was determined to have survived to the initial stage of emergence prior to succumbing to the larvicides. Test results indicated that up to the initial stage of emergence these pupae may have been protected from the toxic effects of the larvicides in solution.

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BLOOD MEALS AND EGG PRODUCTION OF *CULISETA ALASKAENSIS* (LUDLOW) IN CAPTIVITY (DIPTERA:CULICIDAE)

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INTRODUCTION. A laboratory investigation of the feeding capabilities of wild caught Alaskan mosquitoes was undertaken to determine their potential as biologic vectors of pathogens among animals. At least two blood meals would be required, with the interval between meals sufficient for multiplication of the pathogen in the mosquito, thus number of blood meals taken by individual mosquitoes, interval between meals, and interval between first and last meals were determined. Information was also obtained on: number of blood meals taken to produce each batch of eggs and interval between batches; number of eggs in each batch and total number of eggs and batches produced by each individual; lifetime of female in captivity; and interval between oviposition and hatching.

CONDITIONS AND EQUIPMENT. There was no natural light in the laboratory, which is underground. Overhead fluorescent lights were all turned on by day and one-quarter were on at night in an attempt to simulate Alaskan summer conditions. Specimens were kept on shelves in low wooden cabinets, open on the front, so they received only indirect artificial light except during twice-daily examinations. Laboratory temperature remained fairly constant at 65° F., rising occasionally to 71° for brief periods. Fresh air was provided by a fan in the intake duct of the air-conditioning system.

Cages for individual specimens were made from 3½ ounce Lily Tulip water cups #450, 5½ cm deep, and 6 cm across the mouth. These paper cups are plaited and rimmed. A hole 18mm in diameter was cut in the center of the bottom, and another hole 7mm in diameter midway on the side, using #10 and #3 cork borers. The mouth of the cup was covered with a 10 cm square of nylon stocking held in place with a rubber band. The side hole was plugged with absorbent cotton for use as a sugar sop. Early in the season a willow catkin was substituted for the sugar sop in a few cages.

Fifteen to 18 cages were placed in white porcelain pans (41 x 25 x 6 cm) containing water 1 cm deep.

PROCEDURE. Each mosquito caught in the field, either by netting or after landing, was brought to the laboratory in a plastic culture tube with pin holes in the lid. The specimen was then transferred to its cage by inserting the mouth of the tube through the bottom hole of the cup-cage while its mesh-covered surface faced the light. The cages, each containing one specimen, were placed in a pan of water. The cotton plugs were moistened with sugar-water, and wetted thereafter with distilled water twice a day.

Each mosquito was fed by lifting its cage from the water, covering the bottom with a small jar-lid and placing the mesh surface against my arm. When first introduced into the cages, specimens were occasionally too excited to feed, but if left until quiet they usually fed readily. When interested in feeding they walked about or probed. Otherwise they were inactive and not easily aroused, as if actually asleep. Breathing on them occasionally stimulated activity and biting. Biting without obviously taking blood was not considered a meal. The actual quantity of blood consumed at each meal was not known, but the mosquitoes were allowed to take as much as they wanted.

Early in the investigation specimens were offered a meal once a day, but after a short time it became obvious they fed less often so they were offered a meal only when active, or when they could be aroused and began to probe. It is quite possible they had the urge to feed at other times when blood was not available.

Pond water, containing bits of *Carex*, was used in the pans in an attempt to stimulate oviposition. Later, following the technique of Frohne (1953), larvae from the egg rafts were introduced into the pans making sure at least one larva was maneuvered through the hole into each cup. Toward the end of the season tap water and even distilled water were used and rafts continued to be laid. Water and cages needed to be changed as soon as they were soiled to prevent trapping specimens in excrement or on the water.

Egg rafts were removed without injury by centering the raft over the hole and lifting the cage from the water. The raft remained on the film of water suspended across the hole. By placing the cage at a slant in a small Petri dish of distilled water the raft transferred intact from the film to the water. Each egg raft was so isolated until hatching occurred, when the eggshells were counted.

RESULTS. Forty-two *C. alaskaensis* females were collected between May 3 and 13, 1968, in the vicinity of Fairbanks, Alaska. During their lifetime in captivity they took a total of 222 blood meals. Individuals took from 1 to 13 meals, averaging 5 per specimen. The interval between the first and last blood meal of each specimen ranged from 3 to 114 days with an average interval of 40 days. Total number of blood meals taken, number of mosquitoes involved, average interval between first and last meals, and average lifetime in captivity are shown in Table 1. Three specimens survived more than 110 days, and maximum survival time was 132 days, from May 3 to September 12.

TABLE 1.—Blood meals, time lapse, and longevity.

Total Meals Per Specimen	Specimens	Average Days Between First & Last Meal	Average Days Alive
1	4	..	16
2	5	4	7
3	2	13	21
4	5	26	31
5	6	34	42
6	6	34	45
7	7	48	61
8	2	95	107
9	3	93	109
11	1	79	90
13	1	51	66

Minimum, average, and maximum number of days between consecutive blood meals are given in Table 2.

Thirty-seven specimens oviposited, producing 98 rafts totalling approximately 13,573 eggs; an average of 366 eggs per female. Six rafts were the most produced by an individual. The largest quantity of eggs produced by one specimen was 614, in three rafts from 6 blood meals. Next largest was 611 eggs in 6 rafts from 8

Table 2.—Period between consecutive blood meals.

Specimens	Meal Count	Days Between Consecutive Meals		
		Minimum	Average	Maximum
42	1	..	..	..
38	2	1	7	20
33	3	½	9	27
31	4	1	8	20
26	5	1	6	18
20	6	2	9	38
14	7	1	11	35
7	8	2	16	43
5	9	1	10	20
2	10	5	8	10
2	11	8	14	19
1	12	6	6	6
1	13	4	4	4

blood meals. The largest raft contained 287 eggs produced from 1 blood meal in 7 days. The shortest period for production of eggs was 5 days. Usually the number of eggs diminished in each successive raft, as indicated in Table 3. Only 7 of the 98 rafts contained more eggs than their predecessors.

Table 3.—Egg count of successive rafts.

Raft Category	Average Eggs Per Raft	Females Ovipositing
1st	202	37
2nd	134	29
3rd	95	17
4th	34	10
5th	26	3
6th	44	2

In general the interval between successive rafts increased with longevity, although there was considerable variation, as shown in Table 4.

Of the 98 egg rafts produced, 53 percent were from 1 blood meal, 30 percent from 2 meals, 12 percent from 3 meals, 3 percent from 4 meals, and 1 percent each from 5 and 6 blood meals. Table 5 indicates that while the number of eggs per raft generally decreased as specimens aged, the time required for egg production increased and more eggs were produced in a shorter time from fewer meals.

Table 4.—Interval between successive rafts.

Raft Categories	Days Between Successive Ovipositions		
	Minimum	For 50 Percent or More of Rafts Involved	Maximum
1–2	8	8–10	67
2–3	9	10–12	30
3–4	5	10–18	40
4–5	16	16–21	28
5–6	13	13–17	17

Only 3 of the 98 rafts failed to hatch. They were fourth and fifth "rafts" consisting of only 3 to 8 separate eggs, some of which sank. One of these was followed by a sixth normal raft containing 57 eggs which hatched. Eighty percent of the rafts hatched in 5 or 6 days and 20 percent in 3 or 4, with an average interval of 5 days.

Larvae from a few of the later rafts were allowed to mature in the laboratory. Some adults emerged and were placed in a small 5 x 5 x 5 inch cage with access to a sugar sop and moisture from a sponge on which the cage rested in a pan of water. A larger cardboard carton covered the cage and rested on the pan, but air was free to circulate from beneath. Nine females took blood meals on September 16 and were transferred to individual cages; two deposi-

Table 5.—Quantity and rate of egg production in relation to number of blood meals involved and longevity.

Raft Category	Average Eggs Per Raft: Average Days Between First Meal Involved* and Oviposition		
	1 Meal	2 Meals	3 or More Meals
1st	260:8	208:17	184:22
2nd	138:11	132:12	131:29
3rd	99:11	89:12	......
4th	36:13	......	23:29
5th	29:15	......	14:29
6th	44:13	......	......

* A meal taken just the day before oviposition was counted as contributing to the production of eggs in the next subsequent raft.

ted a raft of eggs 10 and 13 days later. A second raft was laid 10 days after the first.

Discussion. Conditions in the laboratory were far different from those of nature. There were no predators. Once feeding started the mosquitoes could take as much blood as they wanted without interruption. The mosquitoes could not get much exercise and, if they flew erratically, they might get bogged down on the water. They could not rest on a horizontal surface except when on the water or upside down on the mesh. They preferred the mesh and sides of the cage. There was no natural light, no great daily fluctuation in temperature as outdoors, and only a narrow choice concerning relative humidity. The sugar sops may have been a poor substitute for nectar because a few specimens became bloated and died, though one did not and recovered after a month. Yet under these unnatural conditions, feeding, egg production, and longevity far surpassed expectations.

The laboratory temperature was considerably higher than that out-of-doors at night, but cooler than outdoor daytime temperatures. Both outdoor extremes probably slow mosquito metabolism. The temperature and humidity in the cages approached the optimum mentioned by Hopla (1965) and may have been largely responsible for the surprising results. It also seems possible that in nature each mosquito is relatively solitary during gestation, in which case individual cages may be a distinct advantage over large cages used by other investigators to house many specimens.

A blood meal was taken the day before deposition of egg rafts on 11 of the 98 occasions of oviposition, and in 6 of those 11 cases an additional blood meal was taken within a day after the eggs were laid. I have never seen a gravid female seek blood from me in the field, so, unless there is an alternation of hosts in nature, feeding just prior to oviposition appears to have been induced by laboratory conditions.

Apparently a few specimens took too much blood at one feeding, for they were dead on the water a day or so later, with what appeared to be an internal abdominal rupture. Some specimens appeared to pass much of a blood meal with little or no digestion taking place. No attempt was made to time the feeding, but in general older specimens seemed to take longer.

For specimens having four or more meals (Table 1), the average interval between first and last meal ranged from 26 to 95 days. This may be significant in terms of pathogen development within the mosquito even though the average period between any two consecutive meals (Table 2) may be too short.

If only one blood meal were taken in nature to produce a batch of eggs, as was the case with 53 percent of the rafts produced in the laboratory, the range of 8 to 21 days between ovipositions for 50 percent or more of the rafts produced (Table 4) is still a considerable period of time. The one-meal per raft column is the only complete column in Table 5, indicating that one meal was taken to produce eggs in all raft categories.

Frohne (1954) mentioned that in the Anchorage area biting by *C. alaskaensis* decreased steadily during May and June so that July rafts, like July bites, were scarce, and an August raft or bite was a great rarity. The raft scarcity suggests that an alternation of hosts is not involved. It may also mean extrinsic conditions in the Anchorage area are such that the potential capabilities for feeding and egg production are not fully utilized, assuming specimens in the Anchorage area possess the same capabilities as those studied. Predators and lack of blood source might also have accounted for the raft scarcity mentioned by Frohne.

The aged specimens often became almost nude of scales; sometimes their wing tips were damaged, and occasionally they lost a leg or two. As already mentioned, death seemed attributable to a number of causes, but none died containing fully developed eggs.

Conclusions. In the Fairbanks area the females of *Culiseta alaskaensis* are capable of taking multiple blood meals over an extended period if extrinsic conditions are favorable; and the majority of specimens are capable of depositing two or more egg rafts, the production of each requiring at least one blood meal. Therefore the feeding capabilities, in terms of number of blood meals taken, and intervals between meals, indicate that the females have the potential for biologic transmission of pathogens among animals, assuming other conditions are suitable.

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SUMMARY. Forty-two wild-caught females of *Culiseta alaskaensis* (Ludlow) from Fairbanks, Alaska, were isolated, each in a paper-cup cage in the laboratory. They took a total of 222 blood meals, averaging 5 meals per specimen, and 13 meals were the most taken by an individual. The greatest interval between first and last blood meal was 114 days, with an average of 40 days. Ninety-eight egg rafts were deposited, containing a total of 13,573 eggs. Maximum number of rafts laid by a single specimen was 6, containing a total of 611 eggs, produced from 8 blood meals. Of the 98 rafts 53 percent were produced from 1 blood meal. The average interval between consecutive blood meals ranged from 4 to 16 days. The period between successive egg rafts, for 50 percent or more of the rafts involved, ranged from 8 to 21 days. The longest lifetime in captivity was 132 days, from May 3 to September 12, 1968.

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