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INSECT DISPERSAL STUDIES IN NORTHERN ALASKA[1]

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Abstract: Studies of natural dispersal of insects were carried out at Point Barrow and Cape Thompson during the summers of 1966 and 1969. Large nylon nets were arranged to constantly face the wind, and were emptied three times per day. Weather data and activities of free-living insects were correlated with trapping results. At Point Barrow, 2,745 specimens were trapped in 1966 and 7,020 in 1969. At Cape Thompson, 4,465 were trapped in 1966 and 551 in 1969.

INTRODUCTION

Most of the effort during the two summer seasons work here reported concerned the natural dispersal of insects. The northern and northwestern corners of Alaska were chosen for the sites of these studies for several reasons. A continental coastline, and one that is minimally sinuous, is appealing from the standpoint of study of natural dispersal because there may by opportunity to detect organisms blown or washed ashore from across sea, and conversely to detect them in the process of being blown from land outward over ocean. Furthermore other continenal masses are not so very far distant from this coastline. Moreover, snow and ice surfaces render displaced insects more readily visible than in most other environments. Lastly, logistics and facilities available at the US Naval Arctic Research Laboratory rendered the project viable.

Among questions to be answered were those relating to the problems of natural methods and rates of dispersal of land arthropods across the tundra, and toward or away from the coastline. Additionally there was the question of extent and trends of reoccupation of areas which became ice-free after the end of the Pleistocene, or the occupation of new areas of land formerly forming part of the submarine continental shelf. Likewise there was the question of extent and nature of dispersal across the Arctic Sea from other continents like Europe and Asia, or from northern Canada or Arctic islands. In order to evaluate natural dispersal it was considered essential to sample and become familiar with the general local fauna in its natural environment. After trapping equipment was set up and operating, during both seasons, much effort was put into sampling of the soil and free-living fauna. Equipment was prepared for aerial trapping with light planes available at NARL, but various circumstances prevented the realization of this part of the program.

The work in 1966 was carried out by C. M. Yoshimoto, assisted by Miss J. Campbell and E. G. Brown. That in 1969 was done by J. L. Gressitt with the help of Earl Bishop and Eugene Holzapfel. Between these operations, during the summers of 1967 and 1968, Dr R. W. Strandtmann, also representing Bishop Museum, carried out work on free-living mites, but also continued some of the air-screening on a limited scale. Dr Strandtmann was assisted by Paul Schaefer and Dan Womochel.

1. Contribution from Bishop Museum; supported by the Arctic Institute of North America (ONR-386, 1966; ONR-424, 1969).

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Before this work of 1966—1969, little if any concerted work on natural dispersal of insects had been done in northern Alaska, and rather little in far northern North America as a whole.

Studies on the land arthropod fauna of the Point Barrow area have been done by Weber (1950, 1954), Hurd & Lindquist (1958), Bohnsack (1968), Strandtmann (1971) and others. A discussion of the environment was presented by Brown (1968). The Cape Thompson environment and fauna was discussed by Wilimovsky, Wolfe et al. (1966).

The Environment

Point Barrow is situated at the northernmost point of Alaska, just north of 71°15' north latitude. The area terminates in a cape, and a small narrow peninsula pointing north into the Arctic Ocean, with the Beaufort Sea to the east and the Chukchi Sea to the west. The northern portion of this cape, where the Barrow area studies were made, is all extremely low in altitude, and nearly level, with an altitude of barely over 10 m a bit south of the study areas, and average relief of less than 5 m. Most of the land surface is formed in polygons from ice action. The ground is frozen to 300 m depth or more, and thaws in summer to about 40 cm depth.

This area is very young geologically, being late Pleistocene. This portion of the coastal plain was the last to emerge from beneath the sea. There are many shallow lakes in the area (see Brown 1968).

The climate is characterized by long, dry, cold winters and short, moist, cool summers. Freezing occurs in every month and snow may occur at any time. Temperature maxima exceed freezing on an average of 109 days per year (see Table 1). Precipitation is only 116 mm, mean, per year. March to May are driest and July-August wettest. Greatest snowfall is usually in October. Snow patches may remain on the ground well into summer. During the summer of 1969 snow covered the ground a considerable portion of the time. Fog and cloudy weather are common, particularly through the summer, with the maximum in September. Wind may be from any direction but the prevailing direction is easterly. Annual mean hourly wind speed is 21.6 km/hr. The highest monthly mean speed is 24.6 km/hr in October, and the March and December means are lowest at 19.8 km/hr.

Table 1. Climatic comparisons of subpolar areas

	Mean monthly temp. (C).	
	Min.	Max.
Point Barrow, N. Alaska	−31	+1
Cape Thompson, N. Alaska	−25	+8
Campbell Island, Southern cold temperate	+4	+9
South Georgia, Subantarctic	−3	+6
Maritime Antarctic (Signy I., S. Orkney Is.)	−12	+1
Antarctic continental fringe (Cape Evans)	−26	−3

Soils are of limited types locally. Three wet soil types are predominant: Upland Tundra with moderate to poor drainage, on fine-grained parent material with peat up to 7.5 cm thick; Meadow Tundra, wetter with 7.5—15 cm thick peat; Bog, still wetter with more than 15 cm thick peat. Of limited local occurrence is Arctic Brown, which is somewhat acid, on coarse grained material with good drainage—on top of raised inland beach ridge, with Regosols present where beach ridge gravel is excessively drained (Brown 1968).

The Barrow area is covered with a rather thin arctic tundra consisting of short grasses and sedges, cryptogamic plants and scattered small herbs with a few severely stunted or prostrate small shrubs, rarely more than just a few cm high.

The Arctic Fauna

There is essentially only a single arctic fauna, around the Arctic Sea, with few differences between Old and New World. Although some species may only be recorded from one continent or another, in many cases it may prove that different species are not involved, or at most subspecies or weak races. Thus, in the trapping studies, it may be difficult to be sure of the origins of insects suspected to have been carried great distances over the Arctic Sea by air currents.

Composition of the Point Barrow Fauna

The land arthropod fauna of the Point Barrow area (Hurd & Lindquist 1958; Bohnsack 1968; Strandtmann 1971) does not represent a typical cross-section of the North American fauna in terms of proportionate representation of the various taxonomic groups. To begin with, the spiders, mites and springtails (Collembola) together include about 4/5 as many species as all the rest, or the true insects, combined. (Some authorities consider the Collembola to be true insects — they are hexapods — and others place them in a separate class.) The free-living mites are better represented than are the Collembola. Trichoptera and Diptera are quite well represented, whereas Hemiptera, Lepidoptera and Coleoptera are rather poorly represented. Hymenoptera are fairly numerous, constituting 1/5 of the insect species above the Collembola.

The local fauna is restricted by the limited tundra environment which usually provides wet peat soil with thin covering of grass, sedges and cryptogamic plants, and only a few dwarfed or prostrate higher plants. The adverse climate is of course a factor. The paucity of Lepidoptera and Coleoptera is particularly noticeable. This might be assumed to be partly because many members of these orders are associated with higher plants, and particularly with broad-leaved trees. However, it may also be significant that members of the Lepidoptera and Coleoptera are infrequently taken in the air-screenings in various situations, including high southern latitudes and over tropical seas or islands. On many oceanic islands, however, Lepidoptera and Coleoptera are much better represented in the native faunas than in the air-screening in such areas or in the screening for local fauna at Barrow. This discrepancy is considered to relate to the much greater age of such oceanic islands, than of the environment of Barrow, along with a more favorable climate and varied environment. Thus, over a period of say hundreds of thousands of years, even with infrequent immigration, available niches have been occupied on those islands. For the Barrow environment, an age of only a few tens of thousands of years at most is involved, the climate is harsh, and the environment is relatively uniform. Furthermore, the area is covered with snow the greater part of each year. Thus the Lepidoptera and Coleoptera may not have had sufficient time to establish extensively on the former submarine shelf constituting the Barrow area.

Among possible reasons for the scarcity of Lepidoptera and Coleoptera in air-screening may be the nature of wings and of flight for Lepidoptera and the high specific gravity, weak flight or flightlessness in Coleoptera. In Lepidoptera the fragile wings of of many groups are torn by strong winds, rendering them relatively flightless or less likely to be carried passively by the wind. Strong-flying Lepidoptera may often be able to control their flight and avoid being carried long distances involuntarily.

It is interesting to compare the Barrow fauna with that of Antarctica and of subantarctic islands (Table 2). Antarctica has a much more rigorous climate than does Barrow, whereas most of the subantarctic islands have higher average temperatures, and particularly milder winters, than does Barrow. Campbell Island (southern cold temperate and not subantarctic, according to strict definition) has a slightly larger arthropod fauna than does the Barrow area, but has a much better representation of Lepidoptera and

Table 2. Comparative representation (species) in arthropod fauna at Barrow, Lake Hazen and far southern areas.

	Barrow (Hurd, Bohnsack)	Lake Hazen (Downes, Leech)	Campbell I.* (Gressitt, 1964)	South Georgia (Gressitt, 1970)	Antarctica (Gressitt, 1967, 1971)	World (1/3000)
Araneida	18	13	16	4	–	16
Opiliones	—	—	2	—	—	1+
Acarina	60	49**	71	67	73	15
Collembola	25	14**	46	16	16	2
Orthoptera	—	—	1	—	—	25
Psocoptera	—	—	2	—	—	1
Thysanoptera	2	3	1	1	—	1
Mallophaga	17	6**	25	35	40	1
Anoplura	3	1**	3	1	4	0.1
Homoptera	1	5**	4	—	—	9
Heteroptera	1	—	—	—	—	11
Plecoptera	1	—	3	—	—	1
Neuroptera	1***	—	—	—	—	2
Trichoptera	5	1	1	—	—	2
Lepidoptera	4	20**	29	—	—	40
Coleoptera	14	5**	43	7	—	100
Diptera	130	149**	81	13	2	34
Siphonaptera****	—	—	3	1	1	1–
Hymenoptera	40	362*	10	1	—	38
Totals	322	328	351+	146	136	300± (× 3000)

*Excluding some groups not found at Barrow.

**Includes species added by D. R. Oliver (pers. comm.)

***Taken in air-screening, 1969 — not previously recorded.

****A species was taken at Cape Thompson by Strandtmann & Womochel.

The last column indicates relative representation of these groups in the world fauna (multiply by 3000).

Coleoptera, and fewer Hymeoptera. Campbell Island also has more groups of arthropods represented in its fauna than does Barrow. South Georgia, with the richest fauna, as far as known, of the true subantarctic islands, has a smaller number of species than does Barrow, but a better representation of mites and lice, while Barrow has more Diptera and Hymenoptera. Barrow has 5 orders of insects lacking in South Georgia, but the latter has a flea whereas none have been recorded from Barrow (one was taken at Cape Thompson by R. W. Strandtmann). Antarctica has still more groups lacking

(Coleoptera, Hymenoptera) which are present at Barrow, but has more mites and lice known and a higher percentage of its fauna consists of Collembola. Antarctica also has an endemic flea. In general Diptera and Coleoptera are more equally represented on subantarctic islands than at Barrow (ratio: about 2:1 instead of 9:1)

The fauna at Cape Thompson has not been well documented, but is considerably richer than that of Barrow (see AEC report 1966). Among other groups, Ephemeroptera and Siphonaptera occur at Cape Thompson, as well as more families of Heteroptera, Homoptera (Psyllidae) and other orders. Also there are conspicuously more Lepidoptera and Coleoptera at Cape Thompson.

Cape Barrow has 106 species of vascular plants. This is slightly fewer than occur on Campbell Island (116) but many more than occur in Antarctica (2) and South Georgia (32).

Methods and Material (1966)

The Bishop Museum team first started the air dispersal studies in the Britten Manor and Voth Creek areas. Miss Campbell was assigned to operate the Berlese funnel and trapping operations in the Point Barrow area. Edgar Brown took charge of the Cape Thompson trapping operation.

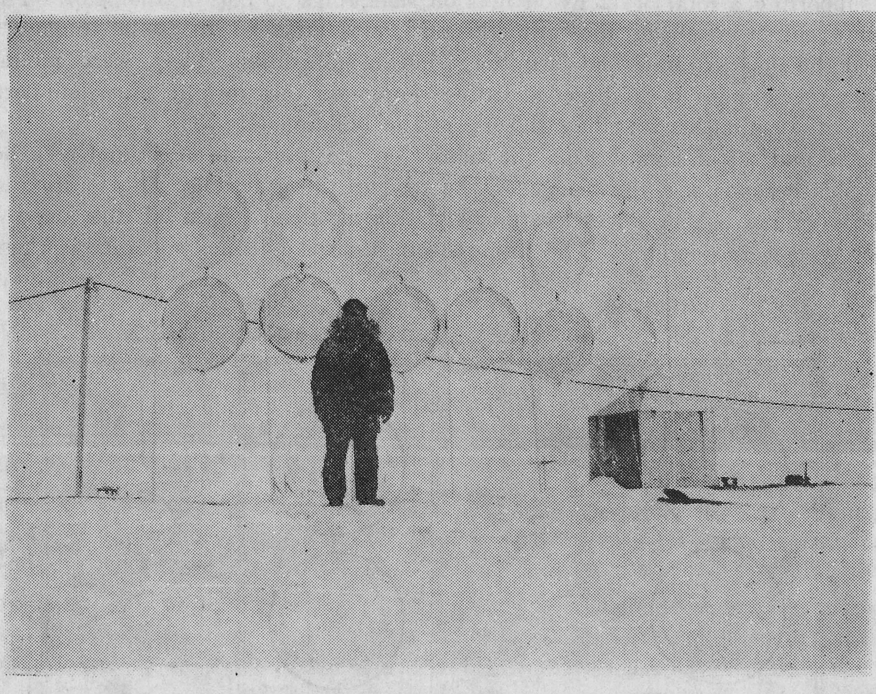


Fig. 1. Aerial trap nets on Fletcher's T - 3 Ice Island in 1966.

During late June to end of August 1966, 16 trap nets were set up at Voth Creek — Britten Manor near Point Barrow and Cape Thompson. The 75 cm diameter steel ring nets were attached to a swivel-pulley system. Nets were placed approximately 1.5 m and 2.5 m above the ground and rotated freely in the direction of the wind (fig. 1). They were emptied 3 times daily, midnight (24:00), morning (8:00) and at noon (12:00). Specimens were examined and meteorological data documented at the field station.

From 10 to 17 June 1966, 12 trap nets were placed on "Fletcher's T-3 Ice Island," some 650 km NE of Point Barrow. The ice island originated from the Ellesmere ice-shelf before 1951 and had been drifting near the North Pole for some years.

Methods and material (*1969*)

Three participants (Gressitt, Bishop, Holzapfel) from Bishop Museum worked at the Arctic Research Laboratory in 1969. Principal emphasis was on the dispersal studies, with secondary sampling of local fauna for comparative and checking purposes. Gressitt and Bishop set up the trapping equipment on 4 and 5 June, Holzapfel finished up the season in early September, and Bishop worked through most of the summer, spending part of August at Cape Thompson after Holzapfel's arrival at Barrow.

At Point Barrow, 2 main sets of air-screening nets were set up. One set was erected on the top of the NASA tower, north of the station airstrip and northernmost building in Alaska. This set consisted of 2 frames, mounted on opposite sides of the top of the tower, supporting a total of 12 nylon nets on steel rings 75 cm in diameter. The nets flew at about 9 m above the ground and were attached to swivel-pulleys which permitted the nets to rotate and face the wind at all times. They were mounted in aluminum pipe frames with threaded fittings and with the upright pipes supported by lashing to the railing surrounding the top of the building (fig. 2).

The second set of nets was on the tundra on the west side of Voth Creek between the complex antenna and the bridge on the road to the gas well. This location is about 10 km SW of the NASA tower location. At this location 8 nets of the same 75 cm diameter type were operated. The frames were secured by lines anchored in the tundra.

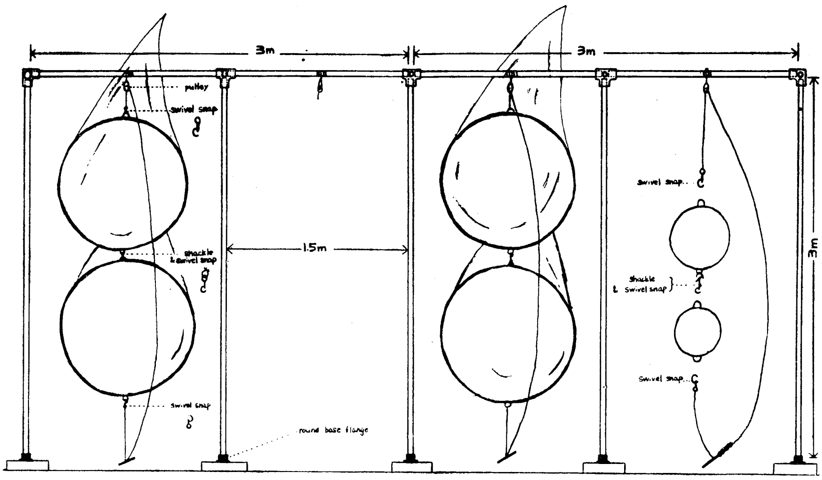
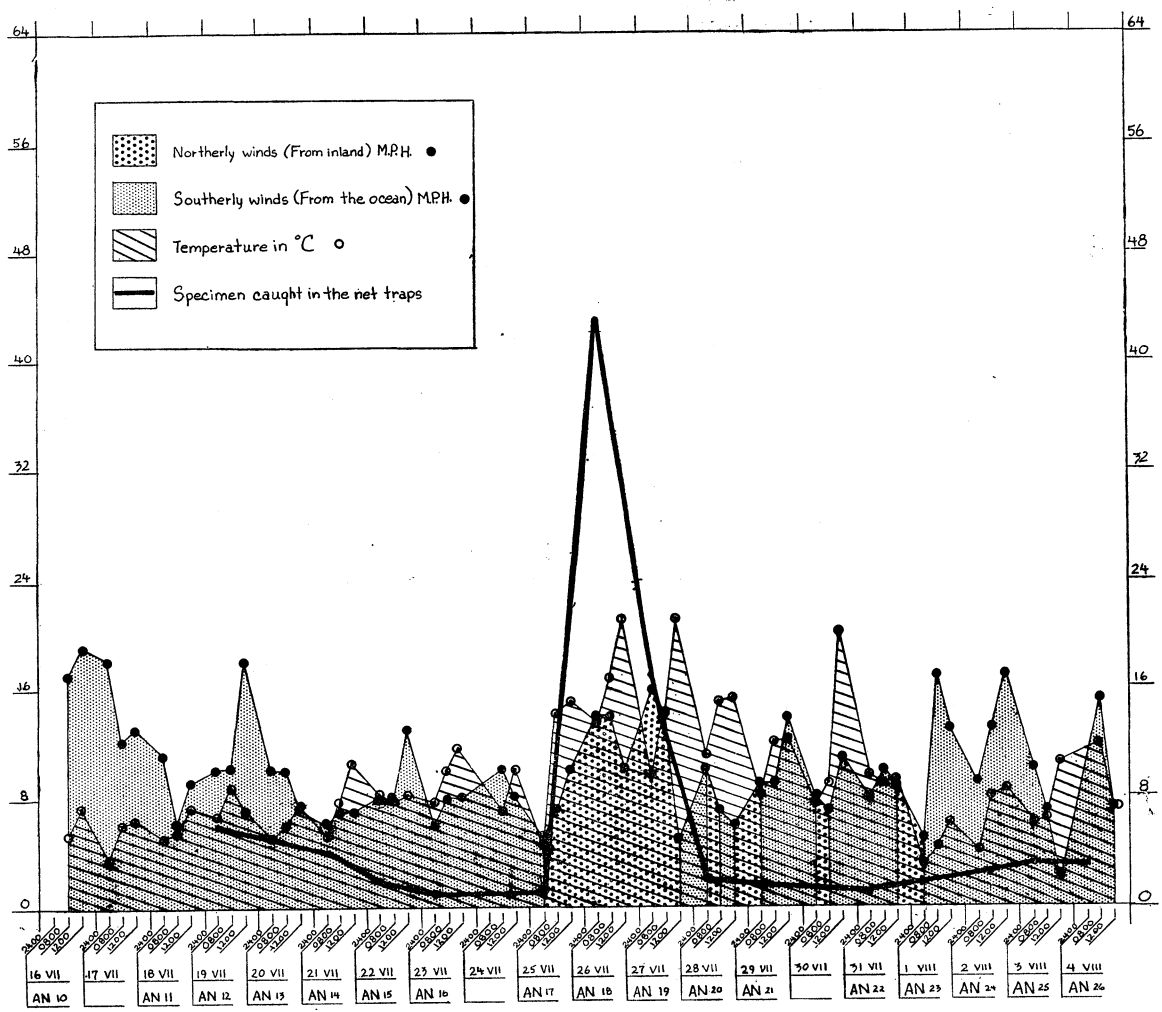


Fig. 2. Diagram of arrangement of frames and nets (latter 75 cm diameter).

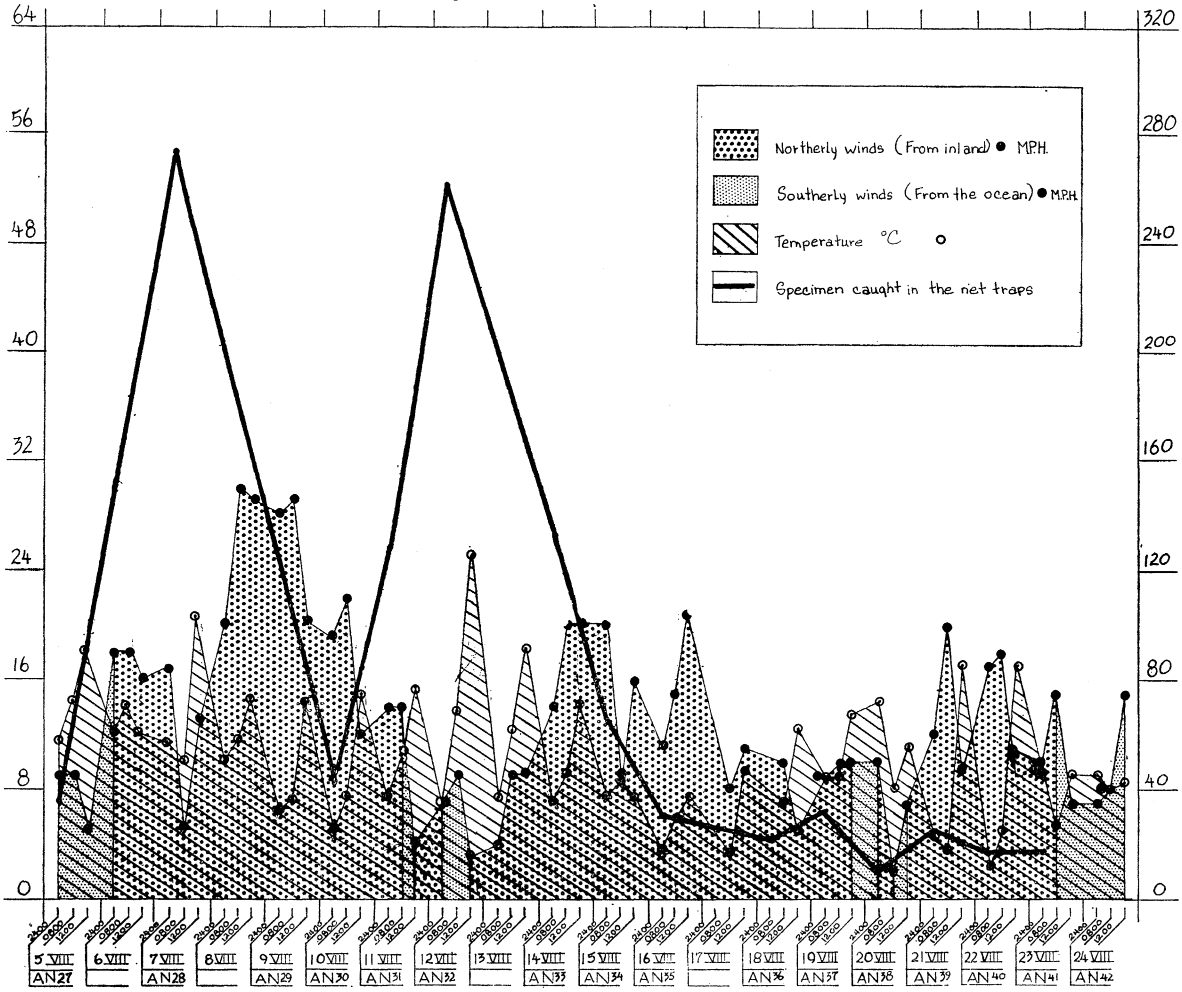


Graph 1. Diptera: Mycetophilidae — Cape Thompson, Alaska, 1966. Scale at left indicates temperature in °C and wind current in miles per hour; scale at right indicates numbers of specimens trapped.

The nets screened air between 1.5 and 2.25 m height above the tundra surface. The nets were checked 3 times a day, usually at 09:00, 17:00 and 23:30.

Another kind of trap, a "Hocking trap" was erected on the tundra NW of the Voth Creek net battery. This trap is like a miniature Malaise trap, mounted on a rotating base so as to face the wind at all times. With separate trapping device on each side, it separately catches those insects flying against the wind and those carried passively by the wind. Unfortunately, the trap proved a little weak for the frequent strong winds, and did not operate adequately much of the time.

At Cape Thompson, from 11 to 21 August 1969, Bishop operated 4 nets. They were set up with pole frames parallel to the shoreline, on a grassy knoll north of the Chariot



Graph 2. Diptera: Mycetophilidae — Cape Thompson, Alaska, 1966. Scale at left indicates temperature in °C and wind current in miles per hour; scale at right indicates numbers of specimens trapped.

camp and about 200 m from the sea. Nets were checked daily at 10:00 and 20:00. Cape Thompson is situated on the west coast of Alaska, on the Chukchi Sea, south of Cape Hope, slightly north of 68° N. lat., and roughly in line with the northern slope of the Brooks Range or southern edge of "north slope." The study area faces southward to the sea so that northerly winds are from the land and thus the reverse of the situation at Barrow. The vegetation at Cape Thompson is more complex, and the flora richer, than at Barrow. The local insect fauna is much more extensive than that at Barrow.

RESULTS (1966)

At Voth Creek and Britten Manor, 2,745 insects and other arthropods were taken in the trap nets (Table 3). The greatest catch of Diptera during July and August included 9 families. Among the flies, Chironomidae and Sciaridae were caught more frequently than others. In early summer, oribatid mites, spiders, springtails, a thrips and a staphylinid beetle were caught in the nets, but no Diptera. This indicated some activity of terrestial insects and arthropods only early in the season since none were

Table 3. Air-screening results (specimens trapped) at Voth Creek — Britten Manor, 1966, by months.

	June (5—30)	July	August	Sept. (1—2)	Totals
Araneida	1	1	—	—	2
Acarina	1	2	—	—	3
Collembola	5	2	—	—	7
Thysanaptera	1	—	—	—	1
Coleoptera: Staphylinidae	1	—	—	—	1
Diptera: Tipulidae	—	7	—	—	7
Chironomidae	—	1,956	48	—	2,004
Sciaridae	—	553	8	—	561
Mycetophilidae	—	28	3	—	31
Culicidae	—	16	—	—	16
Cecidomyiidae	—	29	1	—	30
Helomyzidae	—	5	—	—	5
Chloropidae	—	3	18	—	21
Sphaeroceridae	—	—	—	—	1
Muscidae	—	49	6	—	55
Total					2,745

trapped in late summer.

Soil and vegetation samples from the Voth Creek area were taken and insects and other arthropods were extracted using Berlese funnels. The recovered specimens showed predominantly free-living mites and Collembola and some larval forms of Diptera, Coleoptera and Lepidoptera and adult Coleoptera.

Trapping activity on Fletcher's T-3 Ice Island showed negative results. The short trapping period, the time of the year and the distance from land probably accounted for the lack of specimens.

At Cape Thompson, 4,467 specimens were collected in the aerial nets (Table 4). Winds were predominantly from the NW (from the land). There were several occasions when the wind came from the SW (from the ocean). Trapped specimens were largely Diptera, represented by 27 families and 3,567 specimens. The rest included 8 orders of Insecta of which Hymenoptera were the largest in number with 13 families and 760 specimens. The trapped specimens included parasitic wasps of the superfamilies Ichneumonoidea, Cynipoidea, Chalcidoidea, and Proctotrupoidea, plus 3 specimens in the Tenthredinidae.

In the Empididae (Diptera), 3 subfamilies were represented, Empidinae, Clinocerinae and Tachydromiinae. In the Empidinae, 3 genera and 13 species were collected: Two genera, ***Empis*** and ***Hilara***, each with one species, and the genus ***Rhamphomyia*** with 12 species. In Clinocerinae, 3 genera, ***Clinocera***, ***Trichoclinocera***, and ***Heleodromia***,

Table 4. Air-screening results (specimens trapped) at Cape Thomoson, 1966, by months.

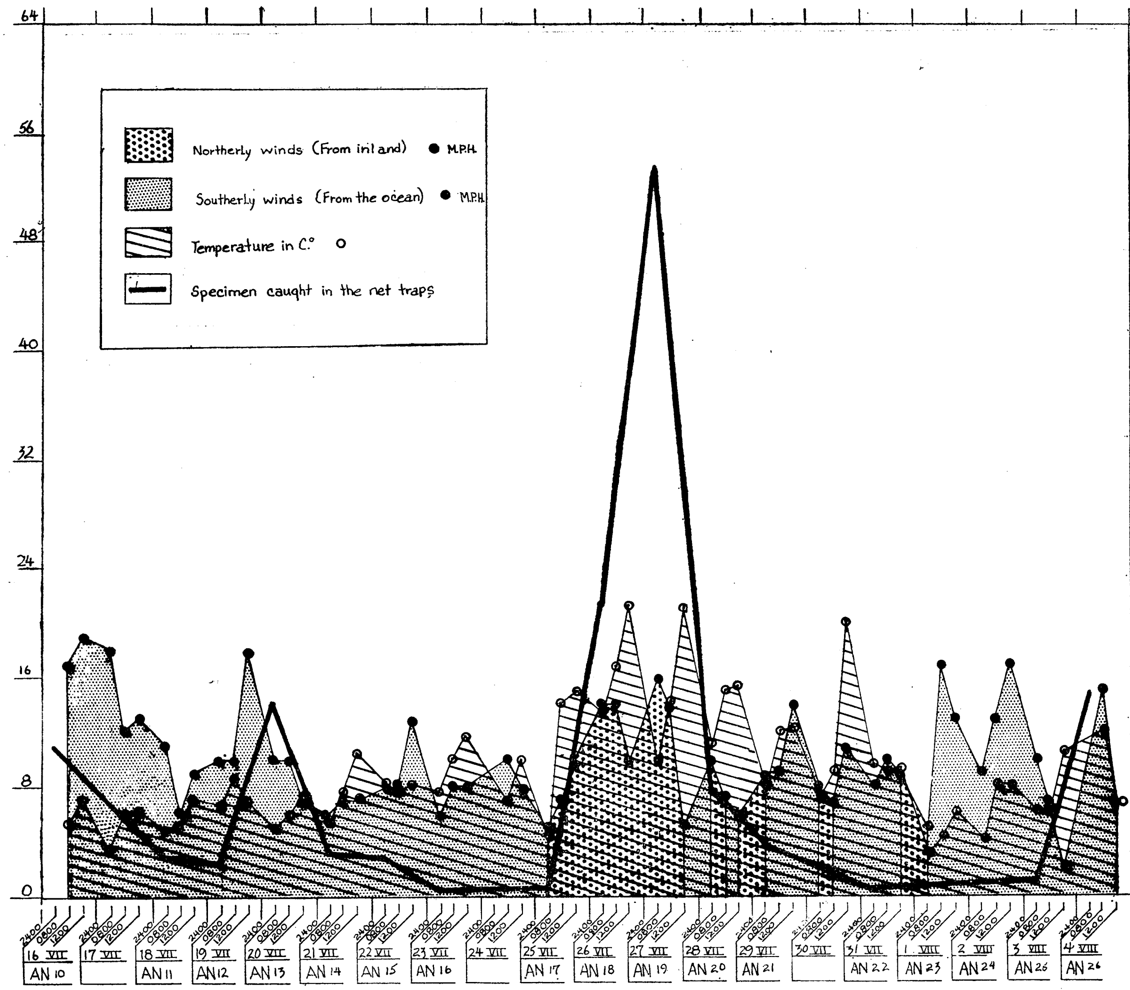
	July	Aug.	Sept. (1—2)	Totals		July	Aug.	Sept. (1—2)	Totals
Araneida	—	—	—	—	Mycetophilidae	257	1,133	—	1,390
Acarina	—	—	—	—	Platypezidae	—	1	—	1
Collembola	—	—	—	—	Bibionidae	1	—	—	1
Neuroptera:					Syrphidae	6	8	—	14
Hemerobiidae	3	—	—	3	Chloropidae	1	155	—	156
Plecoptera:					Sphaeroceridae	34	38	—	72
Nemouridae	1	—	—	1	Ephydridae	2	25	—	27
Ephemeroptera:					Helomyzidae	3	10	—	13
Baetidae	10	—	—	10	Agromyzidae	5	17	—	22
Trichoptera:					Sciomyzidae	—	6	—	6
(?) Grensia	1	—	—	1	Acartophthalmidae	—	1	—	1
Coleoptera:					Piophilidae	—	5	—	5
Curculionidae	1	—	—	1	Milichiidae	4	3	—	7
Staphylinidae	14	—	—	14	Muscidae	56	172	—	238
Homoptera:					Tachinidae	—	1	—	1
Psyllidae	76	—	—	76	Calliphoridae	—	1	—	1
Aphididae	31	—	—	31	Hymenoptera:				
Delphacidae	5	—	—	5	Ichneumonidae	275	—	—	275
Lepidoptera:					Braconidae	164	—	—	164
Geometridae	9	—	—	9	Tenthredinidae	2	—	—	2
Diptera:					Cynipidae	3	—	—	3
Tipulidae	5	21	—	26	Charipidae	24	—	—	24
Chironomidae	288	544	—	832	Mymaridae	9	—	—	9
Cecidomyiidae	40	24	—	64	Pteromalidae	159	—	—	159
Ceratopogonidae	5	14	—	19	Encyrtidae	14	—	—	14
Sciaridae	20	74	—	94	Eulophidae	43	—	—	43
Simuliidae	4	64	—	68	Ceraphronidae	37	—	—	37
Phoridae	4	69	—	73	Platygastridae	5	—	—	5
Culicidae	372	50	—	422	Proctotrupidae	10	—	—	10
Dolichopodidae	—	6	—	6	Scelionidae	3	—	—	3
Empididae	4	15	—	19	Total				4,467

each with one species and Tachydromiinae with 2 species of the genus ***Platypalpus***.

In Hymenoptera, the ichneumonids, with 275 specimens, braconids with 174 specimens and pteromalids with 161 specimens made up the bulk of the catches.

Two families of Diptera, Mycetophilidae and Muscidae were selected for study of correlation of temperature, wind velocity and direction and the number of specimens caught in the trap nets (see graphs). In general, other flies show similar patterns of activity in regard to wind currents and temperature. These trapped flies are classified into categories of weak to moderate flyers (Yoshimoto & Gressitt 1964). The aerial density of insects is correlated with terrestrial ecology (Johnson 1960).

The greatest catches in the aerial nets normally follow the rise in temperature and acceleration of air currents. Both the Mycetophilidae and Muscidae (Graph 1—4) show from 25 to 27 July a great increase in insect catches with high acceleration of air currents from the northwest (from land). Between 10 and 15 August, the Mycetophilidae (Graph 2) shows similar number of catches with those of 5 to 10 August; however, in the

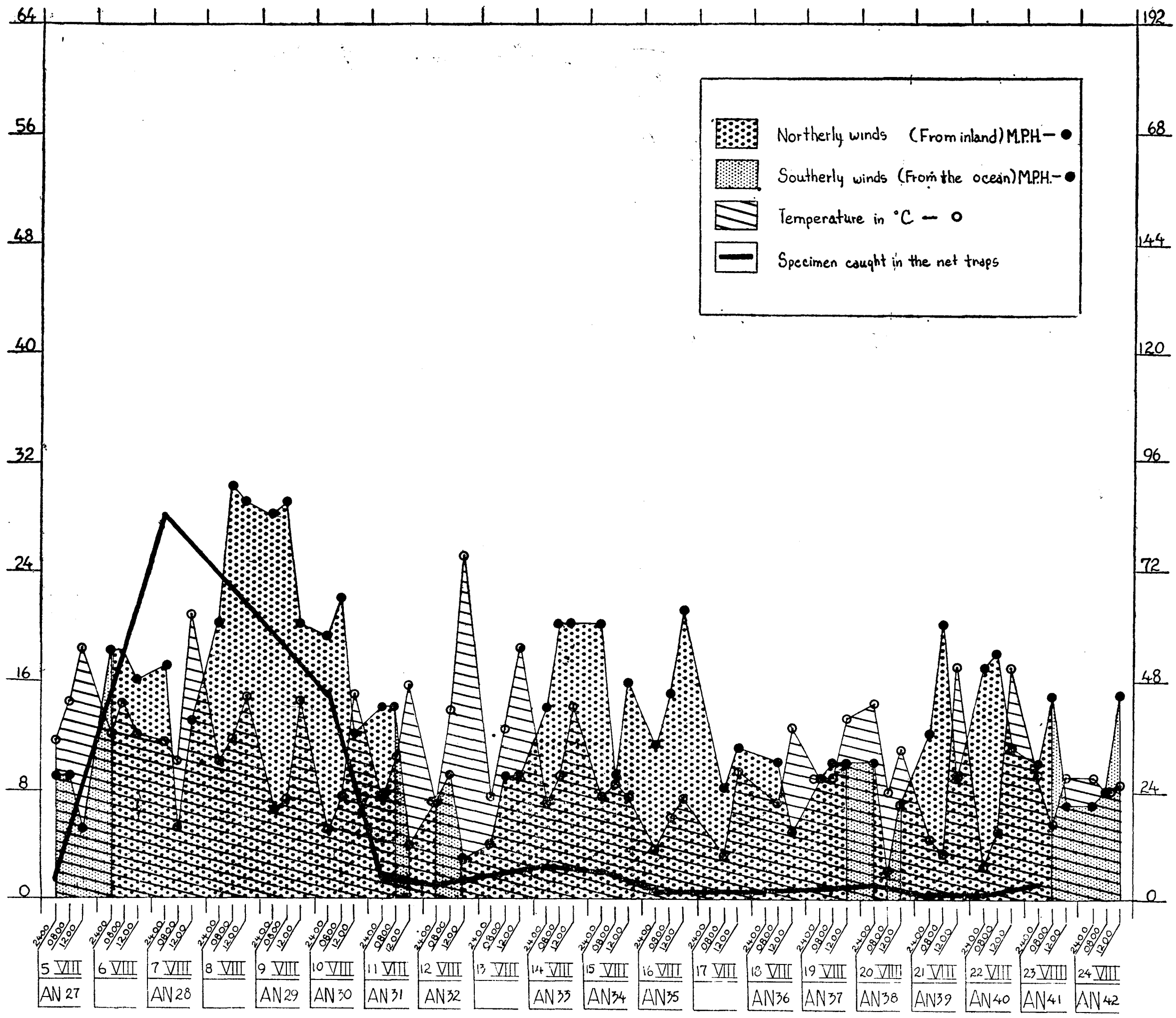


Graph 3. Diptera: Muscidae — Cape Thompson, Alaska, 1966. Scale at left indicates temperature in °C and wind current in miles per hour; scale at right indicates numbers of specimens trapped.

Muscidae, the catches were low.

In many cases where wind speed ranged from 0—19.31 km/hr and the maximum temperature and sunshine hours were high, the insect catches were low. It must be assumed that the daily maximum temperature and maximum wind speeds may cause the insects to avoid flight, harboring close to the ground. However, when the wind velocity dropped to 8.04—9.66 km/hr, for a 3 to 5 hour period, followed by a sudden shift of wind speed of 25.75—45.06 km/hr, the catches were exceptionally high. Exceptions to this occurred during the middle to end of August when insect populations decreased and there were correspondingly smaller catches.

The complete identification of species trapped has not been possible. Though large numbers of species reported are of widespread circumpolar distribution, many groups



Graph 4. Diptera: Muscidae — Cape Thompson, Alaska, 1966. Scale at left indicates temperature in °C and wind current in miles per hour; scale at right indicates number of specimens trapped.

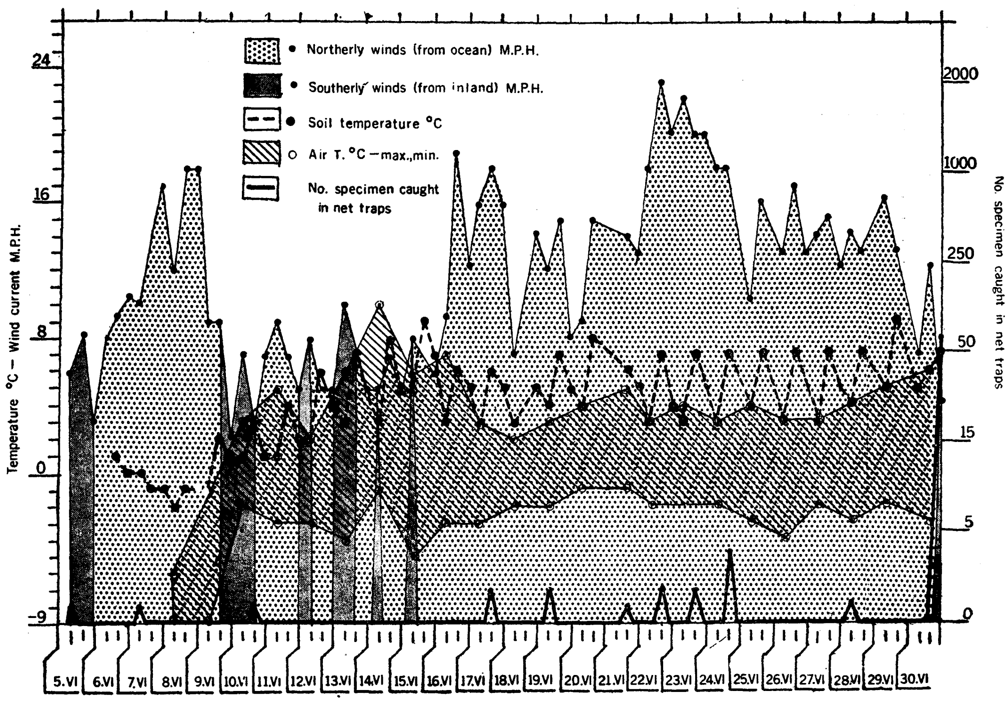
have not been adequately studied or revised (Hurd 1958). The completion of this study will take years of research by specialists throughout the world. There are insufficient specialists available to cover all the groups collected, although contacts and requests have been made.

RESULTS (1969)

The total numbers of insects and other arthropods taken in the Voth Creek trap nets in 1969 are plotted in graphs 5—7. The graphs also show wind speed, maximum and minimum air temperatures 20 cm above the ground, and soil temperature at 1 cm depth. The line for insect catches is weighted for small lots, so they will be noticeable.

The graphs also indicate whether wind was from north or from south. In general correlation between increase in temperature and numbers of insects trapped can be noted. The correlation would be closer if temperatures had been recorded at more frequent intervals, as maximum and minimum temperatures were only recorded once for each 24-hr period. The close correlation with local temperature gives reasonable weight to the assumption that most of the insects caught had become airborne locally just before being caught. The correlation of species trapped with those seen or caught by other means serves as additional corroboration.

The graphs show that the catches were largest in early July, and fluctuated greatly. The season was characterized by a late start and very early termination, except for four 1- to 2-day warm periods between the last day of July and the 2nd of September, when operations were terminated. Even the fourth week of July was largely negative. Thus,



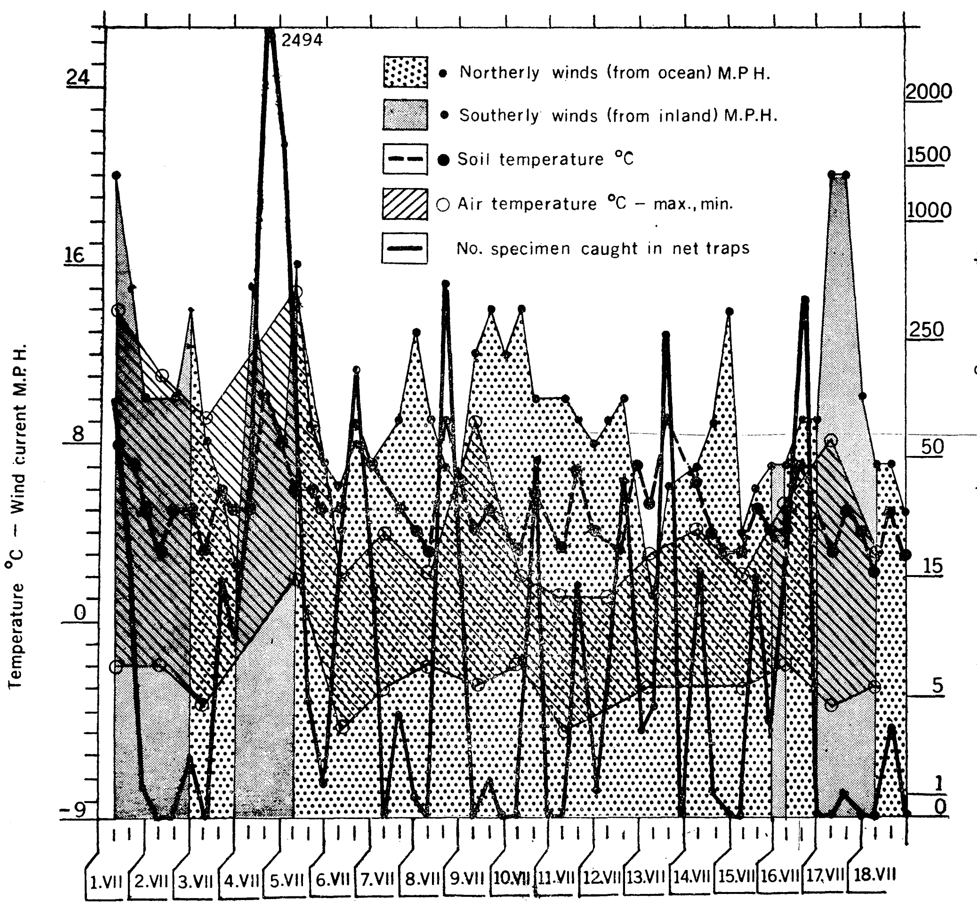
Graph 5. Wind, Temperature and Catch — Voth Creek, Pt. Barrow, Alaska, 1969

above-ground insect activity for the summer was extremely limited, involving short periods interspersed with cold, and frequently with snow and freezing.

Tables 5—7 show the taxonomic breakdown of catches in the same principal series of trap nets. The catches in the Voth Creek nets at Barrow are additionally broken down by months, and show the great contrast between the July catch and those of the other months. It may be noted that Acarina (mites) were taken only during June, and the same was true for Collembola (springtails). It is possible that these minute forms tended to be overlooked when large numbers of larger insects were taken later.

It is of interest that 12 families of insects taken in the trap nets during the short period at Cape Thompson were not taken in the nets at Barrow. This emphasizes the different, and much richer, fauna in the Cape Thompson area. Note in Table 7 that nearly 90% of the total catches at Voth Creek and NASA tower are composed of chironomids.

In general, collecting by miscellaneous methods provided data which correlated with the trap net catches, with some exceptions. In particular, soil sampling by means of the Berlese funnel extraction method produced greatly differing results. The latter collections produced about 15,000 specimens from only 30 samples taken. These were largely tundra turf samples, as well as nests of lemmings or birds, bird carcasses, or other materials. In these samples, great numbers of mites and springtails were taken, as well as members of several groups not taken at all in the trap nets. In general, flies, moths, bugs and thrips were represented by immature stages, while beetles, springtails and mites occurred both as young and adults. In other collecting the first insect of the season noted active above ground was the small black ephydrid fly, *Scatella stagnalis*. This was found in numbers making very short low flights from one grass stem to another in the first



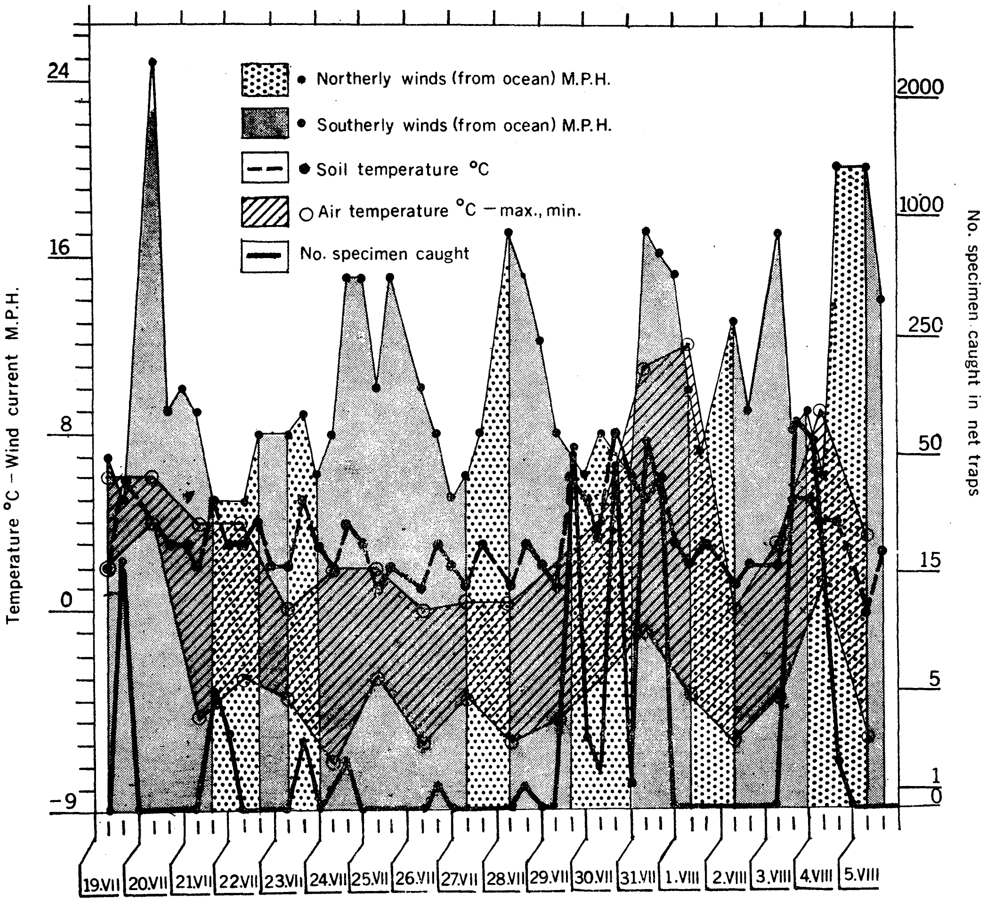
Graph 6. Wind, Temperature and Catch — Voth Creek, Pt. Barrow, Alaska, 1969

patches of tundra exposed by snow melt, 10 June 1969, especially in a more polluted area, near camp and near some whale remains, not far from the new and old labs at Barrow. The first chironomid midges were not noticed till 27 June, and not in great numbers until after the end of June. Bumble bees were noted from 14 June. However, these strong flyers were not taken in the trap nets. Ten kinds of flies were found by 15 June. Stonefly nymphs were collected on 16 June.

DISCUSSION

Relationship of Arthropods to the Local Environment

As Bohnsack (1968) has pointed out, 95% of the arthropods at Barrow occur within 2.5 cm of the tundra sod. Relative humidity in this area is usually near 90% (80—100). Though soil temperature varies less than air temperature, the temperature just above the soil surface may vary more widely than routine weather records demonstrate. Thus the arthropods, spending much of their active periods at and near the soil surface, are



Graph 7. Wind, Temperature and Catch — Voth Creek, Pt. Barrow, Alaska, 1969

subjected to great temperature variations. Bohnsack estimated some populations in favorable environments at 229,000 specimens of arthropods in a square meter, in August 1963. He found Collembola in greater numbers, as compared with mites, in dryer areas.

Relationship of Air-screening to Local Fauna

To some degree the air trapping results correlate with the composition of species in the known local fauna. The five groups with the most species in the fauna, 1) Diptera, 2) Acarina, 3) Hymenoptera, 4) Collembola and 5) Araneida (decreasing numbers of species in that order) are also the five with the highest numbers of trapped specimens. The order in the latter is Diptera, Hymenoptera, Acarina, Araneida and Collembola (1, 3, 2, 5, 4). This is as one might predict because Hymenoptera are winged and Acarina not; also spiders spin silk and Collembola do not. However, probably a number of young mites passed through the net meshes. Coleoptera, the sixth largest group in the Barrow fauna was not obtained in the air-screening, nor were Trichoptera, the next largest group. The great number of Diptera trapped are far out of proportion to the number of species in the fauna. Diptera are usually the most numerous group represented in trappings. This relates to their great propensity for flight together with their low specific gravity and often weak flight (as in most Nematocera, which are by far the most numerous in the trappings). The actual populations of the flies and midges are also high, as shown by Berlese samples and bird feeding. To be sure mites and springtails occur by the thousands, but they occur mostly in the soil besides being flightless (Table 5, 6).

Table 5. Comparisons, species in local fauna and specimens in air-screening, 1969.

	Point Barrow		Cape Thompson	
	Local fauna (species)	Trapped (specimens)	Local fauna (species)	Trapped (specimens)
Araneida	18	3	?	—
Acarina	60	13 (1)*	80	—
Collembola	25	2	12+	—
Thysanoptera	2	—	?	—
Orthoptera	—	—	1	—
Mallophaga	17	—	?	—
Anoplura	3	—	?	—
Homoptera	1	1	3	61
Plecoptera	1	—	2	—
Ephemeroptera	—	—	1	1
Neuroptera	?	1	—	—
Trichoptera	—	—	2	—
Lepidoptera	4	1	—	2
Coleoptera	14	—	43	10
Diptera	130	7099 (148)*	174	409
Hymenoptera	40	14	15	68
Totals	322	7134	333+	551

*Numbers in parentheses are specimens trapped at NASA tower (included in main column), rest taken in nets at Voth Creek.

Table 6. Comparison of 1969 air-trapping with Bohnsack Barrow collections (%).

	Soil samples	*Transect*	*Pitfall*	*Barrow air-nets*
Araneida	—	0.1	12.3	0.04
Acarina	33.8	39.9	*	0.18
Collembola	65.9	59.5	*	0.03
Other Insecta	0.3	0.3	(87.5)	(99.75)
Hemiptera	*	*	0.9	—
Neuroptera**	—	—	—	0.001
Lepidoptera	*	*	0.07	0.001
Coleoptera	*	*	5.3	—
Diptera	*	*	76.0	99.55
Hymenoptera	*	*	5.2	0.2

*Not detailed.
**Not recorded heretofore.

In Pacific air-screening studies Gressitt & Yoshimoto (1964) found a distinct correlation between net samplings and the constitution of insular oceanic faunas, with the major exception that Lepidoptera and Coleoptera were much better represented in the faunas than in the screening samples. As mentioned, this must relate to wing damage in Lepidoptera and high specific gravity and poor flight in Coleoptera, requiring more time for establishment of these two orders. Their paucity in the Barrow fauna corroborates this in terms of the young geological age of the area.

One order, Neuroptera, was represented in the air-screening results at Barrow (Voth Creek), although the order has not previously been recorded from the area. This suggests the possibility that the order is in the process of becoming established, or perhaps that its members have difficulty in surviving the Barrow climate.

Density of Arthropods in the Air

At the NASA tower at Barrow, almost surrounded by sea and bare sand beaches when ice- and snow-free, only 149 specimens were netted. With an average of 10 nets placed higher above the ground than with the nets at Voth Creek, a greater volume of air was screened. The following data concerns the first 63 days, before weather turned bad. With an average daily wind speed of 23.17 km/hr, the air volume sampled was 117,200,000 m^3. Thus an average of only 1 specimen was taken per 780,000 m^3 of air. Wind directions were almost identical at the two localities, the NASA tower being about 10 km NE of the Voth Creek site. At the tower, only four specimens were netted when wind was from the north. One of these was an active flyer (anthomyiid fly) and the other three were chironomid midges. Thus 97.3% of the insects were taken during the 41.6% of the time when the wind was from the south. Density of arthropods in the south wind was one per 327,600 m^3. Among reasons for this much lesser density than at Voth Creek are the greater height of the nets, the lack of tundra close to the nets and the high percentage of water in the surroundings. The nets were operated at the tower until 1 September, but nothing was trapped after 3 August.

The Voth Creek site nets were run from 5 June to 2 September (89.5 days). For comparison with the NASA tower site, the following statistics apply to the first 62 days. Using an average of 7.5 nets a total of 6,871 specimens were netted. Of these, 1,423 were taken when wind was from the north, which was 58.4% of the time. Thus 80%

Table 7. Air-screening results (specimens trapped) at Voth Creek, 1969, by months.

	June (5—30)	July	August	Sept. (1—2)	Totals
Araneida	—	3	—	—	3
Acarina	12	—	—	—	12
Collembola	2	—	—	—	2
Neuroptera: Hemerobiidae	—	—	1	—	1
Lepidoptera: Liparidae	—	1	—	—	1
Diptera: Tipulidae	—	4	—	—	4
Trichoceridae	—	42	2	—	44
Chironomidae	73	5829	229	—	6131
Simuliidae	—	—	1	—	1
Sciaridae	—	483	51	1	535
Mycetophilidae	4	44	34	4	86
Culicidae	—	7	—	—	7
Cecidomyiidae	—	21	—	—	21
Empididae	—	1	—	—	1
Ephydridae	1	8	2	—	11
Agromyzidae	—	14	2	—	16
Muscidae	—	15	4	—	19
Anthomyiidae	—	2	—	—	2
Cordyluridae	—	8	5	2	15
Hymenoptera: Tenthredinidae	—	7	—	—	7
Ichneumonidae	—	5	—	—	5
Mymaridae	—	2	—	—	2
Totals	92	6496	331	7	6923

of the insects were taken during the 41.6% of the time that the wind was from the south (or during periods immediately after shift from south wind to north wind, which involved screening the same air mass). Average density of arthropods in the 67,164,300 m^3 of air screened was 1 insect per 9,774 m^3. However, density in the productive south wind was 1 insect for every 5,128 m^3 of air. During the balance of the period (28 days), when there was much snow with temperatures below freezing much of the time, 101 specimens were netted from nearly 20,000,000 m^3 of air. This means 1 insect per 198,020 m^3 of air (Table 8).

Table 8. Summary of quantitative results of air screening, 1969.

	Barrow area		Cape Thompson
	NASA tower	Voth Creek	
	(5.VI.—4.VIII.)		(11—24.VIII)
Volume of air (m^3) sampled	117,200,000	67,164,300	10,406,000
Insects trapped	149	6,871	551
Density: 1 insect per	780,000 m^3	9,774 m^3	18,615 m^3
(In parentheses: South wind)	(327,600 m^3)	(5,128 m^3)	
	(5.VIII.—2.IX.)*		
Volume of air (m^3) sampled	23,064,000	20,000,000	
Insects trapped	0	101	
Density: 1 insect per	—	198,020 m^3	

*Weather very poor during this period with extensive snow and freezing.

It is fairly safe to say that many of the specimens trapped at Voth Creek were blown off the vegetation or ground near the nets, or were in flight low above the tundra and flew into the nets or were blown into the nets while flying.

At Cape Thompson, air nets were run from 11 August to 24 August in 1969 (13 days), using 4 nets for the entire period. During this time 551 specimens were taken. Volume of air sampled was 10,406,000 m^3. Thus the density of insects in the air sampled was an average of 1 insect per 18,615 m^3. Wind was from the north (off the land) almost throughout the period, and when from the south (1 reading), the air speed was negligible.

Actually densities of arthropods in the air would be much higher for limited periods than the above averages indicate. Circumstances are more favorable at limited times when the combinations of temperature, sunshine, air speed and other factors provide satisfactory conditions for insect flight, or for passive dispersal, or a combination of the two.

Downes (1964) indicated that at or above July mean wind speed of 9.5 m.p.h. (15.3 km/hr) at Isachsen and Mould Bay all insect flight would be prevented. This is considerably lower than lowest mean monthly wind speeds at Barrow, which are not in July. In the Arctic, wind can have a great cooling effect and readily reduce body temperatures of insects below flight activity levels. As pointed out by Johnson (1969), different types of insects may be stimulated to fly at certain wind speeds, at appropriate temperatures, and inhibited at other speeds. Also, that insect flight cannot be correlated solely with temperature (or wind), but that the number of insects in the air is mainly a function of population size and the proportion of the population in flight. Obviously, for the Arctic, unfavorable factors strongly restrict flight, but winds also often capture insects for passive transport. Analysis and interpretation of these functions at Barrow will require considerable further research in the field.

Relationship of Trappings to Diurnal Cycle

There is a distinct relationship between the number of insects trapped and the time of day at which traps are emptied. In general the nets at Voth Creek were checked at about 9:00 in the morning, 17:00 in the afternoon and just before midnight. Those at the NASA tower were often checked at the same times by another member of the team. However, this regularity was not always possible because of movement of personnel, vehicle problems, or weather. Often the same person had to check both sets of nets.

Table 9. Trapped specimens by time of day, 1969.

	Pt. Barrow area		Cape Thompson
	NASA tower	Voth Creek	
9:00	41	342	
17:00	42	4,791	
23:30	69	1,847	
10:00			11
20:00			539

Table 10. Voth Creek trapping by time of day and group, 1969

	9:00	17:00	23:30
Araneida	2	1	—
Acarina	—	12	—
Collembola	—	2	—
Neuroptera	—	—	1
Lepidoptera	1	—	—
Diptera			
Nematocera	323	4,721	1,782
Acalyptratae	7	17	6
Calyptratae	5	28	1
Hymenoptera	4	8	2

In such cases the NASA tower was usually checked first and the Voth Creek nets after that. Thus, the results at the NASA tower do not agree with the general results (Voth Creek and Cape Thompson), wherein the great preponderance of the trappings occurred in the warmer part of the day, between 9:00 and say 18:00 or 19:00. During all the trapping periods the sun was above or near the horizon all the time, but naturally was much higher during usual daytime hours of lower latitudes. This close correlation for the Voth and Thompson trappings is partial evidence that most of the trapped specimens became airborne in the general vicinity and had not been carried, or had not flown, for great distances. With the NASA tower catches the timing problems mentioned above only partly accounts for discrepancy. The rest of the explantation must relate to transport over greater distance for a longer period of time. This in part relates to the much greater elevation above the ground level with the NASA nets, and partly with apparent transport for some specimens northward over the sea and then southward again to the nets. Furthermore, appropriate tundra source is not available near the tower in contrast to the situation around the Voth net complex. The numbers of trapped specimens are presented (Table 9, 10) by times of collection for the three localities.

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