BRODSKY, ANDREI K. 1996. The Evolution of Insect Flight. Oxford University Press, New York. xiv + 229 p. ISBN 0-19-850089-0. Paperback (first paperback edition). $55.00.

In the preface to this translation of the original Russian hardback, the author frankly states that "This book is not for easy reading at idle moments." I like that. Gaining an understanding of the physiology of flight, and indeed of any aspect of insect physiology, is serious business. Brodsky, Professor in the Department of Entomology of St. Petersburg University, St. Petersburg, Russia, has presented an in-depth analysis of the basic principles of flight in part I, and the evolution of flight in Part II. Part I consists of 4 chapters, detailing structure of wings, the way wings work, the aerodynamics of flight, and the role of flight in insect behavior.

In chapters 5, 6, and 7 in Part II, the author describes models and ideas about the origin of flight and wings in insects, with details and examples from mayflies, dragonflies, stoneflies, and cockroaches. In chapter 8 he discusses the differences in flight of four-winged insects and two-winged insects, with examples from Psocoptera, Homoptera, and Heteroptera. Chapter 9 is a discussion of changes in wing structure, thorax, hinging of wings, and musculature as insects evolved into more diverse forms. What, for example, are beetles to do with the hard, inflexible elytra (forewings) during flight? The answer is that all Coleoptera except the rose chafers (*Cetonia* spp.) spread the elytra at some angle to the long axis of the body, and often swing them in small

arcs at the frequency of the hindwings. Tiger beetles, which are fast fliers with rapid take-off from a surface, hold the forewings nearly at right angles to the body axis and support them with the first pair of legs ". . . like the struts of a high-wing monoplane." Especially, but not exclusively, during evolution of Diptera and Hymenoptera changes occurred in wing structure, musculature, and thoracic structure that enabled much faster flight and greater maneuverability, such as hovering and frequent changes in direction. Maneuverability during flight made possible swarming behavior in many small species of Diptera, some of which fly equally well forward, backward, or sideways.

Just as high speed flight is essential to the behavior and biology of flies and bees, so is slow flapping and gliding flight important to some species of Neuroptera, and many species of Lepidoptera. I was surprised to learn that up to 40-50% of flight time in some Lepidoptera is gliding flight. Changes in wing shape in Lepidoptera are traced from the narrowing of the wing plane and development of long fringes on the wings of some small moths, to the large wings of some butterflies and moths. Gliding flight required changes in wing structure and in the articulation of the wings to the thorax. Airflow, vortices, and drag forces are discussed in relationship to wing structure and shape. I found very interesting a physiological explanation for the evolution of the tails of *Papilio* spp. as modifying the drag of air vortices coming off the main surface of the wings, and thus enabling the butterflies "to use greater angles of attack during gliding without significant increase in drag." Other gliding butterflies that do not have tails solved the problem of drag in other ways.

The last chapter is a general summary of the evolution of wing structure, the axillary apparatus that hinges the wing to the thorax, and muscles that power flight. There are 3+ pages of Postscript as a sort of brief summary of principles without technical terms and jargon.

Having to grapple with many technical terms is one of the features of the book that make it, as the author warns, heavy reading. These terms include thoracic anatomy, wing venation, the names of numerous sclerites at the base of the wings, and taxonomic groupings. Many of the anatomical terms are abbreviated, and a list of abbreviations is given at the front of the book. The book is well illustrated with diagrams, and line drawings of thoracic structure, wing structure and venation, and musculature. There are nine pages of references, many of which are in the older literature, and in foreign publications probably less well known to many entomologists. There is a taxonomic index for those who might like to know what the book contains that is relevant to a particular insect or group, and a subject index.

I recommend this book to those teaching introductory entomology, insect anatomy, and insect physiology. It is packed with useful information, and is well worth serious study.

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