

SCUDDER'S WORK ON FOSSIL INSECTS.

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Scudder was the founder of American Palæontology, and by far the largest contributor to the subject. He described over a thousand species, ranging from the Carboniferous to the Quaternary, covering a much larger field than any of his successors in this country. His great knowledge of living insects, and broad grasp of biological problems, especially fitted him for this work, while the discovery of some extraordinarily rich deposits gave him unusual opportunities. It is true that some recent writers have felt obliged to disagree with certain of Scudder's conclusions, but considering the difficulty of the subject, it cannot be doubted that he did excellent work; nor is it by any means certain that all the revisions of later years will be found valid. When we compare Scudder's work with that of European palæontologists, we are struck by the methodical and detailed descriptions of his species, the frequent synoptic tables, and the abundant illustrations. We are impressed by the idea that he always did his best, and did not willingly or intentionally leave things in a confused or imperfect state. The European literature, while containing much fine work is full of scrappy descriptions or mere allusions, which are worse than useless. Even Handlirsch, the most eminent living authority, does not hesitate to publish such descriptions (without figures) as this: "*Gryllacris* (s. l.) *Kittli* m. Fundort: Radoboj, Kroatien. Unteres Miocän. Das Wiener Hofmuseum besitzt ein exemplar, welches ähnliches Geäder zeigt wie *Ungeri*; und *brevipennis*, aber nur 28 mm. lange Vorderflügel besitzt." This sort of thing has never been customary in this country, and consequently our literature is not crowded with names which are almost or wholly meaningless unless one has access to the types on which they were founded. Whenever Scudder's species are obscure, it is because they are based on obscure specimens, and in some cases we are obliged to admit that he used too imperfect materials for descriptions.

Scudder not only made himself familiar with American fossil

insects from all horizons, but examined European collections, visited some of the classical localities, and published descriptions of a number of new European species.

Scudder's first paper on fossil insects, published in 1865, related to those ancient forms from New Brunswick, considered by many Canadian geologists to be of Devonian age, but on the evidence of the accompanying fossil plants, referred by David White and Kidston to the Carboniferous. In time, his work on Palæozoic insects assumed large proportions, nearly two hundred species being described. In Scudder's opinion, the Palæozoic insects were not separated into orders like those of the present day, but nevertheless could be divided into groups which more or less resembled modern orders. It was not that the Palæodictyoptera were characterized by any very marked ordinal characters, but they lacked the special features which distinguished the living groups. Even in the case of the Palæozoic cockroaches, Scudder thought that they should be separated from the true Orthoptera, though certainly ancestral to them. These Palæoblattariæ were supposed to be exclusively Palæozoic, until numerous species were found in the "Trias" of Colorado. In the opinion of David White, however, the so-called Triassic beds at Fairplay are not later than Permian, "if indeed they are above the highest Coal measures," and consequently are Palæozoic.

These opinions of Scudder's have given rise to some controversy, and today few would maintain the all-inclusive "Palæodictyoptera" in the sense of Scudder. The following table contrasts Scudder's arrangement of the Palæozoic insects with the most modern, that of Handlirsch:

HANDLIRSCH	SCUDDER
Order Palæodictyoptera.	Palæodictyoptera in part.
Dictyoneuridæ.	Orthopteroidea Protophasmida.
Lithomantidæ.	{ Neuropteroidea Hemeristina.
Lycocercidæ.	" Homothetidæ.
Homothetidæ.	N.* Palephemeridæ (?)
Breyeriidæ.	N. Homothetidæ.
Brodiidæ.	O. Protophasmida.
Paoliidæ.	N. Hemeristina.
	O. Protophasmida.

* N. = Neuropteroidea; O. = Orthopteroidea.

Order Mixotermitoidea	N. Homothetidae.
(?) Order Reculoidea.	(Unknown to Scudder).
Order Protorthoptera.	
Spanioderidae.	N. Palæoptera.
Pachytylopsidae.	N. Hemeristina.
Ædischiidae.	N. Homothetidae.
Geraridae.	{ N. Gerarina. N. Homothetidae.
Order Protoblattoidea	{ N. Gerarina { include genera placed by N. Palæoptera { Handlirsch as uncertain Protoblattoidea.
Protophasmidae.	O. Protophasmida.
Oryctoblattinidae.	{ Hemipteroidea. O. Blattinariae.
Ætophlebidæ (rect. Æthophlebidæ).	N. Palæoptera.
Cheliphlebidæ.	N. Homothetidae.
Eucænidæ.	N. Homothetidae.
Gerapompidae.	N. Homothetidae.
Adiphlebidæ.	N. Gerarina
Anthrocothremmidæ.	N. Homothetidae.
Order Mantoidea* (includes living Mantidæ).	(Unknown to Scudder as Palæozoic.)
Order Blattoidea* (includes living Blattidæ).	
Archimylacridæ.	O. Blattinariae.
Spiloblattinidæ.	O. Blattinariae.
Mylacridæ.	O. Mylacridæ.
Neorthroblattinidæ.	Neoblattariae (includes modern cock- roaches).
Poroblattinidæ.	O. Blattinariae.
Mesoblattinidæ.	Neoblattariae.
Diechoblattinidæ.	Neoblattariae.
Proteremidæ.	O. Palæoblattariae.
Order Hadentomoidea.	(Unknown to Scudder.)
(?) Order Hapalopteroidea.	(Unknown to Scudder.)
Order Perlaria.* (A Permian genus unknown to Scudder provisionally placed here.)	
Order Protodonata.	
Meganeuridæ.	{ N. Palephemeridæ. O. Protophasmida.
Paralogidæ.	O. Protophasmida.
Order Protephemeroidea.	(Not considered by Scudder.)
Order Plectoptera.* (Three genera of Russian Permian, unknown to Scudder.)	
Order Megasecoptera.	Neuropteroidea.
Order Protohemiptera.	Hemipteroidea.
Order Palæohemiptera.	(Unknown to Scudder.)

Orders still living are marked with an asterisk. It will be seen that Scudder admitted some of the cockroaches into the group

still living, but these genera were supposed by him to be later than Palæozoic. On the other hand, Handlirsch, if we except genera unknown to Scudder, places only the cockroaches in a modern order. The main issue therefore narrows down to (1) Whether the Palæozoic cockroaches in general, or only some of them, should be placed in the same order as the living ones, and (2) whether among the Palæozoic insects excluded from modern orders, we should recognize one order or many. Even so, the disagreement diminishes when we note that Scudder opposed his Palæodictyoptera to a group of equal rank including all other insects, and divided it up into sections which he considered related to the modern Neuroptera, Orthoptera and Hemiptera. To a considerable extent the apparent difference is due to different conceptions of what constitutes an order; thus Handlirsch makes several orders out of the living Orthoptera, usually considered to be one. In detail, there is more serious disagreement as to the placing of various genera, and since many of these are known from very unsatisfactory fragments, it is likely that diverse opinions will prevail in the future as in the past. If many writers, for reasons of convenience, adopt throughout the nomenclature of Handlirsch's great work, this will not necessarily imply critical judgment between opposing opinions. In this comparison, the data from Scudder are taken from his summary published in 1886, with some additions from later works.

Since Handlirsch published his classification, Sellards has made known a magnificent series of insects from the Permian of Kansas. In connection with a very large and well-preserved dragon-fly, he discusses the standing of the Protodonata, and arrives at the conclusion that they should rank as a sub-order only, under Odonata. Sellards also reports from these deposits a series of ten genera and thirteen species of Plectoptera (Ephemerids), forming a new family Protereismatidæ (Protereismephemeridæ, Sellards). Summing up, we may consider the following propositions valid, so far as present knowledge goes:

(1.) During the later Palæozoic the Blattoid Orthoptera were well established, and in the latest Palæozoic (Permian) the Ephemerids, and possibly the Perlids and Mantids, had become sufficiently differentiated to be placed in the same orders as their living representatives.

(2.) For the rest, the Palæozoic insect fauna was too primitive to be placed in existing orders, and was undoubtedly far more homogeneous than the fauna of any later epoch. Whether it should be regarded as a single great group (contrasted with a group including all living insects), divided into several "sections," or should be divided into a number of orders, depends principally on one's conception of the limits of an "order." Even Handlirsch does not insist upon the recognition of all his "orders," but expressly states that several of them are provisional. It must also be said that one who felt convinced that numerous valid orders of insects really did exist in the Palæozoic, might nevertheless hesitate to recognize ordinal divisions made so often in ignorance of the metamorphoses, mouth-parts, and other matters considered of prime importance in classification.

Scudder described six species from the Lias of England; four are Blattoids, and two (according to Handlirsch) Prohemerobiid Neuroptera. Twenty-three Blattoids were described from the English Purbeck, which Handlirsch treats as uppermost Jurassic, but A. S. Woodward as lowermost Cretaceous. *Hylobiites cretaceus* Scudder was founded on a fragment of an elytron from the Pierre Shales (Montana Cretaceous) of Manitoba,—a quite unexpected discovery, the Pierre being marine. *Corydalites fecundum* Scudder is a name for egg-masses found in the Laramie beds of Colorado.

The 838 Tertiary insects described by Scudder, principally in his great work "The Tertiary Insects of North America" (1890), represent only a portion of those he accumulated and studied. There are in the Museum of Comparative Zoölogy at Cambridge very numerous specimens representing undescribed species, which Scudder intended to make known. Some of these have been published in later years by other writers, and many others will eventually be described. It is greatly to be regretted that the Museum of Comparative Zoölogy has never felt able to put a series of Scudder's Tertiary insects on exhibition; they are many of them so beautiful and so well-preserved, that they would excite the interest of all visitors, and no doubt some would be led to take up this neglected branch of entomology. The British Museum, having a much smaller collection from the American Tertiaries, has hastened to exhibit them to the best possible advantage.

The work on Tertiary insects was largely based on specimens from Florissant, Colorado, where Scudder himself made a very large collection. He also collected from the White River deposits on the Colorado-Utah boundary, and visited Oeningen, the famous locality in Baden which may be said to represent Florissant in Europe. Scudder's writings on Tertiary insects are so voluminous that it is hardly practicable to review them in this article; but attention must be called to the fossil butterflies from Florissant and from Aix in France, and to the great work on the Rhynchophora. In the course of the work, various important generalizations were made; these are now familiar to entomologists, and need not be discussed in this place. The detailed descriptive work, however, has not received the attention it deserves, and monographers of groups of living insects cannot be too strongly urged to examine Scudder's writings, which will undoubtedly throw important light on problems of descent, and especially on the migrations of faunæ.

Scudder took great interest in the Quaternary insect-fauna, describing 80 species of beetles from the Postpliocene and Interglacial deposits of Canada, and three from Massachusetts. This work was important in a number of ways, but perhaps most of all as indicating the approximate rate of the evolution of species in insects, proving that Coleopterous species, at least, are much less permanent than those of plants.¹ On the other hand, it is seen that the specific changes taking place are comparatively insignificant, and that for generic differentiation in insects, long periods are usually required. From the Tertiary and Quaternary work we conclude that in the rate of evolution, insects stand between flowering plants and vertebrates.

¹ A very exact study of the preglacial flora of Britain was published by C. and E. M. Reid in 1908 (*Journal of the Linnean Society, Botany*). It was found that of 147 species, nearly all were living, but a few apparently extinct.



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