NOTES ON THE BIOLOGY AND CONTROL OF MOSQUITOES AT UMIAT, ALASKA

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INTRODUCTION

In northern Alaska the spring thaw is followed by a sudden emergence of swarms of mosquitoes and other biting insects which persist until the first freeze. Since the insect season coincides with the period of greatest human activity, work is handicapped by the presence of these insect pests. Therefore, studies on the biology of Arctic mosquitoes and attempts to control them were made at the camp at Umiat, Alaska, during the summer of 1947.

LOCATION AND TOPOGRAPHY

Umiat, Alaska, is situated at 69° 24′ North latitude, 152° 8′ West longitude on the north bank of the Colville River. It is approximately 175 miles southeast of Point Barrow and 181 miles north of the Arctic Circle (Fig. 1). This region, known to the geologists as the Arctic Plateaus of Alaska, is characterized by relatively smooth uplands dissected by stream valleys. From a distance the area appears as a high plain, but nearby it is seen as a succession of gently rolling hills interrupted by moderately deep valleys.[1] The Colville River Valley, oriented east and west at Umiat, is approximately four and one-half miles wide with bluffs on either side rising rather abruptly to an average elevation of 500 feet above the river. Several small streams of which Seabee and Bearpaw Creeks are the more important, have cut side valleys in the bluffs on the north near Umiat.

The Colville River has several channels. Consequently, many islands and bars have been formed. The principal channel of the river shifts from the south to the north side of the valley at Umiat. Numerous sloughs and lakes found on the valley floor are evidence that the river has changed its channels many times. A succession of changes in these sloughs can easily be recognized. Some are still an active part of the river. Others are separated from it by sand or gravel bars except during high water following the thaw. Still others remain only as elongated marshy areas with deep pools and lakes dotted along their former course. Three terraces to the north of the river channel at Umiat mark the gradual lowering of the valley by erosion. The present elevation of the river is approximately 350 feet.

Most of the sloughs, creeks, and the river are lined with thickets of scrubby alders and willows. Near Umiat these trees range up to ten feet in height. Between the sloughs, the tundra is characterized by a luxuriant growth of mosses, lichens, and grasses, and later in the summer by numerous wild flowers. The grasses are predominant and grow in clumps which form hummocks or "niggerheads." Because the water table is forced to the surface by perma-frost which never thaws deeper than three feet at Umiat, pools and ponds lined with moss are formed in nearly every depression in the tundra. Some are merely very small pockets of water present between the "niggerheads." These pockets occur not only on the valley floor but on the gentler slopes of the hills as well. In many places the valley floor has been cracked

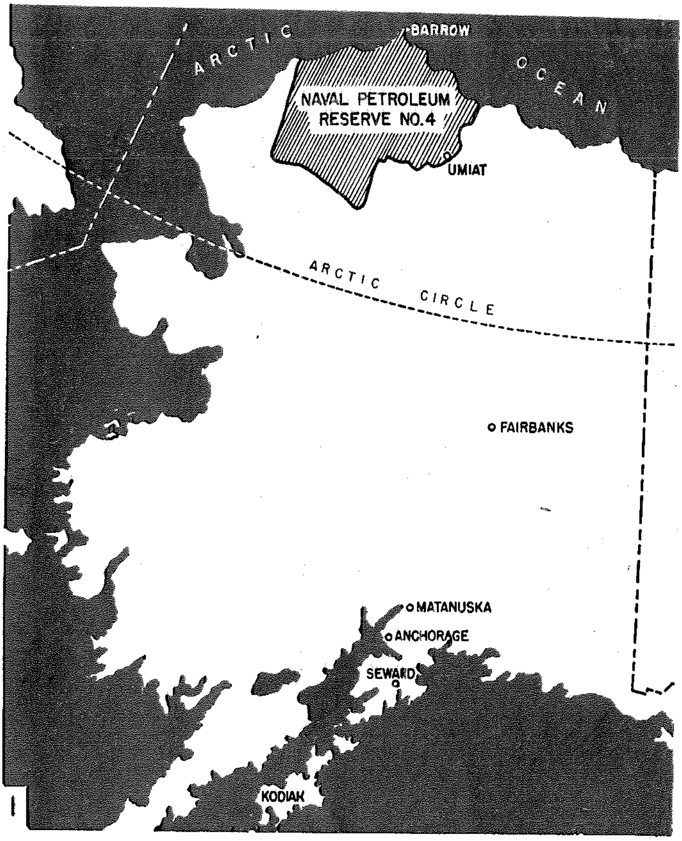


Fig. 1. Location of Umiat, Alaska.

by frost action into huge polygons (usually hexagons). The cracks resemble small ditches and are filled with water up to a depth of six inches.

Weather Data

A knowledge of the weather conditions in the area under study is indispensable in mosquito control work, especially in the Arctic. The disappearance of snow in the spring marks the beginning of larval development. Subsequent air and water temperatures regulate the growth rate of both larvae and pupae, and influence the behavior of the adults. The prevailing wind directions must be known in order to define the area in which mosquito control is desired. The daily wind velocities, maximum and minimum, as well as the maximum and minimum temperatures are essential in planning spraying operations. Therefore, it is necessary to discuss briefly the weather at Umiat during the mosquito months (June, July, and August). However, this discussion is limited to the years 1945 through 1947, since only these records were available.

The last inch of snow at the Umiat weather station melted on 25 May in the 1947 season. Drifts, of course, melted more slowly. Some were present on the valley floor until 9 June while those on the river bluffs persisted until mid-July. In 1946 snow disappeared on 4 June when the last three inches melted overnight. The thaw was later in 1945 for there were still traces of snow in the valley until 30 June, although most of it had disappeared by 6 June.

Although the sun shines for most of the 24-hour period during the mosquito months, except when obscured by clouds or fog, the daily temperatures show a definite rise and fall. Daily temperature curves follow essentially the same pattern with the maximum usually occurring between 1400 and 1600 and the minimum between 0200 and 0400. The daily temperature fluctuations may exceed 30° F. and are usually greater than 15° F. During most of May the daily maximum temperatures gradually increase until by early June they are almost constantly above freezing. In June the maximum may reach 71° F. and in July may soar to 82° F. Early in August the maximum temperatures begin to decline, and in September they are usually down to freezing again. The daily minimum temperatures may fall below 32° F. almost any time during the summer, although freezing weather is not common in July and early August. Lowest temperatures usually occur between 0200 and 0400 and often accompany ground fog or heavy clouds. The frost-free season is very short. In 1945 it lasted from 22 June to 7 August; in 1946 from 3 June to 18 July; and in 1947 from 30 June to 8 August. The average length of this season is 42 days.

Wind velocities are extremely variable. Winds exceeding ten miles per hour occur more frequently than those with velocities of less than five miles per hour. During a 24-hour period the wind may vary from 23 miles per hour to dead calm (25 June 1945). On 17 August 1946 calm conditions prevailed for ten hours, but winds of 15 miles per hour were also recorded on the same day. The daily maximum wind velocities usually exceed ten miles per hour while the minimum is frequently greater than three miles per hour. In sharp contrast to the variable wind velocities are the consistent wind directions. During the months of June 1945 through 1947 winds blew along an east-west axis for 42 of the 89 days (one record was missing). With prevailing winds from the northeast on 24 days, all other directions accounted for only 21 days. In June 1947 winds from the east and northeast occurred on 28 of the 30 days. Winds are more variable in July and August. The prevailing directions gradually shift from the east and northeast to the west and southwest. Winds from the northwest and southeast are uncommon for they prevailed on only 15 of the 275 days during the mosquito months (June, July, and August) of 1945 through 1947 (Fig. 2).

Rainfall usually occurs as light showers during the summer months. However, on 19 August 1947, 1.03 inches of rain fell in a 24-hour period. Ground fogs, moving into the valley from the north or northeast, force the relative humidity to the saturation point but do not produce measurable precipitation. When the temperature is below 36° F., snow flurries may occur even in July.

LABORATORY AND FIELD DATA ON MOSQUITOES

The initial problem in 1947 was to determine as accurately as possible the extent and sites of mosquito breeding. The discussion of topography has indicated that abundant water surfaces occurred everywhere throughout the area. Therefore, it was necessary to check as much of the standing water as possible to determine the actual sites in which mosquito larvae were developing. On 28 May, there was begun a rather complete survey of the waters in an area of approximately six square miles bounded by the bluffs north of Umiat, the Colville River on the east and south, and an arbitrary line drawn between the bluffs and the river on the west.

Larval habitats.—The larger bodies of water subjected to continuous wind, wave or current action (Figs. 3, 4, 5) and the small pockets of water between hummocks contained no larvae. Sites from which mosquito larvae were collected can be classified into the following four main types: grassy sloughs, mossy pools, frost ditches, and willow-alder pools. A species

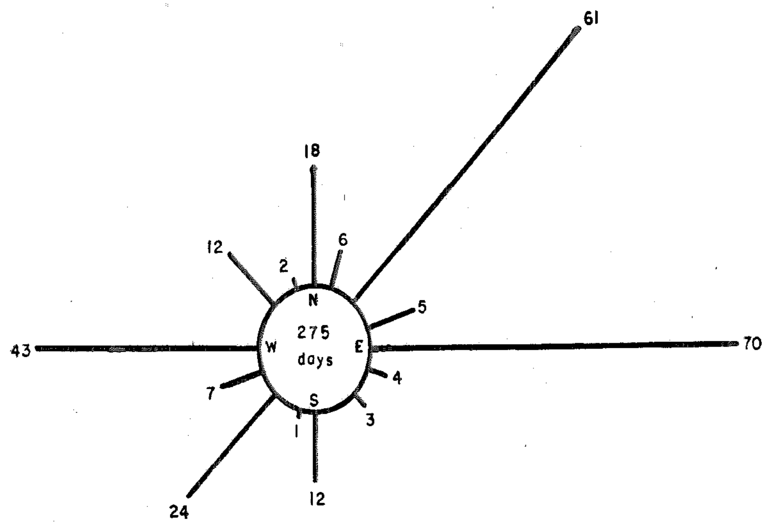


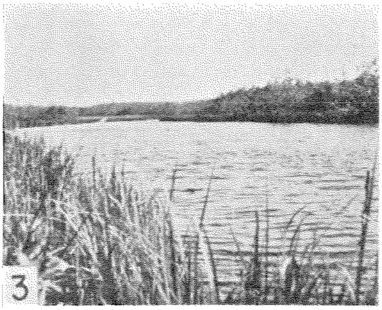
FIG. 2. Summary of the daily prevailing wind directions during the mosquito months 1945 through 1947.

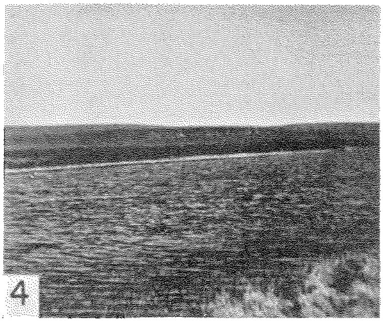
TABLE 1. Summary of larval habitat data, Umiat, Alaska, in 1947.

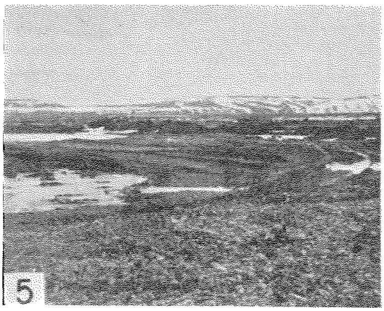
Species of *Aedes*	Number of collections from each type of habitat					Associated species
	Grassy slough	Moss pools	Frost ditch	Willow, alder pools	Total	
A. punctor	18	11	1	0	30	*A. communis* (5 coll.) *A. nearcticus* (4 coll.)
A. communis	5	0	2	2	9	*A. punctor* (5 coll.) *A. nearcticus* (1 coll.)
A. nearticus	0	7	0	2	9	*A. punctor* (4 coll.) *A. communis* (1 coll.)

selectivity for these habitats was observed (Table 1). A detailed description of each habitat is given below.

a. Grassy sloughs.—These sloughs (Fig. 6), which previously have been described under topography, and which were most numerous on the first two terraces, formed a very high percentage of the total water surface in the valley. They ranged from lakes and ponds with relatively little marginal emergent grass to extensive marshes completely overgrown with grass. Larvae usually could be found in the sloughs wherever the water was protected from







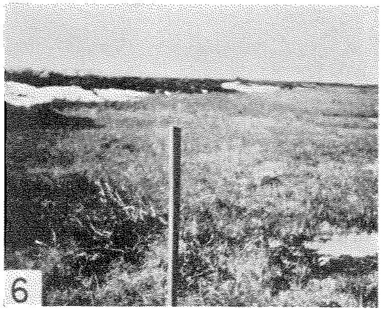


Fig. 3. Current and wind action prevented mosquito breeding in the marshes and open waters along creeks.

Fig. 4. Marshes and open waters of larger ponds and lakes had no larvae because of wind and wave action.

Fig. 5. Man-made ditches and ponds two years old were not breeding sites.

Fig. 6. *Aedes punctor* and *A. communis* larvae were found in grassy sloughs.

Fig. 7. *A. punctor* and *A. communis* larvae occurred in frost ditches. The width of the ditch may be judged by the dipper in the foreground.

Fig. 8. *A. communis* and *A. nearcticus* larvae were present in willow-alder pools. This particular pool, larger than usual, was in a well-protected location and contained *A. communis* larvae only.

wind action. However, as the season advanced and the water in some of the sloughs was reduced to small pools at the lowest points, larvae were concentrated in the open waters. They were found in water depths ranging from 1 to 12 inches. The bottoms of the slough breeding areas consisted of muck, covered with variable amounts of decaying vegetable matter. In almost all cases, breeding was associated with abundant numbers of copepods, snails, water mites, and diving beetles. Frequently larvae of other insects, such as *Dixa* and *Mochlonyx,* also were present.

Toward the end of the larval developmental period, many of the drying areas developed not only biological surface films but also copious amounts of dark brown scum on all underwater surfaces. In such places, the larvae usually also were coated with this material. At this time some larvae were found with a filamentous green alga growing on their bodies, particularly on the anal gills. Neither the scum nor the alga seemed injurious to the mosquitoes. Until mid-summer the emergent grass, which is the dominant floral characteristic of the sloughs, consisted of dead plants of the previous year. These stems and leaves seldom emerged more than 12 inches above the surface. Occasionally, the emergent stems had fallen onto the surface. New grass growth was first observed above the water surface late in June.

b. Mossy pools.—All larval collections from this habitat type were from second and third terrace levels. Probably the typical "tundra pools" of other authors, these pools were small (one to ten feet in diameter), shallow (usually two to eight inches in depth) and very clear, with mossy sides and bottoms. A few emergent grass stems were sometimes present. Snails were absent, and copepods scarce. Diving beetles occurred and occasionally chaoborid larvae were associated. Water mites were abundant. The number of larvae from single pools was never very large.

c. Frost ditches (Fig. 7).—Most numerous on the second terrace, these ditches were one to two feet deep and two to four feet across at the top. The edges were usually noticeably ridged above the surrounding ground level. Their courses were angular and frequently the geometrical patterns were plainly recognizable. Although they were most noticeable in the sloughs, ditches also were present on the surrounding tundra. The sides and sometimes the bottoms of the ditches were moss-covered. Occasionally, low bushes (alders, etc.) growing along the margins provided vegetable litter which covered the bottoms of the pools. The contained water was without current, was clear, and ranged from one to six inches in depth. In addition to a few small emergent bushes there were usually some marginal emergent grass stems. Copepods, diving beetles, and water mites were usually present. Snails were not abundant.

d. Willow-alder pools.—This type of larval habitat frequently occurred in the willow and alder thickets just above the floor level of the river and creek courses (Fig. 8). The pools were generally two to six feet in diameter and one to eight inches deep. Their surfaces were rather clear of emergent material and the bottom was littered with fallen leaves and other vegetable matter. In comparison with the grass sloughs, animal life was not abundant, but any or all of the previously mentioned organisms could be present.

Identification.—In order to facilitate identification of the mosquitoes, 38 collections of larvae were brought into the laboratory and reared to either fourth instar larvae or adults. For positive identification, fourth instar larvae were isolated and the larval and pupal skins were then associated with the resulting adults. In the 130 isolation-rearings completed, associated material was obtained for three species: *Aedes (Ochlerotatus) punctor* (Kirby), *A. (O.) communis* (De Geer), and *A. (O.) nearcticus* Dyar. One third-stage larva of a fourth species, probably *A. (O.) nigripes* (Zetterstedt) or *A. (O.) cataphylla* Dyar, was found, but without either fourth-stage larvae or adults it cannot be positively identified. Numerous specimens of females caught in the field resembled *A. nearcticus* except for their larger size. These are probably *A. nigripes,* but in the absence of associated larvae or males this identification cannot be verified.[2]

Life history.—From the data gathered it is believed that all of the mosquito species of the true tundra country overwinter in the egg stage. Frozen clumps of tundra marginal to suitable breeding pools were brought into the laboratory soon after the spring thaw and immersed in water. Larvae were found in these pans within 15 hours. Several species of mosquitoes common to southern Alaska, but not found at Umiat, are known to hibernate in the adult stage in the hollows and crevices found in forested areas. Consequently, the absence of forests in the tundra country may partially account for the absence of species hibernating as adults.

The eggs hatch almost immediately after the spring thaw. If a freeze occurs after this, the larvae will freeze into the ice and later thaw out with little adverse effect upon them. Thus, on the first day of the survey (28 May) larvae *(Aedes punctor)* were found in water having temperatures of 35° to 37° F. Some of these larvae were collected and set out in glass jars. On 29 May freezing temperatures occurred which persisted until 2 June (Fig. 9). During this period, water containing the larvae was frozen solidly. After thawing, most of the larvae completed their development. Although small differences in developmental periods were found between the different species, the

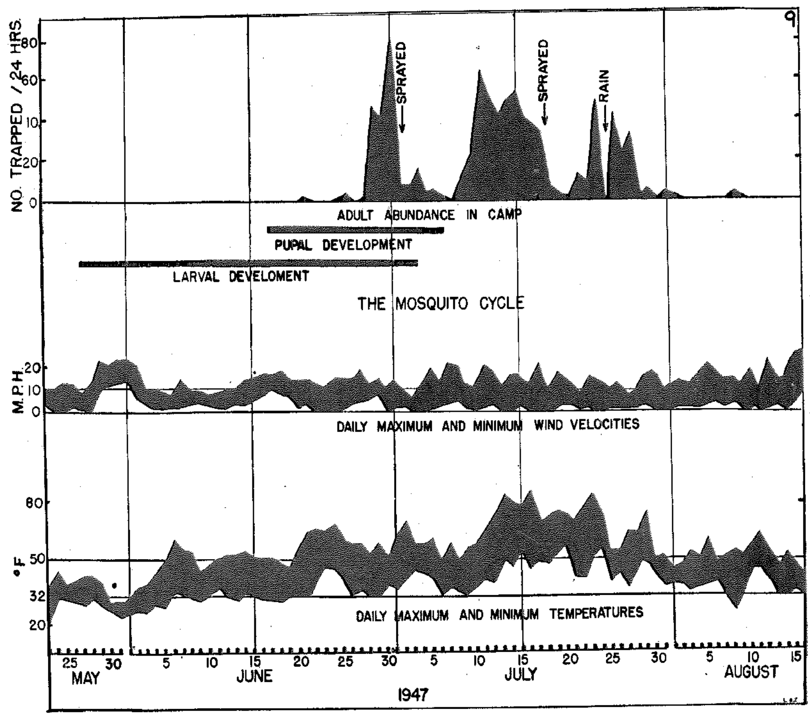


Fig. 9. Relation of the abundance and development of mosquitoes to weather conditions at Umiat in 1947.

period of larval development was approximately 28 days. The pupal period required from three to five days. It was interesting to find that the developmental period of one species *(A. punctor)* depended upon the terrace on which it was found. The higher the level and the more remote it was from the river, the later the date at which the adults emerged. This was true even though the difference in elevation of each terrace was only about 20 feet. This wide range in development is perhaps due to differences in the water and ground temperatures over the various levels of the valley and at varying distances from the ridge to the north for bottom ice was found in the small tundra pools on the third terrace and the portion of the second terrace that lies closest to the hills long after it had disappeared on the first level. Moreover, no larvae of *A. punctor* were found on the first terrace after 18 June, whereas they were found on the second and third terraces as late as 1 July. The first pupae *(A. nearcticus)* were not collected in the field until 17 June, and the last ones *(A. communis)* were found on 5 July. However, larvae brought into the laboratory pupated as early as 12 June.

Although the first adult mosquito was collected in the field on 22 June, emergence continued until 7 July. Peak activity of flying mosquitoes occurred on 1 July when the temperature was high and the wind relatively light (Fig. 9). The males emerged first and remained in the vicinity of the breeding area until the females appeared. Mating was not observed, but must occur almost at once, with the males dying quickly afterwards. Even in the period of their emergence they are seldom encountered naturally. This is particularly unfortunate for at present the adults of these far northern species can be accurately identified only in the male.

Female mosquitoes were encountered everywhere in the area studied, but were most noticeable in the willow and alder thickets. Wind velocity and temperature noticeably influenced their activity (Fig. 9). They were most troublesome on clear warm days when the wind velocity was below five miles per hour. Flying mosquitoes on the open tundra began to disappear when the wind velocity reached seven miles per hour, were scarce at ten miles per hour, and were absent when the velocity was over ten. The adults were strongly responsive to temperature changes. During the chilly night hours they gathered in large numbers about the open doors of heated quarters or hovered in the warm draft from chimneys. When the temperature was less than 47° to 50° F. the activity of the mosquitoes on the open tundra was markedly reduced and at 45° F. they disappeared. A similar reduction in the mosquito density was observed during the afternoons of 13 and 16 July when the temperature approached 80° F. The mosquito population disappeared on 8 August when the daily minimum temperature dipped below freezing for 5 hours. They failed to reappear.

The source of blood meals for the female mosquitoes in this area has not been determined, but if such meals are necessary to produce eggs there is an abundant fauna available to provide them. In addition to occasional bears and moose, there are herds of caribou, large populations of rodents, and numerous nesting birds (ducks, geese, ptarmigan, and song birds).

MOSQUITO CONTROL PROGRAM

This program was not intended to be experimental. Therefore, control was attempted with the materials and equipment that were immediately available.

Equipment.—Most of the spraying was done aerially with a Fairchild "Pilgrim" plane rigged with three 55-gallon drums fitted into the passenger space. The drums were connected by means of rubber and aluminum tubing to a discharge pipe located under the tail. The spray was released through four venturis spaced along the discharge pipe. Loading the plane was facilitated by the use of a centrifugal pump mounted on a "Weasel" (M29C cargo carrier) and powered, by means of a belt connection, by the "Weasel's" motor. The pumping speed was ten gallons per minute. Under calm wind conditions the swath width of the spray pattern was 70 feet when the plane was flown at an estimated air speed of 90 miles per hour and at an altitude of 15 to 20 feet. However, in spraying operations the swath was reduced to 50 feet to assure complete coverage. The spray was discharged at a rate of eight gallons per minute.

Materials.—Ample supplies of both Diesel fuel oil (30 cetane) and DDT were on hand and about 50 gallons of Stoddard's solvent were available. Two hundred and fifty gallons of an auxiliary solvent (Velsicol AR–50) arrived in mid-July, too late for all but the last adult spraying.

Aerial spraying.—On 10 and 11 June, at moments when suitable weather conditions prevailed, the area north of Umiat camp was given a larvicide spray of 450 gallons of pure Diesel oil. Upon checking the results, it was found that the oil had not spread as a film on the surface of the water, but remained clumped as discrete droplets. Supplementing laboratory experiments showed that at low air temperatures (43° to 54° F.) and lower water temperatures (37° to 39° F.) this Diesel oil would not spread on the surface of the water. However, after testing the available materials the addition of 2.5 gallons of Stoddard's solvent to a drum of oil provided satisfactory spreading properties. Twenty pounds of DDT were added to this mixture in order to increase its insecticidal activity. This preparation sprayed on 12, 13 and 14 June treated an area of approximately 3.7 square miles (Table 2). On 2 July approximately two and one-half square miles were sprayed with 600 gallons of 5 per cent DDT in oil solution to kill adult mosquitoes. The area was resprayed on 18 July with 600 gallons of 10 per cent DDT in oil plus auxiliary solvent.

Hand spraying.—Following the aerial larviciding spray several breeding places found to be inadequately treated were sprayed by hand using two-quart continuous sprayers. The marshes and pools in the valley of Bearpaw Creek, inaccessible from the air, were similarly treated.

Results.—The pure oil spray dispersed from the plane deposited sufficient oil to kill most of the larvae, but due to the failure of the droplets to spread on the surface of the water no larvae were killed. The second spray, the DDT, fuel oil, Stoddard's solvent preparation, produced erratic results. In the marshes exposed to the full sweep of the wind the larvae were all dead at the leeward end, but many were alive at the windward end. In the remaining places, the control was complete, or larvae could be found only after prolonged search. However, because of the number of fairly large breeding areas that required supplementary hand spraying the aerial larvicidal program was unsatisfactory with the dosage and materials used. Following the supplementary hand spraying all mosquito breeding seemed to have been eliminated over an area of approximately two and one-half square miles. Nevertheless, when the mass emergence occurred between 27 and 29 June, both camps were overridden by mosquitoes which presumably infiltrated from surrounding areas.

To check the effectiveness of adult spraying operations daily collections of mosquitoes were made in the vestibule of the laboratory quonset and in the control tower of the radio building, both of which served admirably as mosquito traps. Although not all of the mosquitoes that entered the buildings were captured, the collections did provide an index to the population in the controlled area. Collections were made at irregular intervals at three other sites in the treated area and at two locations outside of the controlled area by aspirating the mosquitoes alighting on one's clothing in a five-minute period. The results were not entirely satisfactory because, regardless of the mosquito density, the maximum number that could be caught in that manner was about 40 in five minutes.

The first adult spraying, using 5 per cent DDT in Diesel oil, was made on

TABLE 2. Summary of aerial spraying program at Umiat, Alaska, in 1947.

Time of spraying		Weather data during spraying				Spraying data					
		Av. temp. °F.		Wind						Dosage/Acre	
Date	Hours	Air	Water	Av. vel.	Prev. dir.	Approx area treated (sq. mi.)	Purpose	Type spray	Amount (gal.)	DDT (lb.)	Oil (gal.)
10 June	1855–2005	43	38	4	N	0.6	Larvicide	Diesel oil	150	—	0.5
11 June	0915–1122	44	39	2	N	1.3	Larvicide	Diesel oil	300	—	0.5
12 June	1437–1833	50	41	8	NE	1.8	Larvicide	DDT*	450	0.2	0.5
13 June	1512–1618	51	42	6	NE	0.6	Larvicide	DDT*	150	0.2	0.5
14 June	1040–1305	51	42	4	NE	1.3	Larvicide	DDT*	300	0.2	0.5
2 July	1000–1600	63	—	4	E	2.5	Adult	DDT†	600	0.2	0.5
18 July	1530–1930	50	—	7	NW	2.5	Adult	DDT‡	600	0.4	0.5

* 5% DDT + 5% Stoddard's solvent in Diesel oil.
† 5% DDT in Diesel oil.
‡ 10% DDT + 10% Velsicol AR 50 in Diesel oil.

the morning of 2 July. Daily collections at the laboratory quonset beginning on that date indicated that the spraying reduced the mosquito density appreciably for four days (Fig. 9). After weather conditions had checked their activity for an additional three days the population built up to the prespraying density. The second spraying, completed on the evening of 18 July, reduced the population for five days. Mosquitoes disappeared again on 26 July, but this reduction was obviously due to weather conditions since it was a cold and rainy day and the mosquitoes reappeared in numbers the following day. After 1 August few mosquitoes were caught inside or outside of the controlled area. On 8 August cold weather ended the 1947 mosquito season.

SUMMARY

1. Studies on the biology and control of Arctic mosquitoes were made at Umiat, Alaska, in 1947. Larvae were found in grassy sloughs, mossy pools, frost ditches, and willow-alder pools, but not in waters subjected to wind or wave action. A species selectivity for these habitats was observed. Associated rearings were made of three species: *Aedes punctor* (Kirby), *A. communis* (De Geer), and *A. nearcticus* Dyar. One third instar larva of an unidentified fourth species was found.

2. There is only one generation of mosquitoes annually and the Arctic *Aedes* apparently overwinter in the egg stage. Larvae emerge as soon as the ice thaws from around the eggs. Larval development requires almost a month, pupal development about five days, and the adult female mosquitoes persist until the first heavy frost. The adults do not fly when winds exceed ten miles per hour, or when the temperature is less than 45° F. or greater than 80° F.

3. Aerial spraying of fuel oil alone as a larvicide was unsatisfactory, while spraying with a 5 per cent solution of DDT in fuel oil produced erratic results. Five and 10 per cent solutions of DDT in fuel oil applied aerially in a dosage of 0.2 and 0.4 pounds of DDT per acre markedly reduced the adult mosquito population for approximately five days.

ACKNOWLEDGMENTS

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