FOSSIL INSECTS, WITH SPECIAL REFERENCE TO THOSE OF THE TERTIARY LAKE DEPOSITS OF THE SIMILKAMEEN VALLEY, B.C.

By Alfred E. Cameron, M.A., D.Sc., F.E.S.

MEANS OF FOSSILIZATION

Abundant as insects are at present, they are comparatively rare as fossils, the fossil species forming a very insignificant percentage of the total number of described species of insects. The absence of insect remains in sedimentary rocks of marine origin is explained by the fact that almost no insects inhabit salt water; and terrestial forms, in general, are ill-adapted for fossilization. The hosts of insects that die each year leave remarkably few traces in the soil, owing perhaps in great measure to the dissolution of chitin in the presence of moisture.

Most of the fossil insects that are known have been found in vegetable accumulations such as coal, peat, lignite, or else in ancient fresh water basins, where the insects were probably drowned and rapidly embedded. At present, enormous numbers of insects are sometimes cast upon the shores of our great lakes—a phenomenon which helps to explain the profusion of fossil forms found in some of the ancient lake basins.

Insects in rich variety have been found in amber, the fossilized resin of coniferous trees. This substance, as it exuded, must have entangled and enveloped insect visitors, just as it does at present. Many of these amber insects are excellently preserved, as if sealed in glass. Copal, a transparent amber-like resin from various tropical trees, particularly Leguminosae, has also yielded many interesting insects.

Ill-adapted as insects are by organization and habit for the commoner methods of fossilization, the number of fossil insects already described is now more than 6000.

LOCALITIES OF FOSSIL INSECTS

The Devonian of New Brunswick in Canada has furnished a few forms, found near St. John, in a small ledge that outcrops between the tide-marks. These forms, though few, are of extraordinary interest, as will be seen.

For Carboniferous species, Commentry in France is a locality noted through the admirable researches of Brongniart (6), who described from there 97 species of 48 genera, representing 12 families or higher groups —10 of which are regarded as extinct—without including many hundred specimens of cockroaches which he found but did not study. In this country many species have been found in the coalfields of Illinois, Nova Scotia, Rhode Island, Pennsylvania and Ohio.

Many fine fossils of the Jurassic period have been found in the lithographic limestones of Bavaria. One hundred and forty-three species from the Lias—four-fifths of them beetles—were studied by Heer (1).

The Tertiary period has furnished the majority of fossil specimens. To the Oligocene belong the amber insects, of which 900 species are known from Baltic amber alone, and to the same epoch are ascribed the deposits of Florissant and White River in Colorado and of Green River, Wyoming. These localities—the richest in the world—have been made famous by the monumental works of Scudder. At Florissant there is an extinct lake, in the bed of which, entombed in shales derived from volcanic ash and sand, the remains of insects are found in astonishing profusion. For Miocene forms, of which 1550 European species are known, the Oeningen beds of Bavaria are celebrated as having furnished 844 species, described by the illustrious Heer (1).

On our Western Coast it is interesting to know that quite a rich stratum of fossil-insect remains are located in the Tertiary lake deposits of the Southern Interior of British Columbia, there being in all something like 135 species, which have been described by the three distinguished palaeoentomologists, Scudder, Cockerell and Handlirsch. In 1910 Handlirsch (2), dealing with a collection of 73 specimens of fossil insects disinterred by Lambe of the Canadian Geological Survey, and submitted to him for investigation by Dr. A. P. Low, Director of the Survey, made a valuable contribution to the study of Canadian fossil insects. The localities in which these insect fossils of British Columbia have been found is confined to a comparatively small area, extending from the Similkameen in the south to Quesnel in the north, and include the deposits along the Nicola River, the Tulameen River one and a half miles above Princeton and opposite Vermilion Cliff, Tranquille River, Horsefly Mine, Ninemile Creek, Quilchena. One specimen is recorded from Vancouver Island, an unidentified specimen of the Chrysomelid genus Microrhopala described by Chagnon.

Of the 73 specimens collected by Lambe, Handlirsch distributed them among the systematic groups as follows: Orthoptera (Acridioidea), 1; Coleoptera, 4; Hymenoptera—Ichneumonidae, 1; Rhaphidioidea, 1; Diptera—Bibionidae, 54; Ptychopteridae, 1; Tipulidae, 2; Empidae, 1; Hemiptera—Pentatomidae, 1; Gerridae, 1; Homoptera—Cercopidae, 3; Insecta incerta sedis, 6. In all there were 41 species, of which 20 belonged to the genus Penthetria of the dipterous Bibionidae.

Including the Tertiary insects previously made known from British Columbia, chiefly in the works of Scudder—which Handlirsch (2) for the sake of completeness inserted in his list—the species are systematically distributed among various families by this author as follows:

Orthoptera—Acridioidea, 1. ? Mastacinae, 1.

Coleoptera—Carabidae, 1; Nitidulidae, 1; Tenebriondidae, 1; Elateridae, 5; Buprestidae, 3; Hydrophylidae, 1; Chrysomelidae, 3; Scarabaeidae, 1; Coleoptera incertae sedis, 3.

Hymenoptera—Ichneumonidae, Pimplinae, 4; Braconidae, 2; Formicidae, 3.

Neuroptera—Hemerobiidae, 1.

Diptera—Orthorrhapha nematocera, Mycetophilidae, 5; Bibionidae, about 35; Ptychopteridae, 1; Chironomidae, several; Tipulidae, 2; Orthorrapha brachycera, Asilidae, 1; Empidae, 1; Dolichopodidae, 1; Cyclorrhapha-Borboridae (Acalyptrate Muscidae), 5; Anthomyiidae, 2.

Hemiptera—Gerridae, 2; Pentatomidae, 2.

Homoptera—Fulgoridae, 1 (? 2); Cercopidae, 12; Aphididae, 2 (incerta sedis, 1).

Insecta incerta sedis, 7.

With such a small number of species as have been found, it is difficult to judge accurately the age of the given deposits. Handlirsch argues that since no representatives of the latest and most highly specialized insects have been found, the deposits belong to the early Tertiary. For instance, the Aphididae, Muscidae, Syrphidae, Rhynchophora, Cecidomyiidae, Lepidoptera, Thysanoptera, Termitidae, Forficulidae, Chalcididae, etc., are either absent or only feebly represented, and likewise the Lamellicorns and Formicidae. All these groups have doubtless persisted since the Cretaceous. Nevertheless, in the early Tertiary they did not for a long time attain that pre-eminence for which they were noted in the late Tertiary, the Quaternary, and especially in recent times, where they are distinctly dominant forms. In the early Tertiary they were certainly also well represented in British Columbia, and, if they are lacking in the collections, this fact must in part be attributed to accident, and in part to their still meagre numerical development at that time. Moreover, this fact may also be accepted as proof of the relatively great age of the beds in question. A further argument of perhaps greater significance, rests on the relatively strong representation of groups of Old-world forms, as, for example, the Elateridae and Buprestididae (which were numerous even in the Lias); the species of the genus Pimpla, belonging to the most primitive apocrite Hymenoptera; the Cercopidae, which are also of Jurassic age; also a form of Acridiidae, which does not strictly coincide with any of the recent sub-groups; a Rhaphidian in which are found characters of both existing genera of this order, and, finally, a very primitive Ptychopterid, the representative of a family existing today in a few surviving forms.

The Diptera clearly furnish the most reliable data. Of these forms, the nematocerous Orthorrhapha with their eucephalous larvae, also the above-mentioned ptychopterid, as well as the Chironomids, Myceto-

philids, and Bibionids, have a relatively strong representation, and outnumber all other Diptera threefold. Today, these conditions are exactly reversed. The Bibionids were especially prominent, and appear to have formed the principal element of the fauna of that time. They are exclusively represented by the genus **Penthetria (Plecia),** which throughout the world, at present, includes but few more species than are comprised in the small collection of Lambe. The number of species of this genus was much larger in the early Tertiary than in the late Tertiary, where the genus **Bibio** was beginning to become more prevalent, as judged by their geological distribution in the European Tertiary. Hence Handlirsch came to the conclusion that the occurrence of so disproportionately large a number of species of **Penthetria** in the Tertiary of British Columbia, contemporaneous with the absence of **Bibio,** also indicate that the beds in question belong to the early Tertiary, and are at least Oligocene in age. The genus **Bibio** is now represented in the American Tertiary and the supposition is that the genus **Bibio** originated in the East, probably in Europe, and later found its way to America. Today, the genus **Penthetria** exists principally in tropical and subtropical countries. In temperate zones, it survives only in individual forms; one of these being the single dwarf European species **P. holosericea. Bibio,** on the other hand, is especially abundant in the temperate regions of North America and Europe, but is sparingly represented in the South. So much the more interesting, then, is the occurrence of such a large series of fossil species of Penthetria—the representatives of existing thermophilous forms—in a latitude so high as is the region of the Similkameen River. Not only in the Penthetrias, however, but also in **Promastax** (primitive Acridioid) and the numerous Cercopids, and particularly in the huge **Aphrophora angusta** Hand, the fulgorid, **Ricania antiquata** Scud, etc., are found proofs of a warm climate at that time. These data, therefore, taken together, lead to the safe conclusion that the Similkameen deposits are at least Oligocene in age.

GEOLOGICAL RECORD

Although insects have a very long pedigree, it is as yet a very imperfect one. The remains of creatures that can be referred to the class Insecta have been found, it is said, in Silurian strata; only one or two of these very early forms are at present known, and the information about them is by no means satisfactory. If insects at all—as to which some doubt exists—they apparently belong to very different forms, though, like all the earliest fossil insects, they are winged. In the strata of the Carboniferous epoch numerous insects have been detected, in both Europe and North America. These early insects are called by Scudder—quoted by Sharp (8, p. 486)—Palaeodictyoptera. According to this author they are separated from the insects around us, because he considers there existed among the Palaeozoic insects no ordinal distinctions such as obtains in the existing forms, but that the

primeval creatures formed a single group of generalized Hexapods. Brauer on the other hand—also quoted by Sharp (8)—considers that these earlier forms can be relegated to families existing today and forming parts of the Orthoptera, Neuroptera and Hemiptera. Since it is chiefly the wings of these forms that have been found, it would seem arbitrary to assign the species to a separate order, said to be extinct, on merely alar evidence. The fact that there is one species, **Eugereon bockingi,** with head and mouth parts of a hemipterous or dipterous nature while the wings are distinctly neuropetrous, seems to us to weaken Scudder's position.

In the more recent rocks, insect remains become comparatively numerous, and in Mesozoic strata forms that can be satisfactorily referred to existing orders are found, the Palaeodictyoptera of Goldenberg and Scudder having disappeared. The Blattidae do not apparently present any great discontinuity between their Palaeozoic and Mesozoic forms. It would be well to remark here that the history of the cockroaches is the best preserved in the rocks, of any insect. In the Carboniferous epoch they existed in considerable numbers and variety, and a still earlier but doubtful fossil has been found in the Silurian of Calvados. It is curious to note, according to Brongniart (6), that some of the females of these fossil Blattidae had a well-marked ovipositor, in the shape of an elongate, exserted organ at the end of the body, by means of which the insect may have desposited its eggs in trees and other receptacles in the manner prevailing among Orthoptera of our own times.

In the strata of the Secondary epoch, remains of Blattidae have also been discovered in both Europe and America, in Oolitic, Liassic and Triassic deposits. From the Tertiary strata, on the other hand, comparatively few species have been brought to light. A few have been discovered preserved in amber.

According to Scudder (5, p. 109) not only were insects abundant in the Tertiaries, but their remains indicate conditions of existence very similar to what we find around us today. "Certain peculiarities of secondary sexual dimorphism accompanying special forms of communistic life, such as the neuters and workers in Hymenoptera and the soldiers of the Termitidae, are also found, as would be expected, among the fossils, at least through the whole series of the Tertiaries. The same may be said of other sexual characteristics, such as the stridulating organs of the Orthoptera, and the peculiarities of ovipostion, as seen in the huge egg-capsules of an extinct Sialid of the early Tertiaries. The viviparity of the ancient Aphididae is suggested, according to Buckton, by the appearance of one of the specimens from the Oligocene of the Florissant, while some of the more extraordinary forms of parasitism are indicated at a time equally remote by the occurrence in amber of the triangulin larva

of **Meloe** and of a characteristic strepsipterous insect. Not only, too, are the parent tribes of gall-making insects abundant in the Tertiaries, but their galls as well have been found."

Following is a brief outline of our knowledge of fossil insects as culled from Folsom (9):

Phryganeidae. Abundant remains in the Tertiaries. It is a remarkable fact that a larval case has been found in amber, which seems to point to the arboreal habits of the species, quite rare today. Adult fossils are very abundant at Florissant (Tertiary Lake Basin). In Auvergne, the so-called industrial limestone, two or three yards thick over a wide area, is supposed to be composed chiefly of the cases of larvae of this family.

In the Mesozoic epoch some wings have been found in the lower Purbeck, and similar wings in the Lias. A tube of a supposedly Phryganeid larva has been found in the Cretaceous of Bohemia. The palaeontological evidence does not appear to supply any information regarding the theory that the Phyrganeidae are allied to the early conditions of the Lepidoptera.

Acridiidae. Have never been found in amber, probably owing to their strength and size. Few fossil remains are known and these do not extend further back than the Mesozoic. Several forms found at Florissant. Brogniart has found some representatives at Commentry in the Carboniferous strata (Palaeacridiidae), which are said to be abundant in this epoch.

Forficulidae. Occur in the lower Lias of Aargau and Jurassic in Eastern Siberia, but the forms are not well preserved. They are common in the Tertiary formations, as in the Lower Miocene beds at Florissant.

Ephemeridae. The palaeontological record of this family is both rich and remarkable. Several forms are preserved in amber. The family is represented in the Tertiaries (Florissant), Jurassic, Devonian and Carboniferous, all more or less akin to our existing Ephemeridae. All evidence points to the fact that our fragile, short-lived may-flies appear to be, as Scudder says, the lingering fragments of an expiring group.

Perlidae. Occur in amber, Eocene (Isle of Wight); Miocene (Europe); Jurassic (Siberia); Carboniferous (Commentry).

Sialidae. Found in Tertiary and Mesozoic. The red sandstones of Connecticut have yielded a larval form of Sialid (Scudder), which is the oldest larva known (**Mormolucoides articulatus**). From the Carboniferous of Illinois several specimens have also been disinterred.

Termitidae. Very abundant in Tertiary times, when the genera appear to have been much the same as at present. In Mesozoic strata,

the remains of true Teremitidae apparently exist in the Lias in Europe, but further back than this the history is not traceable satisfactorily. They are not now supposed to have existed in the Carboniferous strata.

Some of the extinct Neuroptera of palaeozoic times were insects of large size, surpassing considerably in this respect any of those now known. Some possessed abdominal tracheal gills comparable to those found in the immature condition of the present day Ephemeridae and analogous to those of the adult of **Pteronarcys.** Further, some had wing-like expansions on the prothorax.

Thysanoptera. Tertiary epoch of Europe and North America.

Buprestidae. Remarkably rich in fossils. Twenty-eight per cent. of fossil beetles of the Mesozoic period found by Heer in Switzerland are referred to the Buprestidae.

Diptera. A considerable variety of forms have been found in amber and many in the Tertiary beds. A very few numbers of the Cyclorrhaphous sections are, however, found among them. Tipulidae are richly represented. In the Mesozoic epoch the order is found as early as the Lias, the forms being exclusively Orthorrhaphous, both Nematocera and Brachycera being represented. All are referred to existing families. No evidence has been found tending to connect the Diptera with other orders. No Palaeozoic Diptera are known.

Hemiptera. Several Palaeozoic fossils have been found but their identity has been disputed. **Eugereon bockingi** belongs to the Permian strata. Facts show that the Homoptera appeared before the Heteroptera and date as far back as the Carboniferous period.

Ants. They are among the earliest of the Hymenoptera. Remains referred to the family have been found in the Lias of Switzerland and in the English Purbecks. In Tertiary times Formicidae appear to have been the most abundant of all insects. At Florissant they occur in thousands and form in individuals about one-fourth of all the insects found there. They have also been met with in large numbers in the European Tertiaries, and Mayr studied no less than 1500 specimens found in amber.

Oestridae and other parasites (Mallophaga). Although in many cases the rocks have yielded us no direct information regarding such highly specialized parasitic insects as the warble flies of oxen and deer, we may be assured that they only became differentiated during those later stages of the Kainozoic period which witnessed the evolution of their respective mammalian hosts. Carpenter (*7*, p. 108) states that "some instructive hints as to differences in the rate of change among different insect groups may be drawn from the study of parasites." For example, V. L. Kellog (10) points out that an identical species of the

In Memoriam

TOM WILSON

It is with a feeling of deep regret that I put pen to paper to record the life-work of our late lamented colleague and friend, Mr. Tom Wilson, who met his death in a disastrous fire at the Coquihalla Hotel at Hope, B.C., on March 6th, 1917. On the other hand, it is with immense satisfaction that I can call attention to the wonderful influence his life and personality brought to bear on the work of our Entomological Society, as indeed upon the interests of all field naturalists. His intimate knowledge of our birds, mammals, plants and insects was nothing short of marvellous, and it was conceded by all who knew him that he represented the best type of field naturalist the Province has enjoyed for a great many years. He could discourse freely upon the habits of many native animals and insects—facts known to only a few but facts learnt by observation and experience—and he could bring his memory to bear onto the distribution of the majority of our native plants and trees. There were few parts of British Columbia where he had not been, after thirty years sojourn in the Province. While the habits of insects and animals attracted his regard to no small extent, it was really upon the mysteries of plant life, growth and ecology, that his mind really loved to dwell. A tramp through the woods, especially on Vancouver Island and on the Lower Mainland, was to his heart its greatest pleasure, and hours spent in his company on such occasions were hours of inspiration and delight.

He was born at Musselburgh, Scotland, on July 25th, 1856. In his early twenties he studied horticulture and forestry, and for a while was employed as foreman in the Royal Botanic Gardens at Edinburgh. India then claimed his attention, to which country he went at the age of 24. Here he was engaged as Superintendent of some tea plantations in Lower India and Burmah. After six years spent in the tropics, he returned to his home in Scotland, only to set sail shortly afterwards for Canada. He was for a time employed on railway construction work on the main line of the Canadian Pacific Transcontinental Railway, and as he used to remark, "he walked into British Columbia before the railway was completed." From 1886 until the date of his death he remained in British Columbia—in very truth one of the pioneers of this great Province. In 1896 he was appointed Fruit Inspector in the Provincial Department of Agriculture. In 1900 he entered the service of the Dominion Government as Superintendent of Fumigation, and in 1906 the Inspectorship of Indian Orchards was added to his duties. The importance of the work necessary to develop Indian agriculture grad-

which prevails today in the case of those of Europe and Palaarctic Eastern Asia. Since there was also a similar condition of affairs in the Tertiary, we may conclude that insects were repeatedly given the opportunity of passing between Eurasia and North America."

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THE LATE MR. TOM WILSON,

Dominion Inspector of Indian Orchards
President, Entomological Society of British Columbia, 1912