae brought into the laboratory in late fall and winter, stated that most larvae when held at room temperature and provided food would change instars, pupate, and the adults emerge over a period of weeks. Those samples retained in a room with uncontrolled temperatures, were not aerated, and mortality was a factor which always eliminated a considerable portion of the samples.

From November, 1960, to February 1961, many larvae were brought in from the field, provided with food, and retained in a room at 75° ± 5° F., either in distilled water in small paper cups or in aerated distilled water in pans. Of larvae which were brought in from the field in the fourth instar, the writer was never able to obtain higher than 46 percent pupation, excluding mortality (average = 34 percent). The average length of the tests was 56 days. Of larvae brought in from the field in the third instar and that molted to the fourth instar, the writer only attained a high of 34 percent pupation, excluding mortality (average = 3[illegible] percent). The average test length in the fourth instar was 40 days. Ninety-three percent of the fourth instar larvae brought in during late Februray pupated after [illegible] days. There can be no doubt that many of these overwintering fourth instar larvae were in a definite condition to diapause and would not feed and proceed through their life cycle. Some fourth instar larvae supplied with food at room temperature remained as larvae for 71 days. Several attempts to break diapause by increasing the photo-period were not successful.

The longevity of *erythrothorax* larvae when held in a refrigerator at about 57° F. was quite surprising. A fourth instar larva, collected in the field in early November and supplied with food, pupated after almost 24 weeks (165 days). A first instar larva collected at the same time and supplied with food, reached the pupal stage in about 28 weeks (195 days). A fourth instar larva kept in distilled water with no food, finally died after more than 8 months (246 days).

Colonization.—A laboratory colony of *rythrothorax* was established in 1961 and s now in the seventh generation. The olony was started from many fourth nstar larvae brought in from the field n January. Larvae were reared in white namel pans which contained either aer-ted distilled water or aerated water from breeding site. An adequate supply of round dog food was provided and by sing aeration, the water usually only eeded to be changed several times dur-ng the aquatic cycle. The shortest aquatic ycle observed was 13 days in water from breeding site and 15 days in distilled vater. A large percentage of the larvae ook longer than this time to mature. 'he following minimum times were ob-erved in the various instars and pupal tage: 2–3 days in the first, second, and iird instars; 4–5 days in the fourth in-tar; and 2–3 days in the pupal stage. 'upae were collected in containers and laced for emergence in cages measuring ither 20 x 21 x 26 inches or 18 x 27 x 28 nches.

Emerged adults were provided with ried raisins and 10 percent honey water nd sugar water on cotton pads. Females d readily on a human arm. The time equired to complete a blood meal ranged om 2 to 10 minutes, which indicated *ythrothorax* is somewhat of a slow, nethodical feeder. Some females fed on our separate occasions over a period of nany weeks. The maximum observed fe spans for males and females were and 13 weeks, respectively. The colon-zed adults appeared to be normal sized, rong, and healthy.

A pan of water from the breeding site as provided for egg deposition. Egg afts were deposited 4–7 days following ne blood meal. The maximum number f eggs noted in a raft was 195. Eggs nvariably hatched 3 days following ovi-osition. The lack of viability of many f the egg rafts was a problem during ne first several generations. In an at-empt to stimulate sexual activity, the umbers of mosquitoes were increased in the cages and the cages were often placed overnight in a room adjacent to windows so as to expose them to the normal change of natural daylight (Haeger, 1958). Considerable numbers of egg rafts were obtained (15–50) daily although some were still sterile. Egg rafts were more often deposited during the evening hours. All stages were held in a room that possessed a temperature of $75° \pm 5°$ F. and 75 ± 5 percent relative humidity.

Autogeny.—About 200 adults of *erythrothorax* (120 females) reared from field-collected larvae were confined in a cage measuring 9 x 9 x 11 inches and supplied with dried raisins, sugar and honey water, apple slices, and water for oviposition. No blood meal was offered to these mosquitoes. Fifteen small egg rafts were obtained beginning about 9 days after female emergence. Only one raft was viable and it produced 40 larvae. This is the first report of autogeny in *erythrothorax*.

SUMMARY. Water samples from 46 breeding sites of *Culex erythrothorax* possessed a mean pH of 7.6 ranging from 6.8–9.1. The total soluble salts ranged from 237–7,300 p.p.m., with an average of 1,780 p.p.m. This species has only one principal brood each year. Egg rafts were usually deposited from September to early November. Most of the resulting larvae overwintered in the second to fourth instars. Pupae were never observed after early November and prior to late February. Seven overwintering larval broods were dipped weekly over a 3-year span and of these, three populations overwintered without undue reductions, two were decimated, and two were completely eliminated.

Over 50 percent of the fourth instar larvae brought in from the field in late fall, held at room temperature, and provided with food, did not pupate during a 56-day period. Some of these diapausing fourth instar larvae remained as larvae for 71 days. A fourth instar larva held at a temperature of 57° F. in distilled water without food remained alive for 246 days.

A colony was established in 1961 and is now in the seventh generation. The aquatic cycle was completed in a minimum of 13 days when larvae were reared in aerated water from a breeding site. Males and females lived as long as 9 and 13 weeks, respectively. Some females made at least 4 feedings and the maximum number of eggs observed in a raft was 195.

Autogeny was observed for the first time for this species, as about 10 percent of a population possessed this trait.

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A SURVEY FOR AUTOGENY IN SOME NEVADA MOSQUITOES

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Autogeny is defined in the dictionary as "self-generation." Roubaud (1929) used the term autogeny to denote the trait which permits unfed females to deposit viable eggs. A further diversity in the meaning of autogeny was used by Spielman (1957), who described autogeny as the absence of a developmental diapause condition of the ovary. Autogeny is now considered by many investigators to encompass those individuals that are capable of developing a fully formed batch of eggs (stage V) without a blood meal o external source of protein. Attaching th requirements of oviposition or viabilit appears to be unwarranted, especially i laboratory studies, since these factors ar intimately connected with very differen stimuli. The criterion used here was base solely on the ability of the females t deposit eggs.

Excluding the genus *Toxorhynchites* which is said to be wholly autogenous approximately 30 species of mosquitoes i the world are reported in the literature a autogenous (Haeger, personal correspondence). Only 12 of these species occur i this country, namely, *Anopheles crucian* Wied., *Culex pipiens molestus* Forsk *Culex tarsalis* Coq., *Culiseta inornat*

[1] In cooperation with the Nevada Agricultural Experiment Station, Reno, Nevada.

[2] J. S. Haeger, Entomological Research Center, Vero Beach, Florida, provided the writer with the list of known autogenous species and their references.