NOTES ON ACTIVITIES OF ALASKAN *CULISETA* ADULTS (DIPTERA:CULICIDAE)

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Several standard mosquito trapping techniques used with considerable success in biological and arbovirus studies at lower latitudes, were tried out in the Cook Inlet area during the summer of 1963. The following information on *Culiseta* activities was in part a by-product of this trial trapping. Although limited, this information supplements the studies by Frohne (1953, 1954) on the bionomics of *Culiseta impatiens* (Walker) and *C. alaskaensis* (Ludlow), and by Price (1961) on *C. morsitans* (Theobald).

Information on flight activity of *alaskaensis, impatiens,* and *morsitans* was obtained from samples taken once a week from June 25 through October 9. The samples were collected in a funnel-trap mounted on top of a jeep which was driven, at 20 to 25 m.p.h., throughout the dairy farm area of Palmer, about 50 miles northeast of Anchorage, Alaska. Information on resting, mating, flying and swarming of *C. impatiens* and to a lesser extent, *alaskaensis,* was obtained on thirteen occasions between September 20 and October 21, by direct observation along the Seward Highway for a half mile below McHugh Creek, approximately 16 miles southeast of Anchorage on the shore of Turnagain Arm. The two localities are strikingly different.

The Palmer area consists of a broad floodplain with marginal hills, cultivated fields, pastures, wooded areas, some ponds, a slough, with mountains in the distance. Trial trapping runs were made here once a week during the last week of June and the first two weeks of July at hourly intervals from shortly before sunset until after sunrise. These runs showed that the total mosquito catch was greatest during the period immediately after sunset, so subsequent flight sampling was started just before sunset and continued for an hour after sunset. Time of sunrise and sunset was taken from the daily newspaper and agreed fairly well with the actual time the sun disappeared below the Aleutian Mountain Range. On June 25 sunrise was at 2:23 a.m. and sunset at 9:42 p.m. The sun rose and set approximately three minutes later and earlier respectively each subsequent day, with sunset occurring at 5:07 p.m. on October 9. Air temperature and relative humidity readings were determined by use of a sling psychrometer. Some *Culiseta* were caught on each trapping run through October 1. The temperature and relative humidity readings at the beginning of the runs ranged from 62° to 49° F. and 58 percent to 94 percent, and at the end of the runs from 60° to 40° F. and 61 percent to 100 percent.

C. alaskaensis was represented in the trap collections by a total of 74 specimens (47 males, 27 females). The first males were caught July 10 and males were taken on each run thereafter through October 1, but were most numerous on August 27. Females were taken intermittently and in declining numbers from June 25 through August 20, but some or all of these may have overwintered. Females first occurred in consecutive weekly collections September 5 and were most numerous on that date. They were last taken October 1.

C. impatiens was the least numerous with only 39 specimens (27 males, 12 females) taken in the trap collections. The first male was caught July 18; and except for a few overwintered females in the June collection, the first females were caught August 20. Both sexes were most numerous in the August 27 sample, with the latest record for females being Sep-

tember 23 and males, October 1. A mating pair, consisting of an *impatiens* male and a *morsitans* female, was found (dead) in the August 13 catch. Mating probably took place in the 5 x 5 x 5-inch collecting cage.

C. morsitans was the most abundant *Culiseta* in the trap collections with 98 specimens (35 males, 63 females). The first male was caught on July 3, on the midnight run, and males were again taken the following week in the midnight to sunrise collections, but males did not occur in the sunset collections until July 27. The first female was taken July 18—the greatest number of males, September 11—females September 18; and the last collection of each sex was October 1. The females outnumbered the males, and this was the only species of *Culiseta* taken in the few midnight to sunrise collections. Gravid females were not taken, so in this area perhaps inseminated females overwinter, instead of eggs as suggested by Price (1961), with reference to Minnesota.

Judging from these trapping samples, the following observations southeast of Anchorage occurred well after the seasonal activity peak. Observations and collections were made on September 20, 21, 22, 24, 25, 28, and October 2, 3, 8, 10, 11, 17, and 21.

In the McHugh Creek area the mountains abruptly meet the shoreline, which lies in a northwest-southeast direction. A ridge rises at the mouth of the creek from 250 feet in elevation and extends eastward two miles to a 3,500 foot peak. The blacktop highway is less than fifty feet above the shoreline. Cliffs above the highway have a few accessible cracks up to six inches wide, and at scattered places there are patches of boulders at the base of the cliffs. The nearest marshy area of any size appears to be at least five miles away, —up the highway at Potter, down at Indian, and across the water in the vicinity of Hope.

C. alaskaensis and *impatiens* were the only species of mosquitoes collected in this area during these observations, and they were more plentiful at three particular sites which were examined at each visit. Each was a cavity just a few feet above the highway.

Site 1 was a large hole formed by a big boulder, flat on the underside, resting at an angle on other boulders several feet apart at the top. The cavity narrowed downward for about eight feet to the underlying rocks. The opening, located at an outer curve along the highway and facing slightly south of west, was large enough to get head and shoulders inside. There were more big boulders above this particular one and at this site the ridgetop was about 500 feet elevation.

Site 2 was a six-inch hole, possibly a small animal run, formed by two small rocks in dirt leaning against the cliff at the northwest end of a wide and high, but shallow, concavity in the cliff. The hole faced southwest and undoubtedly led to cavities between the underlying rocks. Elevation of the ridgetop here was about 650 feet.

Site 3 was at the entrance of a small man-made cave in a cliff. The entrance was four feet above ground and four feet in diameter, and the 20-foot cavity tapered to two-and-a-half feet in diameter at the end. The face of the cliff was slightly concave so the overhanging top formed a sheltered area at the mouth of the cave. In contrast with the dark opening there was a weather-bleached log ladder at the entrance and another similar log along the base of the cliff to the left, which extended to a boulder under a sharp undercut where dried leaves had drifted. A mouse was seen there about dusk on several visits. There was a small slide area ten yards to the right of the cave with a cottonwood tree at one side and a few smaller trees and bushes higher up, frequented by a tree squirrel. The mouth of the cave faced slightly west of south. The top of the ridge was about 750 feet high.

The resting mosquitoes were taken from the rocks with a modified flashlight-type aspirator powered by three dry cells. The aspirator had been further modified by inserting a one-hole stopper into

the 1¼-inch (inside diameter) plastic intake tube. The stopper was fitted with a 6-inch length of 9/16-inch (inside diameter) rigid plastic tubing which had a piece of nylon mesh over the inner end, held in place by a rubber band. This made it possible to pick off mosquitoes about 15 inches beyond arm's length using one hand only. The tube could be put very near the specimen, the switch pushed on and the specimen drawn in without inspiration, gagging, or fouled-up rubber tubing, as with a mouth-operated aspirator.

Resting *Culiseta*, mostly *impatiens* according to collection samples, and to a lesser extent *alaskaensis*, were found in sheltered and shaded niches and crevices on the cliffs and on the underside of boulders, on all visits, twelve of which were made in the afternoon and one in the late morning. Throughout the area the adults were most numerous on the first few visits when the air temperature was in the middle and high fifties, and scarce on the last visit when it was in the low forties (° F). Males far outnumbered the females, which were new and fresh in appearance, whereas the males were generally rubbed, faded and worn. Inside the cave, the resting mosquitoes were usually within a yard of the entrance, concentrated on the ceiling.

It was impossible to see the resting mosquitoes inside Site 2, and difficult to see them inside Sites 1 and 3. Soon it was discovered that on most occasions the mosquitoes could be aroused momentarily by saying "mmmmmmmmm" pitched at F# below middle C. Simultaneously they flew a few inches from the surface and then settled back again; so a rough estimate was possible. But if they were stimulated three or four times in succession they failed to respond further. Either pitch is extremely critical or perhaps an unknown factor is involved because the mosquitoes did not respond at all on September 22, although temperature, humidity, and period-before-sunset were within the range when reactions occurred on other days.

Six mating pairs of *impatiens* were taken at these three observation sites September 20 to October 17 between 2:15 and 4:20 p.m. when the temperature and relative humidity ranged from 54° to 43° F. and 55 percent to 95 percent. Courting and mating were seen at Site 3 on September 24 at 3:40 p.m. and followed in general the procedure observed in captivity by Frohne (1953) with the exception of coupling which took place while resting. The two were side by side on the ceiling of the cave, and the male occasionally touched the female's legs, until they finally both flew off the surface about an inch, then landed close together. While resting thus the male succeeded in coupling on the second attempt, and then hung suspended from the female. Mating pairs beyond reach down in the rocks were removed by touching the female gently with a stick to which she clung.

There appeared to be a gradual increase in the resting population in the late afternoon as swarming time approached. Site 1 was visited several times during the afternoon of September 24 and the number of mosquitoes seen resting there increased at each visit,—from 12 at 3:55 on the first visit to 30 at 4:20 on the last; and the maximum seen there was estimated to be 40 on September 21 at 4:45 p.m., also the last observation that day. Likewise at Site 2 on October 11 there were 5 at 4:00 p.m. and forty-seven minutes later, 13, three of which were seen to fly out of the opening and alight on the rocks a few inches away.

Little if any flight activity was noticed in broad daylight except for short distances of a few feet when I disturbed the adults while trying to collect specimens.

Male swarms were observed at Site 3 and one or more locations in the general area on ten of the visits. Swarms did not form at Sites 1 and 2. In general the swarms were largest on the first few days of observations and became smaller as the season progressed. The September 21 swarm contained about 100 individuals and the September 24, 25, and October 2 swarms involved about 50 individuals.

After that the swarms were small, consisting of 20 or less. On the four occasions when the swarms were fairly large, an audible hum was produced. Because of the small numbers involved in the swarms only one, and occasionally two, samples were taken. *C. alaskaensis* males were present in all the swarm samples taken throughout the area. *C. impatiens* males were present in the September 24, 25, and October 2 samples. This relative abundance is the reverse of that indicated by the resting collections.

Most of the swarm observations were at the entrance to the cave, which appeared to be a regular swarm site, perhaps because it was sheltered from the wind and rain and also offered considerable contrast between the dark entrance and the bleached logs in comparison with the relatively uniform grey of the cliff. Swarms formed at the dark entrance above the top of the ladder and a foot or less above the log which was at the base of the cliff to the left of the ladder. Swarming usually began first above the ladder with one or two males flying back and forth, turning and dipping, all in a restricted space. As more males joined the activity and the swarm grew in size, occasionally near-collisions occurred, and also individuals alighted on the nearby surfaces and "rested," then rejoined the swarm. There was an interchange of individuals between the high and low swarms and early in the season when the large swarms were formed, the whole space at the entrance to the cave, as well as the sheltered area on both sides was utilized.

The temperature was between 57° and 43° F., and the relative humidity between 55 percent and 80 percent when swarming occurred. On four occasions between September 21 and October 8, the beginning and end of swarming was observed. It started between 40 and 55 minutes before sunset and ended a few minutes after the end of twilight when it was too dark to see the mosquitoes without artificial light. After the swarms had dispersed, searches with a flashlight along the face of the cliff and the usual resting sites yielded only a male or two. This tends to support the information regarding maximum flight activity obtained from the jeep trap samples. Could swarming be a competitive "sport" or a "warm-up" for the dispersal flight that follows?

Swarms were not seen on three visits, —October 10, when there was a strong west wind and temperature 40° F., October 11, when the temperature again was 40° F., and on October 21 when it was too early in the afternoon for swarming. This was the last visit to the area and resting specimens were very scarce,— only three males and two females seen, and collected, in the entire area, including the cave at Site 3, which was carefully examined.

Occasionally during swarming observations, specimens were noticed against the sky, flying along the face of the cliff and low over the roadside. Because of concentration on swarming, samples were not taken until October 8. Ten minutes before sunset that day a few mosquitoes could be seen against the sky flying southeastward past the cave, six to nine feet above the ground, along the roadside to the light-colored jeep where they became lost against the dark background. In that 10-minute period 4 *impatiens*, and 2 *alaskaensis* females were netted individually. A few other specimens were missed. This was the only occasion females were known to be involved in flights of any distance (excepting for the assumed initial flight from the nearest breeding grounds which appeared to be about five miles away). At this very same time about a dozen males (*alaskaensis* according to sample) were swarming at the cave entrance six yards away.

The cliffs in this area faced southwest so the gradual daily emergence of *Culiseta* from hidden cavities may have been in response to temperature change and the warming of the rocks similar to the suggestion by Harwood (1962) with reference to emergence of overwintering *Culex tarsalis* Coq. Or, daily emergence may be a response to direction, intensity, or quality of the light rays. This could be

determined if *Culiseta* congregate both in talus and on cliffs facing northwest, north, etc., around to south, just by observing their daily activity patterns at those different exposures.

Further observation of this talus habitat from break-up to freeze-up may determine if this is the overwintering site of these two species of *Culiseta*, or the summer resting site,—and should also show when the seasonal swarming peak occurs. If this talus is an overwintering site and if the habitat of the immatures is far away as mentioned earlier, perhaps the adults follow local fly-ways, resembling on a small scale the long-distance routes of migratory birds, with return of the females to the breeding area in spring for egg-laying. Prevailing breezes during the suggested migratory periods may provide much of the required energy, in both directions. Or the mosquitoes may be carried here by the breeze and blocked by the mountain, thus having no control over their long-range flight routes, if such do indeed exist.

References

FROHNE, W. C. 1953. Natural history of *Culiseta impatiens* (Wlk.) (Diptera, Culicidae) in Alaska. Trans. Amer. Microscopical Soc. 72(2): 103–118.

———. 1954. Biology of an Alaskan mosquito, *Culiseta alaskaensis* (Ludl.) Ann. Ent. Soc. Amer. 47(1):9–24.

HARWOOD, R. F. 1962. Trapping overwintering adults of the mosquitoes *Culex tarsalis* and *Anopheles freeborni*. Mosquito News 22(1): 26–31.

PRICE, R. D. 1961. Biological notes on *Culiseta minnesotae* Barr and *Culiseta morsitans* (Theobald). Jour. Kansas Ent. Soc. 34(1):22–26.

REVERSION OF DIELDRIN-RESISTANCE IN *ANOPHELES ALBIMANUS* WIEDEMANN

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Dieldrin-resistance in insects is decisive (Brown, 1961) and when fully developed in mosquito larvae it is in the order of several thousand-fold (Davison and Mason, 1963; Klassen and Brown, in press). Although it has been suggested that dieldrin-resistance may arise as a post-adaptation of insects exposed to sublethal dosages of a cyclodiene (Garin, 1953), compelling evidence for this viewpoint has not been published. On the other hand it has been shown that dieldrin-resistance arises as a result of Darwinian selection for preadaptations, and that it segregates as a partially dominant allele in mosquitoes (Davidson and Mason, 1963; Khan and Brown, 1961) and in other insects (Brown, 1961). Nevertheless it is evident from the data of Klassen and Brown (in press) that this allele does not attain full expression until modifiers have been accumulated by intensive selection.

The frequency of this allele was evidently as high as 6 percent in some field populations of *Anopheles gambiae* before cyclodienes had been directed against them in the malaria eradication program (Armstrong *et al.*, 1956). Of course the possibility has not been ruled out that such high frequencies of the allele in mosquito populations have arisen through their inadvertant selection with cyclodienes used against agricultural insects.

Reversion of dieldrin-resistance to complete susceptibility within 25 generations was reported by Shanahan (1960) in a