PRESENT TRENDS AND FUTURE NEEDS OF ENTOMOLOGICAL RESEARCH IN NORTHERN CANADA

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Part I. The Northern Insect Survey. By T. N. Freeman[1]

THE study of insects of northern Canada has in the past depended mainly on a very small number of collections, some obtained on early expeditions searching for the Northwest Passage, and others taken incidentally on subsequent expeditions. The work of Kirby (1837), the reports of the Canadian Arctic expedition (Hewitt, 1922) and of the Fifth Thule expedition (Henriksen, 1937), and a few short papers represent the main contributions for many years.

Organized entomological research in northern Canada began in 1947 as a joint project of the Defence Research Board, Department of National Defence, and the Entomology and the Botany and Plant Pathology divisions, Department of Agriculture. The research program was divided into three major phases as follows: (1) investigations on life-history, habits, ecology, and control of biting flies by the Veterinary and Medical Entomology Unit; (2) the Northern Insect Survey, which deals with systematics, distribution, relative abundance, and ecology of biting flies and other insects, by the Systematic Entomology and Botany units; and (3) investigations on laboratory rearing techniques for northern mosquitoes, and on behaviour and systematics of some mosquitoes of the genus *Aedes*, by the Defence Research Board at the Defence Research Northern Laboratory, Fort Churchill, Manitoba.

During the past ten years, some insect collections have also been made by officers of various government establishments scattered throughout the north, and by individuals supported by grants from the Arctic Institute of North America.

In this paper only a brief summary of the work accomplished can be given, and the writer's views are noted on areas that require investigation and on lines of study that should be emphasized to give a better understanding of the origins and present composition of the northern insect fauna. A short list of references notes the more significant publications that have appeared to date.

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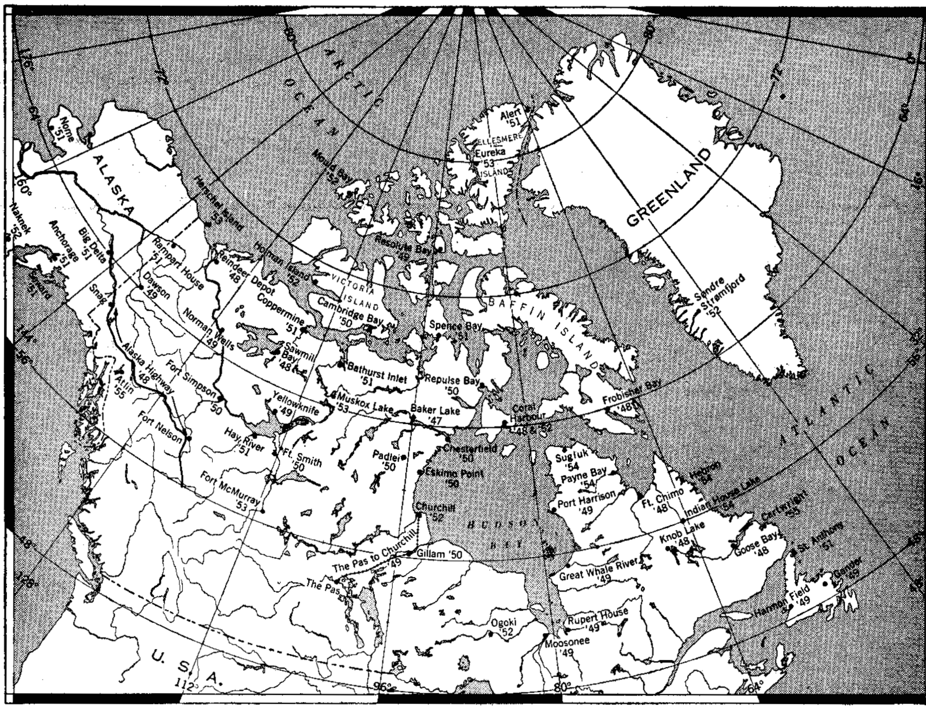

Fig. 1. Areas investigated on the Northern Insect Survey.

Since the inauguration of the Northern Insect Survey in 1947, 56 arctic and subarctic localities have been investigated and some 65 papers, mostly short or preliminary in nature, have been published; the revisionary, or biogeographical studies that are planned will depend on the analysis of a very large body of material, and may be expected to appear over many years. The surveys were made mainly in the arctic tundra and the Northern Transition zone (Halliday, 1937) of the boreal forest of Canada; a few areas were also investigated in Alaska, and one in southern Greenland (*see* Fig. 1).

The coverage of the northern insect fauna has been extensive, but significant gaps in our knowledge of the distribution of the various species still remain. The facts that restrict the distribution of insect species are complex and little understood even in areas that have been studied intensively and that have uniform topography. The Cordilleran systems of Alaska, Yukon, and northern British Columbia, because of their nature, complicate considerably an understanding of the distribution of northern insects. Organized surveys in those areas should be made of both horizontal and vertical limits of the species, with emphasis on restricted regions. In the Mackenzie Mountains, west of the Mackenzie River and extending into east central Yukon Territory, endemic plants have been found, and the possibility that endemic insect species occur there should be investigated. The insect fauna of the interiors of Victoria and other large arctic islands, and of the country between Baker Lake and

Adelaide Peninsula, is not known. The other areas from which collections are required are in the northeast and east. In Baffin Island material is needed from the north and central parts, from the east coast, especially at Clyde, and from the south coast, particularly near Cape Dorset, as the scanty material so far obtained from this coast indicates a rich fauna of parasitic Hymenoptera. In Labrador the Torngat Mountains should be studied. The relict insect fauna in the Gaspé region should be further investigated and also compared with that of the high elevations on Mt. Katahdin, Maine, and Mt. Washington, New Hampshire. Much more work and material are needed from the higher elevations in central Newfoundland. Many smaller gaps also exist between areas that have been investigated; the relative importance of these should be revealed as progress is made on the distribution studies of the major groups.

Many problems are of a broader and more fundamental nature. Survey data suggest that mosquitoes do not occur north of the mean July isotherm of 35°F. Also, the adults apparently emerge approximately four weeks after the mean temperature for 14 days reaches 34°F. The latter observation is based on a correlation of weather data and mosquito emergence from 14 localities across the north during the past six years; observations were made at each locality for one season only and additional correlations are required. If these observations are well founded, the dates of mosquito emergence can be predicted four weeks in advance.

Problems of distribution are very complex. Along the Mackenzie River the boreal forest and boreal insects penetrate almost to the Arctic Ocean. There the effect of the continuous summer daylight on behaviour, particularly of those nocturnal species whose distribution extends southward into the regions of regular day and night, should be investigated, and may help to explain distribution patterns elsewhere. Many of the arctic insects intrude on the northern fringe of the boreal forest, and some boreal species intrude on the arctic region, for example in Bathurst Inlet, although Freeman (1952a) has postulated the principle that arctic and boreal insects are specifically distinct. The extent of these intrusions from one zone to another is not well known or understood. When they are mapped it may be possible to define the Northern Transition zone more precisely. Distribution patterns may be dependent, to a greater or lesser degree, on the soil types and underlying rock formations; for instance, the North American subspecies of *Papilio machaon* Linn. appears to be restricted to those regions in the Northern Transition zone where the granitic Canadian Shield dips under the sedimentary Paleozoic and Mesozoic formations. The adaptation of insects in relation to the absence, presence, or nearness to the surface of permafrost should also be investigated. An ecological study, perhaps at Churchill, might assist in solving some of these distribution problems.

Other major problems include a study of the origins and postglacial histories of the arctic species, and how they are related to botanical views on plant distributions and origins. There is a great need for Siberian material in this study. The origin of the unique Greenland fauna, which consists of nearctic and holarctic species in northern Greenland and palearctic boreal species in southern Greenland although there is no forest, should be investigated. Boreal species of insects also predominate in the treeless areas of the Aleutian Islands, where arctic species would be expected. Perhaps the Aleutians and southern Greenland have some factors in common that are responsible for this unexpected distribution.

All of these perplexing problems point to the need for studying the insect fauna of the Subarctic and Arctic as a whole rather than on a regional basis.

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Part II. Biology and Control of Biting Flies. By C. R. Twinn[1]

Results of biological and control studies of biting flies in northern Canada, carried out by the Veterinary and Medical Entomology Unit of the Entomology Division and associated agencies, have been presented in about 75 papers published in scientific journals or prepared for publication. Among these, two papers by Twinn (1950, 1952) review the investigations and the results obtained from 1947 to 1950, and give references to papers that were published or prepared for publication during that period. Much of the work and published results not included in those summaries are reviewed here.

In the study of the various species and of methods of combating them and securing protection from their bites, it would be very helpful if laboratory colonies of the insects could be maintained. So far, this is possible with few northern species, largely because of inadequate knowledge of their life-histories and habits. McLintock (1952) developed a method of rearing *Culiseta inornata* (Will.), a culicine species whose range extends into subarctic Canada. However, attempts to rear common northern species of mosquitoes (*Aedes* spp.) and black flies (Simuliidae) continuously in the laboratory have not yet been successful, and further attention should be given to this problem. Hocking and Pickering (1954) have described attempts to rear black flies at Churchill, and given records of the seasonal occurrence of 21 species of Simuliidae in northern Manitoba and observations on the life-histories and habits of some of them, especially *Simulium venustum* Say.

Of value in planning measures for control and personal protection are the results of a study on the dates of emergence of certain species of black flies in a series of localities, extending from south to north and from west to east in Canada (Ide *et al.*, in preparation). This study provided data on which the beginning of the black-fly season at various latitudes and longitudes could be predicted.

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Knowledge of the biologies of many of the species of biting flies of various genera that occur in the vast subarctic and arctic regions of Canada is still sketchy. Two recent papers, however, present data on the occurrence, relative abundance, ecology, and development of mosquitoes: one by Haufe (1952) on the species at Goose Bay, Labrador, and the other by Curtis (1953) on the species at Whitehorse, Yukon Territory.

Studies at Churchill on development, behaviour, and local distribution of mosquitoes in relation to meteorological conditions have been completed and a series of papers prepared. A preliminary paper on predicting peak dates of emergence of mosquitoes, based on some of this work, has been published by Haufe (1953). Knowledge of the distribution and behaviour of biting flies under various conditions is important in devising control procedures against the adult insects. Much information of value for this purpose has been obtained, but further study is needed of the vertical distribution of these insects and of their resting sites and resting behaviour, to ensure the most effective and economical use of insecticides.

In the north there are vast areas of permafrost where drainage is poor; mosquitoes breed in the surface pools that form in the spring, black flies in the run-off streams, and tabanids (moose flies and deer flies) in the muck and moss of the swampy forest floor. Under these conditions enormous numbers of the insects develop over thousands of square miles. Accordingly, it is most important in planning control measures to have knowledge of the dispersal habits and flight ranges of the various species. Because of the difficult terrain and lack of roads and other facilities in northern Canada, studies involving the release and recapture of marked specimens have been carried out in Saskatchewan. Methods of mass tagging of black flies with radiophosphorus have been developed by Fredeen *et al.* (1953a) and of mosquitoes by Shemanchuk *et al.* (1953).

Hocking (1953a) followed a different approach to the problem of insect flight range by studying the energy resources of some of the northern species in relation to their power requirements and efficiency in utilizing energy in flight. He concluded that northern biting flies obtain the energy for flight from the nectar of flowers, and by ingenious observations and experiments obtained data on which he based estimates of the maximum distances certain species might travel in still air and their possible maximum air speeds. However, there is still little exact information available on the distances most of the species may travel either in actual flight or with the wind, and the problem needs further investigation.

The nature of the poisons from, and the toxic effects of, insect bites have not been adequately studied. This information is essential in attempts to immunize individuals against the effects of insect bites. The subject is being explored but, so far, apparently with little success. If, as suspected, such immunity is restricted to a species or group of species, the problem is enormously complicated by the large number of different blood-sucking flies involved. Another approach is to seek methods of ameliorating the effects of the bites. O'Rourke and Murnaghan (1953), from studies at Ottawa of the skin reaction to bites of *Aedes aegypti* (L.), reported that the application of a 2 per cent Pyribenzamine cream relieved the reaction and itching from mosquito bites.

Investigations on chemical control of biting flies have been largely confined to the subarctic and temperate regions of Canada. Control measures have been devised that are reasonably effective south of the tree-line against mosquitoes and black flies when properly applied over a sufficiently large area, the size of the area depending largely on local circumstances, such as species and topography. In area control of these insects with DDT applied from aircraft, a rotary brush unit is an effective and economical device for spraying large areas (Brown, 1952).

The development and use of DDT as a larvicide against black flies has been described (Twinn, 1950, 1952). Its use in controlling black flies in the Saskatchewan River from 1949 to 1951 was reported by Fredeen *et al.* (1953b). These authors (1953c) also reported that suspended solids in this river adsorb DDT, and suggested that the effectiveness for long distances of single applications of the larvicide in turbid water is due to the larvae ingesting the DDT adsorbed by the solids. Experiments at Churchill by Hocking (1953b) showed that a water suspension of heptachlor also gave excellent control of black-fly larvae at dosages as low as one-third of that required for DDT. No other promising materials were found.

Although practical methods have been devised for reducing local infestations of mosquitoes and black flies to negligible proportions about military bases and other centres of population south of the tree-line, high costs, lack of facilities, and transportation difficulties render them unsuitable for use where few people are involved. Area control is not feasible on the tundra because the mosquitoes, which are the major pest there, travel long distances, and treated areas are likely to become reinfested quickly. Accordingly, special attention has to be given to developing methods of local and personal protection both on the tundra and in the subarctic forest.

Application of aerosols and fine sprays from easily transportable ground equipment has value in such situations. In ground control experiments, chemical and biological assessments have been made of the performances of a number of machines for this purpose (Brown and Watson, 1953). However, there is need for further work on the effectiveness of insecticidal mists and aerosols under various conditions, and on the use and value of residual and barrier sprays applied to vegetation about campsites and similar situations.

Tabanids are often fierce pests in forested regions, especially in swampy areas, but fortunately they are not a problem on the tundra. In experiments at Goose Bay, Brown and Morrison (1955) found that lindane applied at 0.5 lb. per acre from aircraft was superior to DDT or dieldrin, and that it temporarily eliminated adult tabanids in open but not in dense forest. However, the value of chemical control methods against these insects, like the use of presently available repellents, is still doubtful.

Repellents are effective in protecting exposed skin surfaces against biting flies other than tabanids, and also in preventing insects from biting through clothing that has been impregnated with these chemicals. The period of effectiveness of repellents on the skin is greatly reduced by removal of the material by sweating and by absorption through the skin, so that frequent applications may have to be made, especially by persons engaged in strenuous activities under warm, humid conditions. Furthermore, most repellent materials cause a stinging sensation when in contact with delicate tissues, such as about the eyes and lips, and in some individuals cause general skin irritation.

Studies are being made at Toronto and Ottawa (Roadhouse, 1953) to obtain repellents without these disadvantages. At Ottawa, laboratory screening tests of repellent compounds were facilitated by a method in which guinea pigs were used as the test animals (Kasman *et al.*, 1953). Advantages are that a smaller quantity of the repellent is required than when human subjects are used, it is less expensive and less time-consuming, and toxicity to the host is not a major consideration.

Devices for personal protection such as head nets have definite value. These, however, may interfere with vision, and often make the wearer hot and uncomfortable. Efforts have been made to improve the protective qualities of clothing, both in the choice of materials through which the insects cannot bite and of colours unattractive to them, and in the improvement of design to reduce exposed skin surfaces and to prevent black flies from having access to spaces between the clothing and the skin. The suitability of such clothing must naturally depend on the nature of the activities of the wearer.

A knowledge of the factors that attract biting flies to their hosts and stimulate them to feed is of value in solving the personal protection problem. A series of papers on the responses of female *Aedes* mosquitoes has been published, the latest of which is by Brown (1954). However, this subject is still inadequately understood and further work with species of the several groups of biting flies is needed.

The role of insects, nematodes, microsporidia, and other parasites and predators in the natural control of mosquitoes, black flies, and tabanids is being studied at Churchill and elsewhere, and a preliminary paper has been published (James, 1953). Progress in studies on the use of the precipitin test for determining predator–prey relationships has been reported by Hall *et al.* (1953). This serological method is also used to determine the source and rate of digestion of host blood in mosquitoes (West and Eligh, 1952).

Undoubtedly, natural enemies are of prime importance in reducing biting-fly populations but, although much has been learned about them, a great deal more needs to be known before their effectiveness can be increased by manipulation.

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