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OBSERVATIONS ON MOSQUITOES IN GREENLAND

BY

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WITH 9 FIGURES AND 4 TABLES IN THE TEXT

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Abstract

Observations were made on *Aedes nearcticus* and *Aedes nigripes* in Narssarssuaq and in Godhavn. In Narssarssuaq the emergence took place about a month earlier than in Godhavn. The velocity of the pupal development of *A. nearticus* is higher than in any other mosquito so far examined. Matings take place during the very first days after emergence near the breeding areas. Especially during the first days of adult life the males and some of the females feed on nectar obtained exclusively from *Salix*. A slow dispersal of the females, presumably by wind, may take place over a distances of 3–4 km. Blood-feeding is inhibited by low temperature and high velocity of wind. The annoyance of the biting is enhanced by the method of slow attack. The swarming activity is independent of illumination but correlated positively with temperatures between 7 and 15°, negatively with wind velocities between 0 and 2 m/sec. Swarming between 5 and 7° only occurred once, probably as a lowering of the threshold caused by a long period of enforced inactivity. There is only one case, so far unaccountable, of swarming at high wind velocity.

INTRODUCTION

The main releasing factor for the swarming habit of male mosquitoes has been found to be the change in illumination during twilight. It was, therefore, considered to be of importance to examine the behavior of the mosquitoes in Greenland. In the southern part of this island there is a definite twilight during the season in which the mosquitoes are active, but in the central and northern part of Greenland the sun never sets during this season and consequently there is no twilight. 'Twilight' in this paper is understood to be the period during which the sun's altitude is between $-0°50'$ and $-6°00'$. The first figure is the moment of sunset or sunrise when the uppermost part of the sun appears to coincide with the horizon and the latter is the one conventionally used for the end of twilight in the evening and the beginning of dawn in the morning.

The investigation, therefore, was carried out in two parts: The first one took place from June 7 to June 23, 1961, in Narssarssuaq (61°09′ n. lat., 45°26′ w. long.) where twilight occurs, and the second part at Godhavn (69°15′ n. lat., 53°31′ w. long.) where the sun was above the unobstructed horizon during the period of observation, June 25 to July 18, 1961.

Acknowledgements

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We also want to thank those who helped us plan the investigation by their experience and knowledge of conditions in Greenland, above all Mr. PH. ROSENDAHL, Ministry of Greenland, Professor, Dr. phil. R. SPÄRK, Mag. scient. HØPNER PETERSEN, Dr. phil. POUL MARINUS HANSEN, and Mag. scient. CHR. VIBE.

In Greenland our work was facilitated by kind interest and help from everybody. In Narssarssuaq we want especially to thank Mr. ERLING EDSBO, acting chief of the station; the meteorologists, Mr. NIELS BUNDGAARD and KURT PETERSEN; the chief of the airport, Mr.

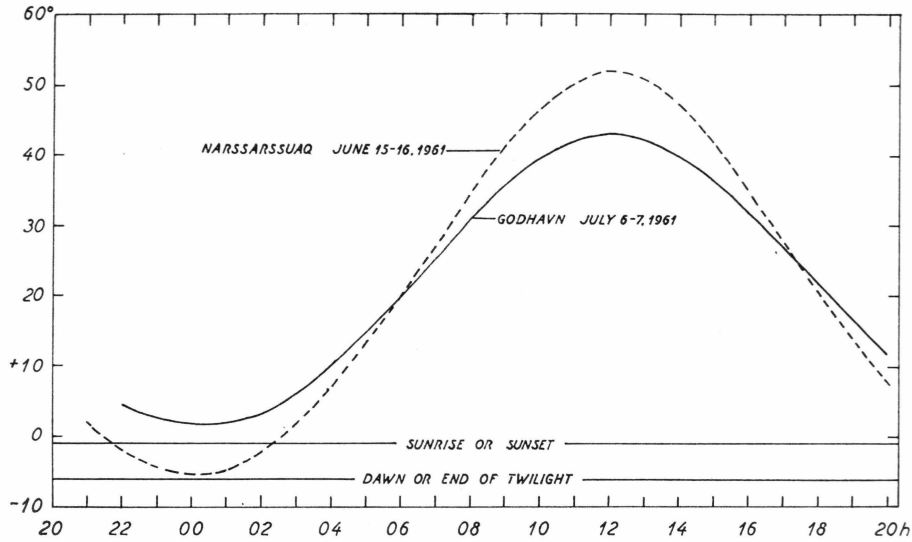

Fig. 1. The altitude of the sun through the 24-hours at Narssarssuaq (the broken line) and at Godhavn (The unbroken line).

EDVARD JESPERSEN; and Mr. JØRGEN TAAGHOLT, C. E. In Godhavn: Cand. mag. SIMON LÆGAARD, director of the Arctic Station; the managers, Mr. ORLA JENSEN and Mr. HARRY CHRISTENSEN; the chief of the district, Mr. J. J. JENSEN, and Mr. STOCKFLET JØRGENSEN, C. E., of the Ionosphere Research Station.

IDENTIFICATION OF THE GREENLAND MOSQUITOES

In the older literature (LUNDBECK 1893, HENRIKSEN 1924, 1937, 1939, and AD. S. JENSEN 1928) the mosquitoes of Greenland were all considered to belong to one single species, *Aedes* (*Ochlerotatus*) *nigripes* ZETTERSTEDT. It had been suggested that also *Aedes* (*O.*) *nearcticus* DYAR (= *impiger* WALKER) might be found in Greenland.

During the present investigation both species were found to be present in Narssarssuaq as well as in Godhavn. In Narssarsuaq *A. nearcticus* appeared to dominate and in Godhavn *A. nigripes*. However, no difference could be seen in their behavior as they were found mixed in the swarms and other activities.

The two species are very difficult to distinguish from one another in the adult stage; and the only certain way to separate them was found to be by the male hypopygium as described by NATVIG (1948).

In general it can be said that the smaller, lighter colored males most frequently are *A. nearcticus* while the larger, darker specimens are *A. nigripes*. But of 22 *A. nearcticus* males, 5 were as dark colored as *A. nigripes*, and of 25 *A. nigripes*, 3 resembled *A. nearcticus*.

Males

I. The dark colored A. nigripes males fit the following description:

Head with dark gray or brownish, narrow scales on occiput, the flat scales on temporae sometimes slightly darker. Hairs black.

Mesonotum with dark, bronzy-reflecting scales and long black hairs, pleurae and coxae with dark gray scales, the hairs are black but sometimes they are slightly lighter (dark brownish) on forecoxae.

Abdomen with rather narrow basal bands of dark gray scales, sometimes they are slightly lighter than the remaining dark brown scales, and on the darkest specimens the basal bands are occasionally so narrow that they only consist of a couple of rows of scales. Venter is clothed with dark gray scales.

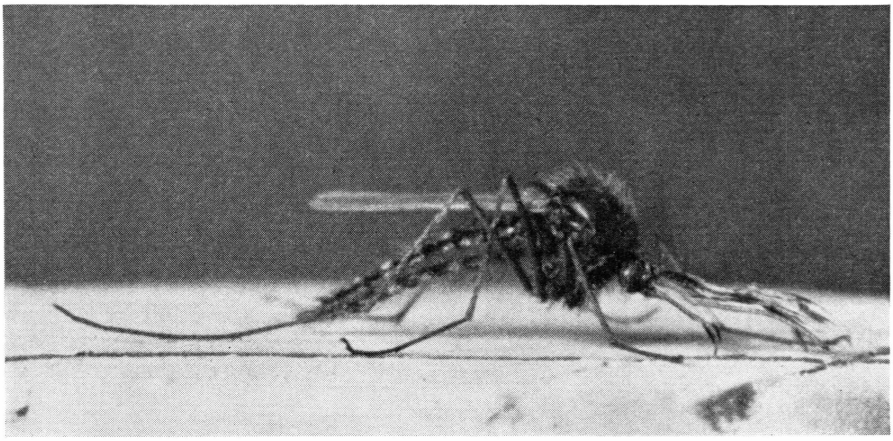

Fig. 2. Male mosquito from Godhavn, probably *A. nearcticus*.

Legs. The scaling on the legs is difficult to determine: the lighter scales are frequently so dark gray as to be hard to distinguish from the browish ones and often all scales are bluish or silvery in reflection.

Wings were not found to have any light scales, but this too might be due to their being dark gray.

II. A. nearcticus males (light colored specimens) look as follows:

Head with at least some pale, yellow or white scales between eyes and on occiput, and a spot of dark brown, flat scales on temporae.

Mesonotum with golden, narrow, curved scales in the middle turning whitish towards sides and the antescutellar space; the hairs are long and black. Pleurae and coxae often with entirely white scales or with a few darker (brownish) scales scattered between the white ones. Often the scales in the upper corner of the post pronotum are slightly more yellowish than on the remainder, but this is far from always the case. The hairs are light colored (pale yellow or white).

Abdomen with silvery white basal bands, venter with silvery or at least light gray scales in basal corners, the remainder of segments brownish.

Legs with numerous white scales on femur and tibia and often also some on the first tarsal segment.

The only difference found between the dark colored *A. nearcticus* and the dark colored *A. nigripes* was that *A. nearcticus* had light colored scales bordering the darker middle line on mesonotum instead of having bronzy scales only.

The light colored *A. nigripes* has only few light colored scales on occiput, temporae are entirely dark scaled. Pleurae and coxae have dark

gray scales (instead of the whitish ones of *A. nearcticus*). The venter of abdomen sometimes has a few silvery white scales at the basal corners, but generally has the usual dark gray scaling.

Females

The females are even more difficult to distinguish from one another, but certain differences have been found, although the present authors are none too certain about the validity of these differences—especially as the females probably vary as much as do the males.

A. nigripes	*A. nearcticus*
HEAD	
Only black bristles between eyes and black upright forked scales on occiput. The narrow, curved scales on occiput and the flat ones on temporae are sometimes dark golden except between the eyes where they are more white.	Black and/or yellow bristles between eyes, the forked upright scales mostly yellow or white, sometimes with a few brown ones in between. The narrow curved scales on occiput and the flat ones on temporae are often very pale yellow; on temporae there is a clearly defined patch of dark brown scales.
THORAX	
The scale patch on sternopleuron reaches frontal border.	The scale patch on sternopleuron does not reach frontal border.

Other than this no differences could be found on the mesonotum of the two species. In both cases there is a dark golden middle line bordered with pale yellow or whitish scales, sometimes a patch of golden scales can be seen just above wing root. The bristles on mesotum are black. On pleurae and coxae the scales are pale yellow or white, sometimes sprinkled with a few brownish ones.

ABDOMEN

The abdomens of the two species, like the mesonotum, show no differences both having fairly wide, white basal bands, the apical part of the segments being dark brown. Venter is white.

WINGS	
The light scales on the base of the wings are confined to a few scales at base of costa, subcosta, radius and analis. The light scales are of a grayish tint.	The white scales are heavily distributed at the base of the wing but sometimes thinly spread out over the basal half of costa and all of subcosta might be white scaled.

LEGS

The light colored scales are grayish, there are generally rather many sprinkled on femur and tibia and just a few at the base of first tarsal segment.	The white scales dominate on femur and tibia and there are always at least some white scales at base of first tarsal segment; sometimes the basal half is entirely white scaled.

The distribution of the mosquitoes in Greenland is unequal. The density of the population is generally larger on the west coast than on the east coast, probably in agreement with the milder climate of the western part of the island.

The highest density is said to be found on the middle part of the west coast around Jakobshavn and Christianshåb. There are also many in the southern part but further north the density decreases and there are only few north of Upernavik (72° n. lat.) according to HENRIKSEN (1900) and personal communication of experienced people.

Nearly all visitors to Greenland have complained of the annoyance caused by the mosquitoes but very few observations on their habits have been reported. The most valuable of the scattered notes are those of FRITZ JOHANSEN (1910). He made his observations at Danmarkshavn (76°46′ n. lat., 18°14′ w. long.) where the population is probably quite small. He found the larvae in small puddles so early in the spring that they were often still covered by ice during the night.

The first adults appeared in June, and at that time every lake and pool, however small, was teeming with larvae. The adults are found "chiefly on mossy stretches, and both males and females are seen, though the former are the most numerous and swarm in the air in small groups, whilst the females sit singly on the ground. Other imagines are met with flying about the surface of the water, often drowned in this, and the ruptured pupa-cases float about on the surface in thick masses. The biting insects are however not yet troublesome by their numbers". (JOHANSEN and NIELSEN, 1910, p. 47).

JOHANSEN mentions further that in the middle of July large swarms of "gnats" (by which term he includes both culicides and chironomids) appear over the lakes. In mid-August the swarms of gnats are definitely on the decrease.

OBSERVATIONS AT NARSSARSSUAQ

In the southwestern part of the coast of the island to which the Norsemen gave the alluring name Greenland, there is a long narrow inlet (Tunugdliarfik) called by them "Skovfjorden", the Wood's Fjord, not unjustified in the arctic environment: the mountain sides are green and covered with a relatively luxuriant vegetation. The birch trees are rarely more than a couple of meters high but the circumference of the trunks may surpass half a meter. Dominant in the copses are willows which alternate with dwarf-scrub, heaths, and grassy slopes, and there are many flowering plants.

Close to the bottom of Skovfjord, opposite the main settlement of Erik the Red, now called Qagssiarssuk, is the funnel-shaped entrance to a system of narrow valleys. The mouth of the valley is a vast, open plain nearly without vegetation, Narssarssuaq, which is the Eskimo term for a big plain. During the second World War, the U. S. Air Force had a base here and it is still used as an airport. The outer part of the plain towards the water is the airstrip. Some of the buildings now serving a number of different purposes are situated on the east side of the airstrip between it and the towering "Signal Hill" while others are scattered further into the valley.

At the bottom of the funnel-shaped plain, just before it narrows down to a valley are the buildings formerly used as a base hospital. This valley with a relatively rich vegetation is called the "Hospital Valley". It continues the main direction of the plain, rises to a swell and descends further on to a lake and some marshy areas deriving from the water melted from a glacier which closes the valley. On account of the swell, the water flows in a detour north and west of the "Hospital Valley" before it enters the plain.

When we arrived at Narssarssuaq on June 6, the emergence seemed to be finished. The first few days we found a few pupal skins in some of the pools, but never a larva or a pupa. It was soon evident that although there probably had been occasional breeding at several places, e.g. on the "Signal Hill" and elsewhere in the hills, the only important breeding area was along the "Hospital Valley". During the first few days of our stay,

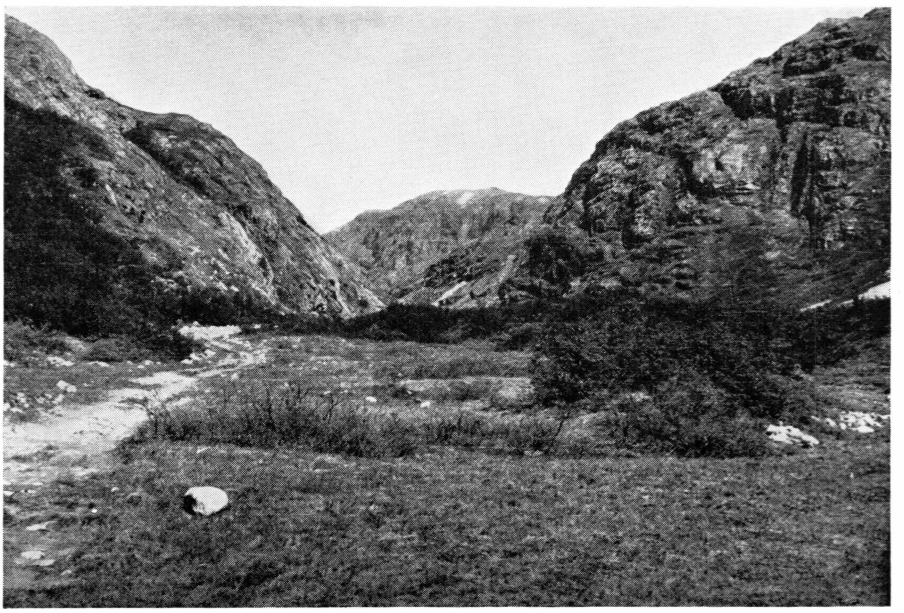

Fig. 3. "Hospital Valley" in Narssarssuaq. In the foreground to the right the willow shrub, in front of which many of the swarms were observed (Station 1).

the only place we found mosquitoes in numbers was in the inner part of the valley between the marshes and the swell.

The wind in the valley was always along the main direction; the fjord-wind from WSW, usually mild and humid, with frequent variations in velocity; and the steady gradient wind from NE, a dry and cold föhn descending from the ice-cap.

June 8, a strong föhn prevailed and the next day large numbers of mosquitoes were found in the outer part of the valley; they had apparently been moved with the wind across the swell. During the following days they entered the inhabitated part of the base, especially the north-eastern, inner part where most of the living quarters are situated. Only few individuals moved further out on the plain, and there were hardly any in the SW section of the base. Further towards SW there are some oil tanks, and people working here complained about mosquitoes which had probably bred in the neighborhood.

We never saw swarms outside the "Hospital Valley"; the individuals entering the base all seemed to be females. This was somewhat unfortunate as we had our living quarter at the opposite end of the base, about 5 km from the valley. The fast changing weather often made it desirable to make observations with short notice but the limited possibilities for transportation made it difficult to make observations as often as we should have liked to, although the acting chief of the station,

Mr. Edsbo, helped us with his Landrover as much as it was possible, and the meteorologists helped us with weather forecasts.

As mentioned above we never found the immature stages at Narssarssuaq; the behavior of the adults seemed to indicate that they were rather newly emerged: The individuals were first strongly concentrated but were later spread out over a larger area; the first days the males were seen feeding on willows; few or none of the females were biting at this time. It is possible, therefore, that during the first week or so of our observations there wøre actually many individuals still in the aquatic stage. The large marsh in the upper end of the valley was not well enough inspected to exclude the possibility of such breeding. On the other hand the decrease in activity noted during June 20 to 22 seemed to indicate that the brood was disappearing and under the presumption that the duration of the adult activity is the same as found for Danish species, we would expect the main emergence to have been three weeks before the disappearance of the brood or at about June 1.

Behavior of the Adult Mosquitoes at Narssarssuaq

Blood-feeding of the females. The biting of the Greenland mosquitoes is a very slow process. They usually fly around the victim, especially on the lee side, for a long time before they make the landing. Many of those landing are only resting without attempting to bite, and those intending to bite will usually probe for some time before they find a place to their liking. *Theobaldia annulata* has a similar behavior; this is a striking contrast to the swift attack of e.g. *Aedes taeniorhynchus* which usually is hardly noticed before the proboscis penetrates the skin. The humming of individuals around the head and the multitude of landing individuals tend to enhance the annoyance of the attack.

As mentioned above, there was very little biting during the first days but from June 9 feeding began to be more common.

The biting of the females mostly occurs at temperatures above 8–10° and when the velocity of the wind is below $^1/_2$ m/sec; at velocities of 1–$1^1/_2$ m/sec the females follow the victim around as a humming cloud to the lee of his body. Above 2 m/sec the biting is negligable. It adds, of course, to the irritation caused by the mosquitoes in Greenland that the biting is worst when the weather is most pleasant.

Whenever the weather was suitable during the ten days, June 9–19, there were many females biting, culminating the last day when we counted a landing rate of 83 individuals per minute on a person sitting in a sheltered place. There was a complete but thin cloud cover, so that the sun could be faintly seen; the temperature was 13.8°, relative humidity was

46 %, and the wind was from SW 1–1½ m/sec. The following days the annoyance was much less, even under favorable conditions.

Feeding on Nectar. Although there were rather many flowering plants in the "Hospital Valley", often visited by other insects, we never saw mosquitoes on other nectar sources than on the catkins of willow (*Salix glauca*). Only few females were seen feeding; one on June 10 had previously had a blood meal. The last females were seen to feed on June 19.

There were no feeding males seen until June 9, the same day the females started biting. During the morning there was a cover of low clouds with the sun shining now and then. The air temperature rose from 6.6° to 8.5°, the wind was from SW, varying from less than ½ to 2 m/sec. The males stayed a long time on the flowers of the willows with the fibrillae closed; they were not easily disturbed even if the branches were moved.

This observation was from a point in the "Hospital Valley" called Station 1. It was an open place where swarms were often observed (fig. 3), and situated rather close to the slope limiting the valley towards northwest. About 20 meters from the swarming site, the slope was covered by willow-scrubs which seemed a preferred place for the mosquitoes to feed.

June 18, in the afternoon, the sky was overcast, the temperature was 9.8° and the relative humidity was about 60 %. There was a very gentle wind from SW, rarely more than ½ m/sec. At 16h30′ there was a very large swarm but only a few feeding. Ten minutes later it was found that the swarm was suddenly much reduced in size, and at the same time the number of individuals feeding on the willows increased. It was observed that when the males arrived at the willows they still had the fibrillae on the antennae extended. They would usually first take a short rest somewhere on a twig, and then close the fibrillae while making short flights in the bushes. Only when the fibrillae were recumbent did they land on the catkins and start feeding. The number was very large, averaging about ten on each branch. Contrary to the happenings on June 9, the feeding animals were easily disturbed and scattered by even slight movements of the observer. The feeding period lasted only a short while and already at 16h45′ the swarm had again increased to the same size as before, with just a few individuals feeding on the willows.

This was the last time we saw males feeding in Narssarssuaq.

The Swarming. The swarms were formed in the open, usually 1–3 meters above the ground. The location of the swarms was not so regular as that for most mosquitoes; one day there could be swarms at one place,

the next at another. It was eventually found that there was a tendency to have two or three different places; on each occasion they selected the one most sheltered from the wind. In some localities it was possible to discern a dark swarm-marker on the ground. At Station 1, the largest and often the only swarm, was formed over a small willow-bush which as yet had no flowers or leaves. There were several small bushes but this was the only one chosen, perhaps because it was the most central one in the open space. If a white net was placed under the swarm, the swarmers either scattered or did not react. A dark blue parka placed underneath caused the swarm it to concentrate over it, and it was possible to move the swarm with the parka. June 9 in the morning there were about 30 males swarming over the little willow; the parka was placed close by. At 10h06′ the parka was moved a couple of meters away and most of the swarm followed it, only 3 remained over the willow. A moment later there were four and during the following minutes one after another left the parka swarm and moved back to the willow. At 10h10′ the stream ceased, and at 10h11′ there were 19 over the parka and 16 over the willow.

The number of swarmers changed fast. None was seen to move from the willow to the parka. However, it was repeatedly seen that swarmers left the parka swarm and flew towards the sides of the valley towards NW and some seemed to arrive from the same side. At 10h16′ there were about 40 over the parka and only one over the willow.

The swarms in the "Hospital Valley" were never very large; rarely with more than 50 individuals and mostly with only 20–30. The shape and the height of the swarm depended on the wind. When it was calm the swarm was globular and dense; it remained dense but flattened out in a very gentle breeze. Higher velocities would disperse the swarm, and at least some of the individuals would take cover in the vegetation; but with falling wind they would again resume the flight. It is not possible to give exact indications of the velocities because the swarms also depended on the temperature. At low temperature the swarms would disperse at velocities around 1 to $1^1/_2$ m/sec but would continue normal swarming at higher velocities in warm weather. On June 13 in the afternoon there was a slight cirrus cover over $^6/_{10}$ of the sky, and also a few cumulus clouds. The sun was shining and the temperature was 16.2° at 17h30′, and 15.6° at 18h12′. Relative humidity was 29 % and there was a breeze of 2 to more than $2^1/_2$ m/sec from SW. There was no swarm at Station 1 but a rather large one (about 50 individuals) at the more sheltered Station 2. The swarm, however, was keeping so high up in the air that the swarmers were actually exposed to the wind. Even when gusts dispersed the swarm, the mosquitoes did not disappear into the vegetation and returned at once to the swarm.

There is no doubt about the urge to swarm being increased by higher temperatures; correspondingly there is a temperature threshold below which no swarming occurs. It was found to be 6°. For several mornings we had arrived earlier and earlier, and every morning found that the swarming had already started. On June 13 the observations began at 03h50′. There was a complete cloud cover of low clouds. The wind was mostly below 1 m/sec, first from SW, at 04h14′ it turned to NE, and from 06h05′ to the end of the observation it was again from SW. The temperature varied from 3.1–4.0° until 08h33′ when it started to rise; it was then 4.7°. The first mosquito seen was a male which swarmed solo between 08h41′ and 08h45′. At 08h47′ the temperature was 5.5°. At 08h49′ a single male started again and one minute later a true swarm was formed with five individuals. Also other swarms were formed at 08h55′.

A similar observation was made on June 16 in the morning. There was a gentle breeze from SW, mostly less than 1 m/sec; at Station 2 it was almost completely calm. The first two were swarming at 04h24′; two minutes later the temperature was 5.8° and at 04h48′ and 05h11′ it was 6.6°. 04h35′ there were 4 or 5 males swarming; at 04h44′ seven. Later on the number varied between 4 and 10. There were no other swarms and only few females.

As already mentioned in the introduction it is generally found that the urge to swarm in mosquito males is an effect of the light change at twilight, and that it was of particular interest to us to examine the Greenland mosquitoes in this respect.

It was already evident from the first days in Narssarssuaq that swarming took place any time during the day, and that changes in illumination caused by clouds obscuring the sun did not have any direct influence. During the morning of June 15, the swarming stopped four times with the disappearance of the sun; the first time the air temperature dropped from above 6° to 5.2° (a temperature drop also felt by the observers) and the other times there was a gust of wind simultaneous with the obscuring of the sun. In neither case could the cessation of the swarming be ascribed to the light change.

During the course of the investigation we observed that every afternoon the swarming stopped between 17h and 18h, and it was presumed that this was an effect in the drop in illumination at this time. It was difficult for us to make observations during the evening and we also considered it unnecessary. We only once made an inspection at 01h30′, and did not find any mosquitoes active; however, it was rather windy, so no conclusion may be obtained from this observation. Eventually we

found that the swarming in the morning in calm weather and at temperatures above 6° would start at a much lower illumination than at the cessation in the evening; and a critical analysis of the situation at the disappearance of the swarms in the evening showed that it usually happened simultaneous with a rise in the wind.

It is possible, but not proved by our observations in Narssarssuaq, that the low illumination may inhibit the swarming. This is further discussed in a later chapter.

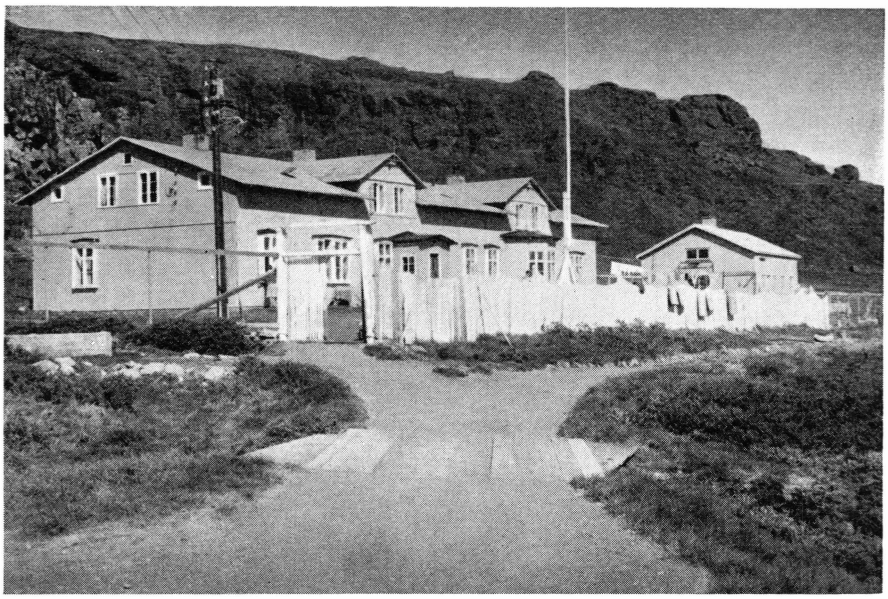

Fig. 4. Arctic Station at Godhavn around which most of the observations were made (see map sketch).

OBSERVATIONS AT GODHAVN

There is no reason to enter into a description of that remarkable institution, The Danish Arctic Station, in Godhavn, on the south coast of the island Disko, as the history and the natural history of the surroundings of the Station have been thoroughly described before (HOLMQUIST, 1959). Nearly all our observations took place immediately around the buildings and on the slope west of them (which continues into a grassy rift running about east-west, parallel to the rather steep slope of the hills towards north and the rocks south). The rift which we called "Myggelien" (the Mosquito Valley) was a main breeding area.

The conditions for mosquito research were extremely favorable in Godhavn; there were plenty of individuals right outside the door and we could inspect them all the time without any trouble. The facilities of the Station were ample for our needs and the timing of our stay was nearly perfect. When we arrived on June 25 a large part of the population was still in the aquatic stage, and the last days we stayed in Godhavn, July 17–20, the swarming had ceased and the annoyance caused by the females was decreasing.

The first couple of days was used to inspect the area, make collections and get things organized; the regular observations began on June

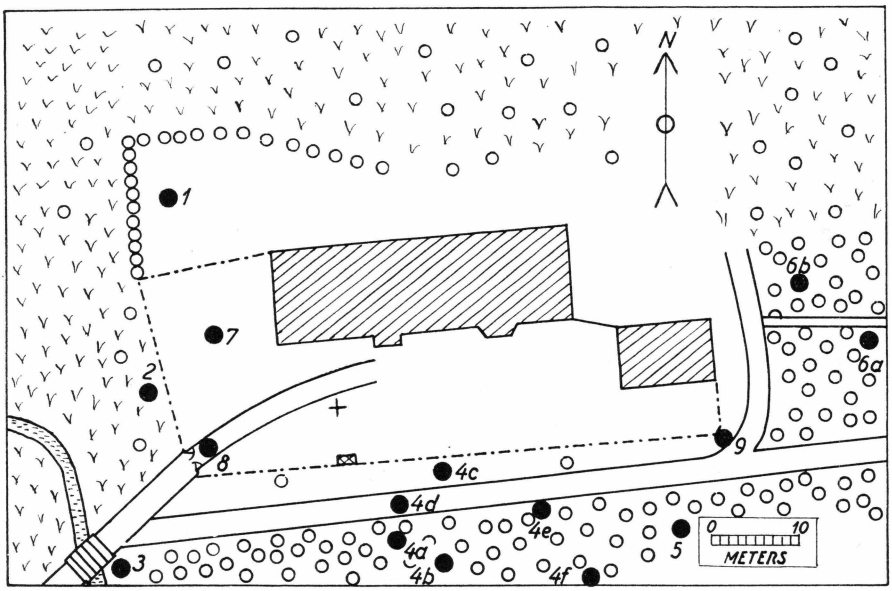

Fig. 5. Map of the observation sites around Arctic Station in Godhavn. The open circles designate willow-shrub, the V-signature other kinds of vegetation. The shaded areas are the buildings. The cross-shaded square shows the meteorological station. The black circles (numbered 1–9) represent the main observation sites which were checked at least 8 times through the diel.

29 and were continued until July 17. Beside observations whenever it was deemed necessary, regular observations of all meteorological factors and inspection of 15 swarming sites and the feeding places around the building were made at the following hours: 00h30′, 03h30′, 07h30′, 10h30′, 13h30′, 16h30′, 19h30′, and 22h30′, West Greenland standard time. As Godhavn is at w. long. 53°32′, local time is 34 minutes later than standard time.

Immature Stages. When we arrived we found both larvae and pupae in numerous pools in "Myggelien" and also in the area south of the road, including a fairly large pond not shown on the map. There was none in the open area east of the Station; presumedly this area is slightly sloping and the water runs into the pools there. In the western part some pools had already dried out, and many more became dry the following days, including the pond. Even if there is only wet mud left at such a place, mosquitoes may emerge from pupae but the larvae will not be able to survive the drying out.

Snow-sparrows were seen feeding along the edges of the drying breeding places.

All the larvae found were *A. nearcticus.*

Fig. 6. "Myggelien" at Godhavn looking east; this was one of the main breeding places for *A. nearcticus*.

We have hardly any observations on the larvae, but as we considered it to be of importance to get some idea of the velocity of the development compared to that of other mosquitoes (NIELSEN and EVANS, 1960) we started already the first day an experiment with pupae. No thermostatically controlled room was available but the larvae were placed in test tubes in racks and submerged in waterbaths; one in an unheated room towards north without windows, the other in a smaller darkroom kept at about 24°. We made one more experiment in which the small darkroom was kept at about 20°. The number of animals was small and the mortality was high at all three temperatures (table 1). The figures are, therefore, not very reliable but there is no doubt that the development of *A. nearcticus* has a much higher velocity than that of other species (fig. 7).

The following observation was made on some pupae kept in the laboratory: When they were disturbed they would, as usual with pupae, leave the surface and swim towards the bottom of the jar. Instead of returning to the surface they would sometimes become attached to air bubbles on the walls of the jar by means of the airtubes probably meant for respiration purposes. In some cases they would leave the air bubble at once, in other cases they would stay for some time depending on the size of the bubble. For small bubbles it was found in four cases

Table 1. *Duration of the Pupal Stage Aedes nearcticus*

Number of		Temperature	Hours	1000/hours
Pupae	Adults emerged	°C		
18	6	14	92.3	10.8
14	7	20	62.0	16.1
13	5	24	42.9	23.3

that they remained attached for 26, 74, 12, and 11 seconds (average 31 seconds), for large bubbles: 41, 25, 100, and 129 seconds (average 72

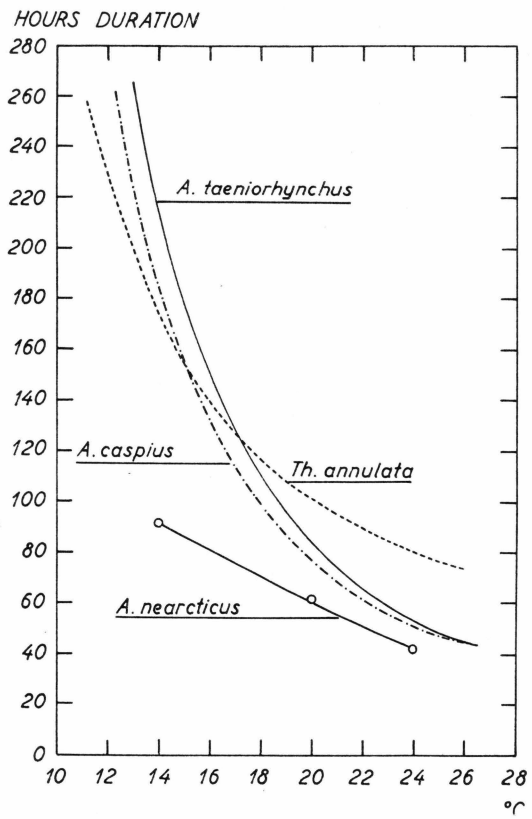

Fig. 7. The duration of the pupal stage of *Aedes nearcticus* compared to that of *A. taeniorhynchus*, *A. caspius*, and *Theobaldia annulata*.

seconds). The ability to use air bubbles for respiration is also found in larvae of other species; this habit is discussed elsewhere.

After the beginning of July the number of larvae decreased rapidly, and the last pupae were seen on July 8.

Behavior of Adult Mosquitoes in Godhavn

Mating. In Narssarssuaq we only saw one mating, the very first day, and close to the presumed breeding area. In Godhavn matings were observed only in the evening of the day we began observations (June 25), and only in breeding areas in "Myggelien". There must, of course, have been copulations of the later emerged females but they must have been more scarce than that first evening. On June 25 about 20h the sun was still shining on the boulders on the south side of the valley but the bottom of the valley was in shadow. Male swarms were so high that they were in the sun, and seen from the boulder against the dark background the swarms were glittering. Females were abundant, many kept on the lee side of the observer, they approached in a very low flight over the ground. Others were probably flying about low over the surface but it was difficult to observe them. Many were sitting on the rocks and in the vegetation. Several matings were seen along the slope; they lasted a rather long time. Sometimes there were 3 or 4 copulations at the same time, sometimes there were intervals without matings for several minutes. It is possible that the copulations occurred when a gust of wind brought the males down to the females cruising just above the ground.

Although observations were made at this place also the following evenings we have no further notes on copulations.

Blood-Feeding of the Females. It was the impression that the biting was increasing during the first week in Godhavn, and according to what we were told by local people, there had not been any annoyance before we came. It was also rather obvious that the biting was less bad during the last few days before we left. However the influence of weather, and especially the wind, was very strong and caused much variation. The serious inconvenience from biting mosquitoes was thus, in Godhavn as in Narssarssuaq, limited to a couple of weeks. Even during this period it was only during the few days with warm and calm weather that the biting was bad. As in Narssarssuaq the most annoying habit of the mosquitoes is the buzzing of the females around the head, and a cloud of them following around on the lee side of people. Also here we found that only a fraction of the females would actually land on the person, and of those landing only about ten percent would be actually biting.

We did not take regular landing-rates except in a few cases but did note how many were flying around the dogs. The friendly and well-treated dogs of the Station would usually sleep on the sheltered side of the house and the size of the cloud around them gave some impression of the activity of the females. It was obvious that the mosquitoes were

guided towards the dogs by the smell: when a dog walked away from a place where it had been resting the females would fly around the place for quite some time.

Snow sparrows were repeatedly seen catching resting or lowflying mosquitoes and they were also seen feeding on the females around one of the dogs; during the feeding it would even land on the dog without causing any reaction. That is quite remarkable because the dogs, when running in the field, often tried to chase snowsparrows and other small birds.

It has often been discussed where the arctic, and especially the Greenland mosquitoes, could obtain blood. It was found worth-while to consider the possibility that these females might be autogenous. A few batches of eggs were sent to Dr. ARDEN O. LEA, Entomological Research Center, Vero Beach, Florida. The eggs did not hatch, however, and we are not able to contribute to this problem; in order to solve this, large numbers of eggs should be collected from different places, especially from areas with a very small vertebrate fauna, in order that the females emerging from these eggs may be tested.

Feeding on Nectar. As in Narssarssuaq we did not see the mosquitoes feed on any other flowers than those of willows. Such feeding took place at several points in our field of observation but the best place was the fence around the yard north of the main building. Here there were usually places sheltered from the wind, and inspections presumedly gave good information about the feeding activity.

Even if females were seen feeding there were considerably more males on the willows. They always fed with the fibrillae of the antennae closed. The nectar feeding seems to be restricted to the very first days of the adult life; the number decreased rapidly after the first couple of days, and we did not see any feeding after July 3.

Sexual Differences in Flight. Outside the swarms the males have a way of flying which can easily be disinguished from that of the females. It is rather slow and straight-lined with few and small changes of direction; the females fly faster, turning and buzzing around, not only when they are pursuing a possible blood feed but also when cruising along. Both in flight and in the resting places there seems to be a general tendency for the females to keep more to the ground than do the males.

The tone emitted during the flight is rather weak in the Greenland mosquitoes (which is fortunate, for the buzzing of bloodthirsty females would be still more intolerable if the humming was as loud as in some of the temperate species such as *Aedes cantans* or *Theobaldia annulata*). Still, the humming of the females is louder and of lower pitch than that of the males which is surprisingly high for a mosquito of this size and so faint that only very large swarms can be heard humming.

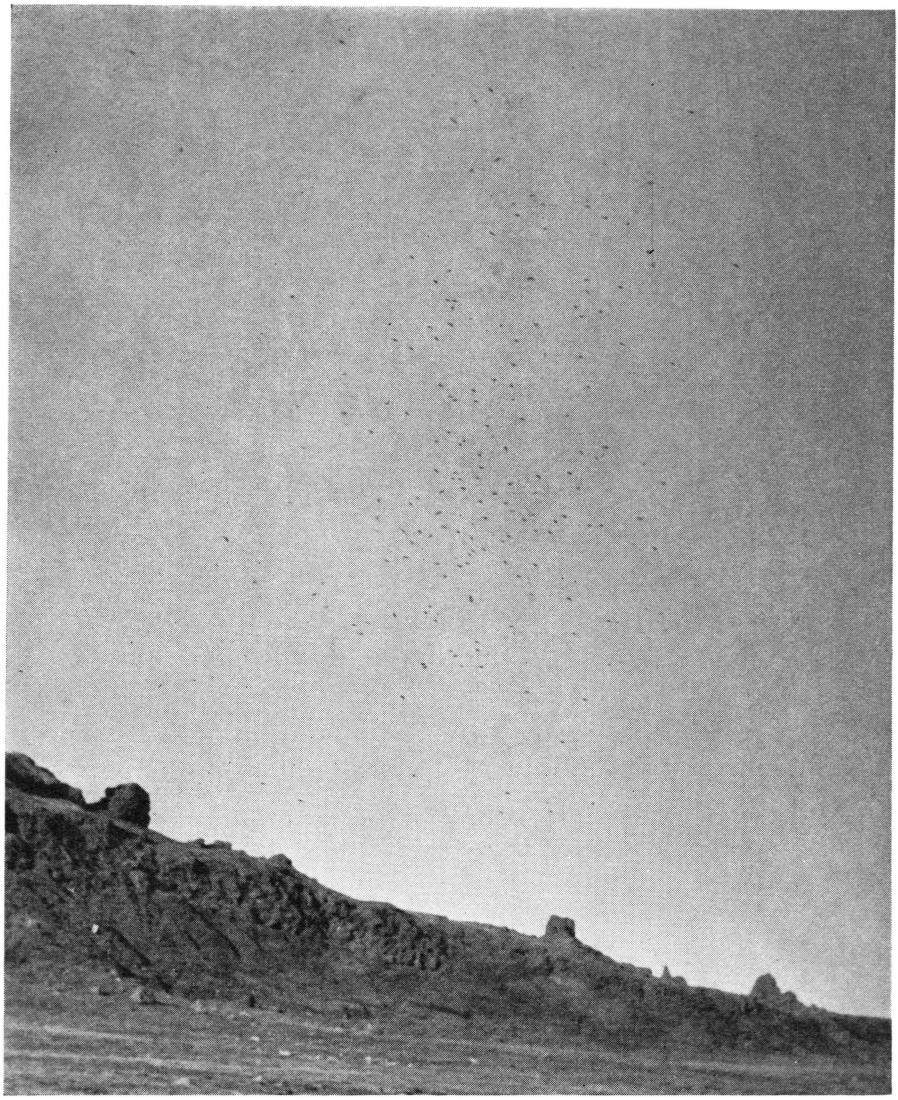

Fig. 8. Swarming mosquitoes east of Arctic Station.

Behavior During the Egg-Laying. We never had an opportunity to see the egg-laying in the field. But several females were kept in cages in the laboratory in order to induce them to lay eggs, using the technique of HAEGER (1958). When the females in these cages were sitting close together as they often were, especially on the gauze wads used for the egg-laying, they often displayed an activity which conveniently could be described as bellicose: suddenly one of the females would rise up on the feet, pointing the proboscis toward one of the others and advance

against her, whirling the fore legs in the air and with the proboscis down as a lance; the other mosquito would reply with similar movements, and with the proboscis turned slightly aside, the two animals would "fence" with the fore legs. Finally, one of them would advance, sometimes stepping on the loser, sometimes the loser moved away to another place. A smaller or disabled loser would be especially threatened with being trodden underfoot The females were not crowded in the cages, and these fights could not be explained as a fight for space.

The Swarming. In order to be able to estimate the results of the 138 observations on hand, it is convenient to use a numerical scale for the activity of the males:

0 No males on the wing during the inspection.
0–1 One or very few flying.
1 Some males flying but none making attempt to swarm.
1–2 Some males flying, one or very few stop in a swarm-like manner against the wind.
2 A few individuals make brief attempts to swarm but soon give up again.
3 One or a couple of open, unstable swarms.
4 At least at one favorable place a small, stable swarm is formed.
4–5 Several small swarms or a large one at a favorable place.
5 Large swarms at several places.
6 Several large swarms, one or more of the columnar type.

The columnar type of swarm was never seen in Narssarssuaq; the column has a diameter of 1–3 meter and may be 6–8 m tall with the base 1–3 m above the ground. The number of individuals can only be roughly estimated as being from several hundreds to thousands.

It will be seen that in groups 0 and 1, there is not the slightest tendency to make swarms; in groups 2 and 3, the urge to swarm is present but not brought out; and 4 (including 4–5), 5, and 6 represent the real swarming in different degrees of completeness.

Table 2 shows the distribution of these classes in the material.

Table 2. *Distribution of Activity for All Observations in Godhavn*

Stage of Activity	Number of Cases	%
0–1	77	54
2–3	33	23
4	15	11
5	8	6
6	9	6

Table 3. *The Influence of Wind, Temperature, And Relative Humidity on the Mosquito Activity*

Wind	Stages of Activity															No. of Obs.
	0–1			2–3			4			5			6			
	No. of Obs.	tp	% RH	No. of Obs.	tp	% RH	No. of Obs.	tp	% RH	No. of Obs.	tp	% RH	No. of Obs.	tp	% RH	
0–0.9	16	6.6	87	11	8.7	78	6	8.3	82	3	12.2	70	4	8.8	73	40
1.0–1.9	13	6.9	82	12	8.2	73	5	9.8	75	4	10.3	66	3	11.3	68	37
2.0–2.9	18	8.2	80	7	9.4	78	2	7.5	88	1	10.5	76	1	12.8	69	29
3.0–4.9	18	6.8	79	2	10.7	69	0	—	—	0	—	—	0	—	—	20
≧ 5.0	12	9.3	64	1	8.8	75	2	14.2	66	0	—	—	1	12.2	78	16
	77	7.5	79	33	8.8	75	15	8.8	78	8	11.0	68	9	10.5	66	142

It will be seen that during more than half of the inspections there was no activity at all, and swarming only occurred in less than one fourth of the observations. Even while the observations were being made we had the same impression as in Narsarssuaq that the main inhibiting factors were high wind velocity and low temperature. The larger number of observations from Godhavn permits a numerical approach to this problem.

In table 3 and fig. 9 are given the number of observations at different wind velocities and the average temperature during observations.

In calm weather swarming may take place at all temperatures above 5°. However, the three observations of swarming at 5° and 6° are all from July 13. It had been cold and rainy weather during the preceding 48 hours and there had not been any swarming during this period. It had also been windy, but on July 13 around noon the wind fell and the rain ceased. The long delay in the release of the urge to swarm may have caused a lowering of the threshold, resulting in swarming at lower temperatures than is normally the case. When the wind velocity is between 1 and 2.9 m/sec, the swarming flight is first performed at temperatures above 7°. The two cases of swarms of type 4 at wind velocities above 5 m/sec are somewhat misleading as these swarms were situated at sheltered places where the actual wind has probably been considerably less.

It is more difficult to explain the only case of swarming of type 6 at wind velocities above 5 m/sec. It was on July 6, a clear day with temperatures between 12 and 13° during the middle of the day. The wind was from SW in the morning and SE in the afternoon, varying in velocity from 1.9 to 9.5 m/sec. Already in the morning there was much swarming activity, and in the afternoon at 16h30′, about the time when

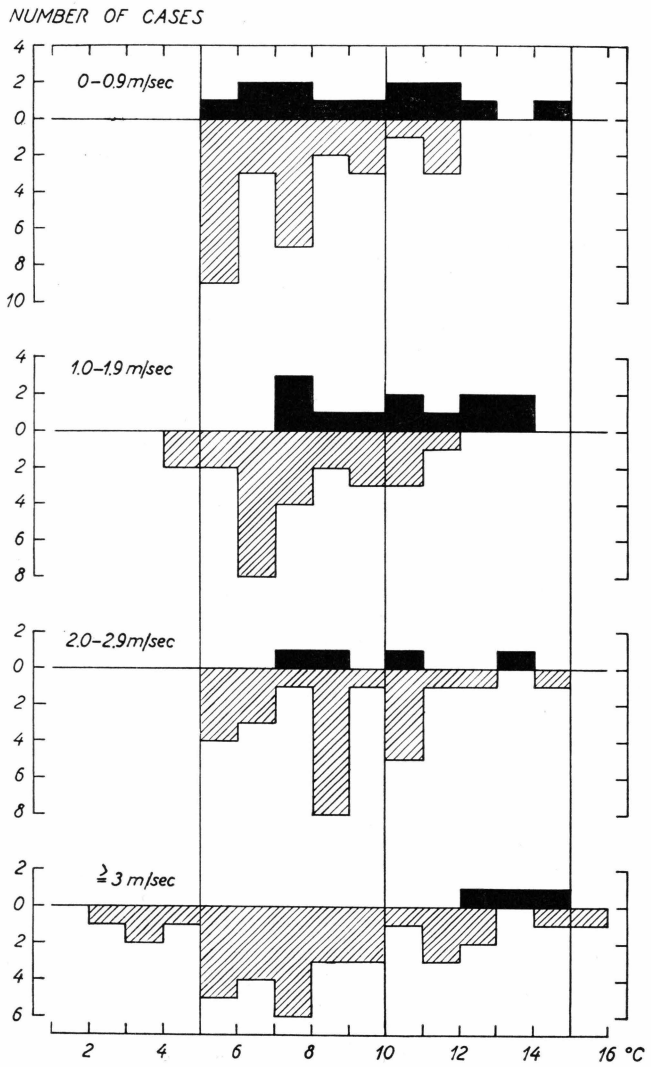

Fig. 9. The influence of wind velocity at different temperatures on the activity of the mosquitoes.

The black figures above the zero-line show the number of cases of swarms observed at the four groups of wind velocity. The shaded figures below the zeroline represent the number of observations with little or no activity.

the wind reached a maximum, there was full swarming including two huge columnar swarms, one of which (map nr. 3) was fully exposed and another one which, during the gusts, looked like a mast falling down. There were several more large swarms, some of them freely exposed. One of them was so high that it could only be seen with a white cloud as background.

We have no reasonable explanation for this swarming. The preceding day there had been swarming in the morning but not in the afternoon or during the night; this delay is no longer than observed in several other cases and cannot have caused the remarkable activity. There is, however, one thing to learn from this observation: it is not physical insufficiency which causes the usual inhibition at velocities above 2 m/sec. It has often been noticed, also in other mosquitoes, that swarms on windy days are also absent from places where there is very good shelter. It is our impression that high winds inhibit the urge to swarm before the animal has actually tried to fly out from its resting place.

Compared with the dominating influence of temperature and wind, the illumination plays a very small role, if any at all.

In the other mosquitoes we have studied, the urge to swarm seemed to appear according to change in illumination, but in the Greenland mosquitoes it is most likely that the urge is present at all times.

In Narssarssuaq swarming during all observations stopped at 17–18h; as already pointed out this is more likely because of the effect of adverse weather conditions than to the illumination. The possibility that the cessation of swarming was caused by the illumination being reduced below a certain threshold between 17h and 18h is very remote; in Godhavn we have seen swarming an hour after midnight at an illumination of 3.80 log lux and the illumination in Narssarssuaq remained above this value until about 21h.

In Godhavn there was swarming activity up to stage 4 at all times. The most highly developed swarms—stage 5 and 6—were only seen between 10h30′ and 19h30′ (table 4). But this is probably also an effect of the higher temperature during this period.

Table 4. *Distribution of Activity During the Diel*

Stage of Activity	Hour (Local Time)							
	01h30′	03h30′	07h30′	10h30′	13h30′	16h30′	19h30′	22h30′
4	1	3	1	4	2	1	1	1
5	0	0	1	1	0	3	1	0
6	0	0	0	1	1	2	2	0
Total	1	3	2	6	3	6	4	1

The peculiarity of fewer large swarms at 13h20′ than at 16h30′ is caused by wind. The morning in Godhavn was mostly calm, but there was an increase in velocity at noon or shortly after whieh reduced the swarming or stopped it for some time.

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