INVERTEBRATE RESEARCH IN ALASKA

R. I. Sailer*

TO THE zoologists of the mid-nineteenth century the invertebrate fauna of Alaska was virtually unknown. Some specimens from coastal localities touched on by earlier expeditions had found their way into various European and North American museums, but much of this material remained unidentified and of all the invertebrate groups only the Coleoptera seem to have received critical study (Mannerheim, 1843, 1846, 1852, 1853). In the interior it was not until 1861 that the first significant collections were made at Fort Yukon by Robert Kennicott, working for the Smithsonian Institution. Kennicott returned in 1865 as chief of explorations on the Western Union Telegraph Company's expedition (James, 1942) but died the following year, and his work was continued by W. H. Dall, who sent back a wide variety of specimens to the Smithsonian Institution.

Towards the end of the century two expeditions made important contributions to our knowledge of Alaskan invertebrates. The International Polar Year of 1882–3 resulted in collections from Point Barrow (Ray and others, 1885) and the Harriman Alaska expedition of 1899 made the most intensive scientific study undertaken in Alaska by a privately financed expedition. The results of the latter expedition, published in fourteen volumes as the *Harriman Alaska Series* of the Smithsonian Institution, contain in volumes 8–14 the most important single source of information on the invertebrates of Alaska and the adjoining seas.

The Canadian Arctic expedition of 1913 to 1918 also made valuable contributions to our knowledge of the northern and western coastal regions as far south as Nome (reports published at intervals between 1919 and 1925). At much the same time the U.S. Bureau of Biological Survey sponsored an intensive study of the biota of the Pribilof Islands (McAtee ed., 1923), and the zoological specimens from the Katmai expeditions of the National Geographic Society in 1917 and 1919 were described in the *Ohio Journal of Science* between 1921 and 1925.

During the 'thirties systematists studied a number of invertebrate groups. Papers on the composition and distribution of land and marine molluscs were published by Berry (1937) and Eyerdam (1939); the spiders were studied by Gertsch (1934) and Chamberlin and Ivie (1939); dinoflagellates and ciliates from adjacent Bering Sea areas were discussed by the Russian authors Kiselev

*Entomology Research Branch, Agricultural Research Service, U.S. Department of Agriculture.

(1937) and Stepanova (1937), and revisionary works, such as Stone's (1938) paper on horse flies of the nearctic region, included Alaskan species, as did numerous short papers in which distribution and new species were recorded.

Thus, until 1940 research on the Alaskan invertebrate fauna remained the province of the systematist, and had hardly passed beyond the descriptive stage. The collectors who gathered the specimens and sent them to museums seldom had the time or facilities for careful observations on life history and ecology. However, Hadwen and Palmer's (1922) working out of the life history of the reindeer warble and nose flies, with recommendations for their control, and the unpublished studies of fly parasites of reindeer undertaken by E. C. Cushing and W. E. Dove from 1929 to 1931 were notable exceptions. Somewhat later Tulloch (1934) spent a season at Fox studying mosquito biology.

With the increasing military importance of Alaska, both during and after the Second World War, funds were made available for scientific research in many fields, and permanent research centres were established. In invertebrate zoology, emphasis has been directed toward quantitative studies on the biology of species and the broader problems associated with the biotic community, particularly those which affect the economy and health of the human population. The task of bringing together the scattered literature and identifying the numerous specimens collected during recent years is also progressing at an appreciable pace, but most of this work, as well as some of the studies in ecology and physiology, is being done by specialists outside Alaska.

In Alaska invertebrate research is being carried on from at least five centres: the Arctic Research Laboratory of the Office of Naval Research at Point Barrow has concentrated on pure research; the Arctic Health Research Center of the U.S. Public Health Service at Anchorage investigates all problems affecting public health; the Arctic Aeromedical Laboratory of the U.S. Air Force at Ladd Field, Fairbanks, is mainly concerned with the health of military personnel, but also supports basic environmental studies; the Alaska Agricultural Experiment Station at Palmer examines crop pests; and at the Alaska Cooperative Wildlife Research Unit of the University of Alaska studies have been made of invertebrates as sources of food for fishes and of their importance to game and fur-bearing animals. In addition to these year-round centres, there is the Alaska Insect Control Project, directed by the Bureau of Entomology and Plant Quarantine of the U.S. Department of Agriculture, with funds provided mainly by the U.S. Army, which has been studying biting Diptera since 1947, though without a permanent staff or fixed headquarters. Finally, there is the research of many private scientists working on their own problems.

Because of the large number of organizations and individuals concerned it is not practicable to give a survey of all the work that has been done or is now under way in Alaska. Invertebrate zoology is a discouragingly large field and directly involves other biological disciplines which are often treated independently. This paper will inevitably reflect my personal preoccupation

with entomology, and especially the problem of annoyance caused by mosquitoes and other biting Diptera. For the most part it will be confined to research accomplished after 1940.

Recent and current research

Insects

It has been stated that biting flies are one of the principal obstacles to the development of the north (Stefansson, 1921, p. 245) and this is certainly true in Alaska where mosquitoes and other biting flies are everywhere a source of annoyance. During years of maximum abundance, mosquitoes infest thousands of square miles in numbers scarcely credible to those who have not lived and worked in their presence. The problem is not medical in the sense commonly true in the Tropics, for in Alaska no diseases are known to be transmitted by mosquitoes. It primarily concerns their effect on manpower efficiency and their ability to harass the settler, his family, and livestock to a point almost beyond endurance.

As a result of work by the Alaska Insect Control Project in central Alaska and that by U.S. Navy entomologists at Umiat, the identity and distribution of the mosquito species in those areas are now well known, and the larval habits and time required for larval development have been established. Except for papers concerned with Umiat (Jachowski and Schultz, 1948; Knight, 1948) and a preliminary account by Jenkins (1948a), most of these data are still unpublished. Adult mosquito activity has also been investigated by the Alaska Insect Control Project: Pratt (1949) has reported on the correlation of activity data with several microclimatic factors, and Sailer (unpubl.) has shown that a correlation exists between mosquito abundance and accumulated precipitation which may make possible prediction of unusually large or small populations well in advance of adult emergence. Finally, studies of prehatching treatments, larvicides, and insecticides, the last applied over areas up to 100 square miles, have provided information on the cost, effectiveness, and practicability of various methods of control (Travis, 1949; Travis *et al.*, 1949, 1950; Wilson *et al.*, 1949), and the effectiveness of repellents has been tested under Alaskan conditions.

Information gathered by the Alaska Insect Control Project on black flies has been published in several papers. General aspects of the problem were covered by Sailer (1953). Jenkins (1948b) has written about their biology and a much more comprehensive paper covering this subject is near publication (Sommerman, Sailer, and Esselbaugh [1955]). A paper on adult taxonomy by Stone (1952) was followed by one covering the larvae (Sommerman, 1953). Jenkins (1948b) also treated the punkies and Wirth (1951) reviewed their taxonomy.

The health centres have also been responsible for work on biting flies. Since 1949 a group at the Arctic Health Research Center under the direction of W. C. Frohne has added much to our knowledge of their biology and control. Williams (1951) has written on the biology of the punkie *Culicoides*

tristriatulus Hoff.; Frohne has published on the life history and habits of the mosquitoes *Culiseta impatiens* (Wlk.) (1953) and *C. alaskaensis* (Ludl.) (1954) as well as on several other subjects pertaining to biting Diptera. Studies of the filth-breeding flies and their possible importance as vectors of disease have been made at the Arctic Aeromedical Laboratory. This laboratory has also supported an investigation of mammal ectoparasites by the Rocky Mountain Laboratory of the National Microbiological Institute.

At present the species of insects that cause injury to garden and field crops are limited in Alaska. However, as agriculture develops, more and more insects are likely to become of economic importance; for instance the first control operations against grasshoppers were made near Palmer in 1953. Research is mainly centred at the Alaska Agricultural Experiment Station at Palmer, where J. C. Chamberlin (1949) was the first agricultural entomologist to deal extensively with Alaskan insects. Measures to prevent the accidental introduction of foreign pests are the responsibility of the Anchorage Office of the Bureau of Entomology and Plant Quarantine.

Working from the Arctic Research Laboratory at Point Barrow, Weber (1950, 1953) has made studies of the arctic insect fauna and has listed about 350 species. In 1952 and 1953 P. D. Hurd was the entomologist on a project concerned with population biology of arctic land vertebrates at the laboratory, and in 1953 he also assisted in another project on the reciprocal relationships of vegetation and the physical environment in the tundra. He has obtained large collections and much information on the importance of insects as food for certain birds, and his observations of insect activity, when correlated with microclimatic data, should add much to our knowledge of the requirements and behaviour of insects living on the tundra.

Parasites

The Arctic Health Research Center and the Arctic Aeromedical Laboratory are investigating the high incidence of parasitism among animals and humans in arctic Alaska. Native mammals and other vertebrates have been found to be subject to extensive infestation by parasites that are actual or potential menaces to human health. Since meat is the most important part of the diet of man and of his principal beast of burden, the implications are obvious, and the subject requires careful study.

Trichinosis has long been known to occur in the Arctic, and recent work has shown this disease to be present in animals not previously suspected of harbouring the parasites. Connell (1949) has summarized our knowledge of trichinosis in the Arctic. Startling information about the incidence of hydatid disease has been published in the last few years, with the result that quarantine restrictions on the movements of dogs have been recommended. The present status of knowledge about the disease and the causal organism has been reviewed by Rausch (1952b) and Rausch and Schiller (1951).

The Arctic Health Research Center has also encouraged the parasitologists on its staff to study parasites of native animals whether or not they appear to threaten human health. Consequently, a number of previously unknown

species have been discovered and described, many of them by Rausch (1951, 1952 a,c) and Schiller (1952 a,b,c,d, 1953). Life-cycle studies are also being made, and the experimental infection of Alaskan gulls with *Diphyllobothrium* sp. has recently been reported by Babero (1953).

Ectoparasites of various kinds have been collected by J. M. Geary at the Arctic Aeromedical Laboratory, and papers recording hosts and describing new species have been published (Keegan, 1951; Keegan and Hedeen, 1952). The paper by Philip, Gill, and Geary (1954) on the role of the rabbit tick in the transmission of tularemia is of special interest.

Arachnida, Crustacea, and other non-insect arthropods

Much of the recent work in these arthropod groups has been taxonomic or distributional. Arctic Alaskan records for Arachnida have been listed (Weber, 1950), taxonomic studies of spiders have been published (Chamberlin and Ivie, 1947), and several new genera and species of mites have been described (Newell, 1949, 1950). Hammer (1955) has published an extensive paper on oribatid mites based on material collected by the Alaska Insect Control Project and by N. A. Weber. In 1953 J. L. Mohr and his associates at the Arctic Research Laboratory began a study of the ecology of arctic Crustacea; investigations by G. Comita of the fauna of an arctic lake near Point Barrow and by John Krogh of a lake near Anchorage (both unpubl.) should also provide useful information. Other published accounts include a paper by R. V. Chamberlin (1946) on Alaskan chilopods, and by Mrs. M. Stratton Wilson (1953 a,b) on the freshwater copepods.

Freshwater and terrestrial invertebrates other than arthropods and parasites

Many of these animal groups have been neglected during recent years, although much material has been collected and distributed to specialists. Among the few recent articles dealing with these groups, the account by Kenk (1953) on the freshwater triclads of Alaska is of general interest, as he found four endemic species that show no close relationship to the present North American fauna, but have unmistakable Eurasian relationships. Pronounced palearctic affinities have been recognized in other groups of the Alaskan fauna, and the probability that a land bridge between Alaska and Asia has existed more than once within comparatively recent geological time is well established. Nevertheless, Kenk's work with the freshwater flatworms has special significance because of the extremely limited mobility of these organisms. It is almost inconceivable that they could have reached Alaska except by way of freshwater streams. The absence of typically North American species of triclads suggests a degree of isolation from the nearctic fauna that would not be suspected from a casual study of a map or knowledge of present physiographic and climatic conditions.

Marine invertebrates

Most of the recent work on marine invertebrates has been carried on from the Arctic Research Laboratory in the waters near Point Barrow, and particularly by G. E. MacGinitie, when he was director of the Laboratory. His

interests were primarily ecological, and many data were obtained on the environmental requirements and behaviour of arctic marine invertebrates. He and his associates also made large collections, which are now being studied by taxonomists, who have already published some papers (Coe, 1952; Pettibone 1951), of which Loeblich and Tappan's 'Studies of arctic Foraminifera' (1953) is the most extensive and also contains much ecological information.

Problems and opportunities for research

Ninety-five per cent of all the animal species in Alaska are invertebrate. Obviously any attempt to enumerate or delimit the problems concerned in so vast a field would serve little purpose for the investigation of any one problem would almost always result in the discovery of others. For example, I will mention a few of the new problems I found in my own attempts to learn something of mosquito and black fly ecology. Why should 2,441 *Aedes communis* (DeG.) mosquitoes with a sex ratio of two males to one female emerge from 4 square feet of pool surface when only 590 mosquitoes of the same species with equal numbers of males and females emerged from the same area of another pool a few feet away? What is the explanation for the variation in colour and structure that makes identification of females of many Alaskan *Aedes* so difficult? The latter question has many ramifications, for detailed information on pest importance and flight-range of species depends upon easy and accurate identification. Why should the black fly *Simulium venustum* (Say) bite viciously at Kotzebue and fail to be recorded as a biting species in other parts of Alaska? And why should some black fly species aggressively attack man late in September and in October but not in mid-summer? In mid-summer they will not even fly except when the temperature is much higher than that recorded during flight activity in the fall.

The parasitologists are rapidly learning what parasites inhabit various species of vertebrates, but questions regarding life cycles are largely untouched, and almost nothing is known of the part parasites play in the population cycles of their hosts. Taxonomists have been enumerating species and recording locality data for many years, but the task of collating these data in such a way as to throw light on Alaska's key position in the zoogeography of the holarctic region has hardly been begun. Ecologists have made comparatively few studies in Alaska yet the geographic position and physiography combine to produce a variety of climates and habitats unmatched in other arctic and subarctic regions. Regional differences are great and sharply delineated, and within each region the precipitation and temperature differ markedly from year to year. These factors contribute toward making Alaska an ideal laboratory for studying the underlying principles of ecology.

Future research could most profitably concentrate on ecological information useful to conservationists and game-management workers. This should include careful studies of the terrestrial and aquatic faunas, for fishing, trapping, and hunting are and should continue to be an important part of the economy. The rapid growth of agriculture will inevitably necessitate greater attention

to crop pests and means for their control. Mosquitoes, black flies, and punkies continue to be a serious problem, and every effort should be made to obtain better means of control, at a lower cost. Also, recently increased interest by pulp and lumber industries in the huge forest resources of Alaska has shown a need for greater knowledge of the forest pests. In 1953 a survey by the Bureau of Entomology and Plant Quarantine revealed that an outbreak of the black-headed budworm extended over practically the entire Tongass National Forest in southeastern Alaska, an area of 16,073,000 acres; an epidemic infestation of the hemlock sawfly extended over approximately 4,000,000 acres in the southern part of the same forest, and bark beetles have killed many Sitka spruce in past years. In the face of diminishing forest reserves, insect-caused losses become increasingly important and can be reduced only by better knowledge of these pests gained through long-term, carefully planned research.

Above all it is essential for the future welfare of the country that the present research centres be maintained on a permanent basis with sufficient funds to carry out studies that will add to our knowledge of how to live prosperously under the rigorous and varying conditions characteristic of Alaska.

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