However, the book is especially timely and pertinent to the information explosion problems of the present decade. Chapters two through six are of especially great importance to all entomologists, since procedures for the preparation and dissemination of entomological information are already beginning to undergo some radical changes and will continue to do so in the near future. Indeed, in terms of its information storage and retrieval concerns, Arnett hopes that his book will introduce entomologists to those changes now in progress, and that by so doing it will help accelerate its own obsolescence. For the professional entomologist, therefore, the time to read this book is now.

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Book Review

MATSUDA, R. 1970. Morphology and Evolution of the Insect Thorax. Memoirs of the Entomological Society of Canada. Ottawa. No. 76. 431 pp., 172 Fig., 24 tables, 744 references, subject and author indices. (Memoirs are included in the subscription price for the Canadian Entomologist.)

This is the second in a series of monographs by Matsuda analyzing structural evolution in insects. He began this project to organize the large quantity of published information which had accumulated since the appearance of Snodgrass' textbook on the subject in 1935. Perusal of the bibliography supports his rationale: of 744 references only 186 appeared before 1935. There are 424 references in English, 180 in German, 79 in French and 61 in other languages chiefly Russian and Italian. As the German and French contributions have importance out of proportion to their numbers the appearance of a review in English is of great value to English-speaking entomologists.

This book deals with the thorax but considers the wings and legs only briefly. Matsuda's conclusions are based largely on his reading, interpretation, and digestion of published works although he contributes original information where required to fill in gaps.

The book is divided into two parts: a discussion of general topics on 87 pages, and a discussion on 314 pages which treats in detail selected representatives of each insect order. For most biologists the first part is of greater use. In it Matsuda establishes the primitive organization of the pterygote thorax. This necessitates a summary of his conclusions from part II. He discusses the neck, tergum, sternum, intersegmental regions, pleuron and aspects of the wings, coxae and spiracles, comments on their embryological and evolutionary origins, analyzes the various theories proposed to explain their evolution, and emphasizes the strengths and weaknesses of each theory. Finally, he presents his own conclusions, synthesizing a theory of homology from descriptive and experimental embryology, postembryonic development, genetics, comparative morphology, paleontology and phylogeny.

In his discussion of wings Matsuda concentrates on their origin, a subject which has intrigued many workers as evidenced by the plethora of theories published to explain their presence. His most interesting discussion here concerns the validity of separating the pterygotes into the Paleoptera and Neoptera. Matsuda concludes that this separation is phylogenetically unsound since the wing mechanism of the Ephemeroptera is very much like that of most neopterous pterygotes, while that of Odonata is not.

In the second half of part I, Matsuda considers the thoracic musculature. First, he presents an illustrated and tabulated description of the musculature of the apterygote *Lepisma saccharina* L. based on the work of Barlet. This serves as a standard of reference for his general discussion of pterygote musculature which follows. Here, he introduces a system of abbreviations used in part II for naming muscles.

The final section of part I (Major evolutionary features of thoracic musculature) is the strongest section in the book. Matsuda concludes that the predominant evolutionary trend of the adult thoracic muscles in insects has been a reduction in number. At the same time however, some muscles have been added and in their turn these secondary muscles have decreased in number also in the higher pterygotes. Thus, the thoracic musculature includes two kinds of muscles of different evolutionary origin: (i) those inherited from a wingless antecedant and (ii) those which have arisen *de novo* in the Pterygota. The former Matsuda calls paleogenetic muscles; the latter neogenetic muscles. A third group, the caenogenetic muscles, are those which have developed exclusively in the immature stages and which have no recognizable homologues in the adults.

Matsuda discusses the gross developmental pattern of the thoracic muscles. There are few if any caenogenetic muscles in paurometabolous insects, but in holometabolous insects these tend to increase. Also, the time of appearance of imaginal muscles and degeneration of larval muscles during metamorphosis varies from one order to another (heterochrony). Immature pterygote insects tend to preserve muscles present in the Apterygota whereas the adults of these insects lack them. There is also a tendency for nymphal and larval insects to preserve muscles present in the adults of related but less derived groups. This last observation, as emphasized by Matsuda, accords with the biogenetic law of Müller-Haeckel i.e. that ontogeny recapituales phylogeny.

Matsuda closes part I with a discussion of the underlying developmental mechanisms for production of new muscles. Differences in the growth rate of epidermal cells and differences in times of connection between muscles and the epidermal cells in various insects result in the production of homologous muscles with new points of attachment and hence new functions. The development of ectodermal parts is often dependent on muscles after the connection of the two is established but not before. Here, Matsuda should have cited the work of Sahota and Beckel (1967. Can. J. Zool. 45:407-434) who showed experimentally that in *Galleria mellonella* L. the topographic relationships between flight muscle myoblasts and the epidermis is the causative factor in determining the orientation of developing flight muscles. Homologous muscles may be inserted on the cuticle in Pterygota and on the epidermis in Apterygota and larval Pterygota. Some muscles are replaced by ligamentous structures which are ectodermal in origin.

The flight muscles have been derived differently in different orders. Fibrillar and close-packed types of flight muscles are specializations of the normal, non-flight muscles which are tubular. Much of this argument is based on Tieg's (1955) classic study of flight muscles, a paper which, in this book, finally receives the recognition it deserves.

In part II, each account of an order is illustrated with fully-labelled drawings. Most of these are modified from other works, but some are based on Matsuda's own observations. Many of the copied illustrations are not of the quality of the originals but all of them show clearly what they are intended to show. Most of the analyses are accompanied by a table providing a uniform system of designation for the muscles found by different investigators in different species. Each table is followed by a list of remarks muscle by muscle. Where information is available both adult and larval musculature and its metamorphosis are discussed. The structural basis for flight is summarized and alary polymorphism is referred to if it occurs in the group under discussion.

Matsuda's phylogenetic conclusions, which are highly controversial, are derived with an appreciation for Hennig's (1966) principles and terminology. He suggests that Embioptera and Phasmida are derived sister groups of Plecoptera. His belief that the Blattaria, Isoptera, Mantodea, Grylloblattodea, and Orthoptera belong together is evidenced by his tabular comparisons of the thoracic muscles of individuals in these different orders. He supports Crampton's (1918) idea that the Dermaptera and Coleoptera are closely related to each other and thus implies that the beetles are only distantly related to the other holometabolous orders. Zoraptera are related both to the hemipteroid orders and to the Isoptera and Plecoptera and Matsuda proposes that the hemipteroids were derived from the same protorthopteroid ancestry as Isoptera. Suprisingly, Matsuda does not discuss the relationships of the panorpoid complex but in grouping most of these orders (Mecoptera, Diptera, Lepidoptera, Trichoptera) together he implies support for Hinton's (1958. A Rev. Ent. 3:181-206) interpretation. Hymenoptera he considers to be a sister group of the Mecoptera and the placing of Strepsiptera, he says, requires further study.

In leaving consideration of Odonata to the end of the book, Matsuda underlines his belief that these insects are only distantly related to the other pterygotes. He proposes that this order could have arisen from a machilid- or japygid- like ancestor and intimates that odonate peculiarities have been derived in such a way as to obscure this order's relationships with the Machilidae and Diplura. I am not convinced by Matsuda that the ectognathous Odonata are closely related to entognathous Diplura.

As the structures comprising the thorax of insects form a functional complex, they are liable to change with changes in the mode of life of the organisms. Thus, insects in different orders with similar methods of locomotion could have similar thoraces arising through convergence. Adaptive features often are of limited value in phylogenetic hypothesizing if they are not used in conjunction with many other characters of different functional significance. I suggest that phylogenies erected on the basis of thoracic structure alone will not persist for very long.

I respect this author for his ability at synthesis. Some workers have criticized Matsuda for relying too heavily on the work of others. Nevertheless Matsuda's conclusions are his own and could only be arrived at by one who has a comprehensive appreciation of thoracic complexity in the whole of the Insecta. To have mastered this amount of information and still found time for original investigation is a remarkable accomplishment.

The book reveals that insect morphology is an active field of investigation, points out that a great amount of information remains to be obtained particularly in the developmental area, and hopefully, shows non-morphologists that this is not the dull subject that many of them believe it to be. I am looking forward to the appearance of future volumes by Matsuda.

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