



The Insects of Australia

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The Insects of Australia

*A textbook for students
and research workers*

SECOND EDITION

Volume I

DIVISION OF ENTOMOLOGY
COMMONWEALTH SCIENTIFIC AND
INDUSTRIAL RESEARCH ORGANISATION



MELBOURNE UNIVERSITY PRESS

First published 1970 by Melbourne University Press
Reprinted 1973, 1979
Second edition 1991
Printed in Australia by
Brown Prior Anderson Pty Ltd, Burwood, Victoria for
Melbourne University Press, Carlton, Victoria 3053
United Kingdom and Europe: University College of London Press,
Gower Street, London WC1E 6BT, UK

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(Division of Entomology) 1991

National Library of Australia Cataloguing-in-Publication entry

The Insects of Australia

2nd ed.

Bibliography.

Includes index.

ISBN 0 522 84454 5

1. Insects—Australia. I. CSIRO. Division of Entomology
595.700994

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Foreword

The first important general work on the insects of this continent, *Australian Insects* by W. W. Froggatt, was published in 1907. It was written primarily from the point of view of the field naturalist, and there is no doubt that it proved most useful to the student of those days. Nineteen years later, the classical *Insects of Australia and New Zealand* by R. J. Tillyard appeared, marking a major advance both in the content of accumulated knowledge and in the wealth of biology and comparative morphology that it presented.

'Tillyard' had long been out of print when, in 1970, the first edition of the present book was published. It was a co-operative venture, sponsored by the Division of Entomology, written largely by Divisional staff, and edited by Dr I. M. Mackerras. That the book received international acclaim was due in no small part to Mackerras's scholarship and commitment. The book has since found wide use as a student text and as an essential tool for professional entomologists.

By 1984 it was clear that the first edition (and material included in the 1974 *Supplement*) was in many respects outdated, and a revised edition was mooted. Where possible, the authors of chapters were invited to revise their 1970 texts or to recommend specialists to assist or replace them in this task. Again CSIRO entomologists assumed a major role. Specialists in other Australian and overseas institutions agreed to contribute and the book is all the more authoritative for their efforts.

The result of the revision is almost a new book. Some text and many illustrations have been retained unaltered from the first edition. However, most chapters have been rewritten entirely to incorporate the wealth of new information now available. Many new illustrations have been added, some illustrations from the first edition have been amended, and most of the plates have been rearranged and relabelled. Material of a physiological and cytological nature, or dealing with aspects of reproduction and metamorphosis, has either been incorporated into other chapters (especially an expanded Chapter 2) or omitted. In its place new chapters deal specifically with the impingement of insects on human history and economy, with the use of insects in scientific research, and with the history of Australian entomology. Another new feature is a key to the insect orders in Chapter 1.

The task of the authors/revisers of chapters was to give an account of the insects of Australia primarily from the systematic point of view, but with some account of their morphology, where they live, and what they do. To achieve even this limited objective in two volumes of reasonable size has involved rigorous selection of subject matter and imposed severe limitations on its presentation. We expect that, in consequence, few authors of the systematic chapters are really satisfied with the adequacy with which the allocated space has permitted them to cover their orders. Apart from considerations of space it has been necessary for all authors to conform rather closely to an established pattern; this they have accepted for the most part cheerfully, although they would sometimes have preferred to deviate to suit their own particular needs.

The expansion in our knowledge of Australian insects since 1926 is reflected in the increase in the number of known species and families. Tillyard estimated 37 300 species and listed 401 families. The first edition of *The Insects of*

Australia recorded 54 071 species (an increase of 45% over Tillyard) and 574 families. In the present two volumes we see the figures escalate to 85 920 (an increase of 59% over the first edition) in 661 families. These numbers reflect increased specialist exploration of the continent but alone do not depict the magnitude of the work still to be done. At least some entomologists estimate that more than half of Australia's insect species have yet to be named. The proportion of species recognisable from the literature, and for which we have even rudimentary biological and distributional data, is certainly smaller. The increases in the number of families of insects known from Australia emphasise that this continent remains an entomological frontier. Some of the new families have come from the subdivision of existing families and others result from the discovery in Australia of existing families previously not known to occur here. There have also been a few notable discoveries of entirely new, exclusively Australian families.

In the teaching of Zoology the trend for some years has been away from a taxonomic approach as a major foundation on which to build other studies. Although this may mean that books like our volumes will progressively occupy a less and less central position in the formal training of students, they will continue to be invaluable sources of information and to provide an entry into the relevant but widely scattered literature. Indeed it is not too much to hope that a work of this sort will stimulate interest in a more broadly based taxonomy than has been general in Australia in the past. The keys—many of which are new—the abundance of illustrations, and the wealth of previously unpublished biological information certainly provide the student with a broad, firm foundation to the subject.

Canberra
January 1990

D. F. Waterhouse,
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Acknowledgments

The indebtedness of individual authors to those who helped them in their work is acknowledged separately in the appropriate chapters. Here we wish to record our appreciation and thanks to those who contributed in more general ways.

The illustrations are as important as the text in a work of this kind. Most of those in these volumes are original and were made, under the guidance of the authors or editors, by the artists whose names appear in square brackets in the legends. We owe a special debt to Frank Nanninga, who painted the coloured plates and drew a great many of the line illustrations. Anne Hastings, Se Kim, Terry Nolan and Sandy Smith contributed most of the new line illustrations included in this edition. Ms Hastings, Mr Kim, Mrs Smith, Chris Hunt and Andrew Carter were responsible for the layout of illustrations and for preparation of these for the Press. John Green and Alan Edward provided the photographic prints and Colin Beaton and Helen Geier the plates of electron micrographs. Where illustrations have been redrawn from published work, this is acknowledged in the appropriate legends. We thank the Elsevier Publishing Company, Amsterdam, for permission to make direct use of Fig. 3.15 (from Berg 1975), Kluwer Academic Publishers, Dordrecht, for Fig. 35.40 (from Lawrence 1985a), and the Editors of the *Memoirs of the Queensland Museum* for Fig. 24.7 (from Rentz 1980). Several other illustrations are reproduced with the permission of the Editors of *The Australian Journal of Zoology* and *Invertebrate Taxonomy*.

Preparation of such a large manuscript in good order is an arduous business, and we are indebted to Irma Pumpurs, on whom the greatest burden fell, for the care and accuracy with which she completed her work. Eric Zurcher processed the many text files into final format for the Press. Judith Olditch, Judith Hull, Heather Baker, Patsy Gillison, Eva Bugledich and Jonathan McCabe also assisted in the keying and correcting of text. Anne Frodsham and Patricia Wellisch (Press liaison) and Ray McInnes provided invaluable support to the Editorial Committee.

The bibliography was checked by Josephine Cardale. Almost all references were confirmed against original publications and we are grateful for the help in this sometimes difficult task which we received from the staff of the CSIRO Library, Black Mountain, Canberra. Ms Cardale also compiled the index.

Many referees and some of the staff and students of the Department of Entomology, University of Queensland, commented on chapters and tested some keys. We thank them for their unselfish, anonymous contributions.

The Utah Foundation, the Ian Potter Foundation, Wellcome Australia and the University of Melbourne generously provided funds to enable the production of many new illustrations. We thank them for their continuing interest in the production of these volumes.

Finally the Editorial Committee would like to record with particular appreciation the cordial and understanding relationship that has existed between them and the Directors and the staff of the Press over what has proved to be quite a long period. Sally Paxton and Kevin Jeans of CSIRO Editorial Services and Susan Keogh, among others of the Press, were responsible for typesetting and page layout.

This work may be cited as: CSIRO (ed.). *The Insects of Australia. A textbook for students and research workers.* 560 + 600 pp., 2 volumes (Carlton: Melbourne University Press).

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(painted by F. Nanninga)

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Introduction

Insects are among the most abundant and successful of terrestrial animals. They include about three-fourths of all the described species of animals, and they have become adapted to a great range of environments, from high latitudes to the equator, from rainforest to desert, from mountains to the shore, and to varied ways of living—phytophagous, carnivorous, saprophagous, parasitic. Many have become aquatic during part or the whole of their life history. The breadth of their adaptive radiations has brought some of them, though only a very small proportion of the total, into close contact with human populations. On the one hand, they damage or destroy crops and domestic animals, transmit diseases of plants and animals, including people, and damage or destroy human habitations. On the other hand, humans have added bees and silkworms to their flocks, and have learned to use other species to control noxious insects and weeds. Moreover, insects have provided some of the most valuable tools of biological research in many fields from the broadest aspects of evolution to the detailed mechanisms of inheritance.

It is natural, then, that entomology should have shared in the steadily increasing volume of research that has made it so difficult to be both brief and comprehensive when reviewing any scientific discipline. Selection is unavoidable, and the purpose of these notes is to set out the scope of this book and the ways in which problems of presentation and compression have been met.

1. It has been necessary to assume that the reader would have a background of general knowledge equivalent to what might reasonably be expected at the end of the first year of a university course in Science. This may

impose some hardship on the amateur entomologists who may wish to use the book, but it is hoped that they will find sufficient explanation in the text and illustrations to meet their needs. There is no glossary. Terms with which the reader might not be familiar are defined in the text and entered in the index.

2. Chapters 1 to 10 have been reduced to the minimum that is considered essential for the general student of entomology as a background for the chapters that follow. Chapter 1 has presented particular difficulty in this respect, because the anatomical terminology used in it has been based, as far as possible, on usage among morphologists, whereas the writers on many of the orders carry the historical burden of a terminology that has grown up with little or no reference to what has been done outside those orders. There seems to be no way to avoid this unfortunate situation. There is the further minor difficulty that the earlier chapters must anticipate Chapters 5 and 6, but a general picture of the classification used may be obtained by referring to Figs 5.1 and 5.5. Chapter 6 differs from other chapters in a few interpretations of morphology.

3. The presentation of the remaining chapters is essentially systematic, an arrangement that serves to emphasise the evolutionary perspective into which any study of insects should be fitted. The systematic statements have been used as pegs on which to hang short accounts of where the insects live and what they do. Wider problems are touched on when describing insects that illustrate them particularly well.

4. The book is designed to cover Australian insects only. The insects of New Zealand, New Guinea and the

Pacific are referred to here only when they are relevant to particular problems that are being discussed. However, an attempt has been made to put the Australian fauna into perspective with that of the rest of the world by including at least a mention of important groups that do not occur here. There are abbreviated chapters dealing with the small orders not represented in Australia.

5. In the systematic chapters the censuses include undescribed species and unrecorded synonymy known to the authors, but the completeness of this information differs from order to order, so the figures should be taken as approximations. Their reliability as indices of the total number of species in the country varies greatly. Thus, it is reasonable to suppose that most of the species of Australian butterflies and mosquitoes are already known; the same cannot be written of the less-studied families of Lepidoptera and Diptera.

6. The keys to families and higher taxa have been based primarily, though not exclusively, on Australian material. Some of them may have a wider application, but they should be used with reserve for placing specimens from other regions. There has not been room for more than a few keys below the family level.

7. Common names have been used sparingly, and only for widely known species. A full list, with standard abbreviations of the names of authors of species, is given by Carne (1987). The techniques of collecting, preserving, and studying insects have been described by Upton (1991).

8. The following abbreviations have been used, where appropriate, for political divisions of Australia:

Qld	Queensland;
N.S.W.	New South Wales;
Vic.	Victoria;
S.A.	South Australia;
W.A.	Western Australia;
N.T.	Northern Territory;
A.C.T.	Australian Capital Territory.
Tas.	Tasmania

T1 denotes the first abdominal tergum (or tergite), T2 the second, etc.; S1, S2, etc. denote the corresponding abdominal sterna (or sternites).

Where appropriate, ordinal names are abbreviated as follows:

COLL	Collembola;
PROT	Protura;

DIPL	Diplura;
ARCH	Archaeognatha;
THNU	Thysanura;
EPHM	Ephemeroptera;
ODON	Odonata;
PLEC	Plecoptera;
BLAT	Blattodea;
ISOP	Isoptera;
MANT	Mantodea;
GRYL	Grylloblattodea;
DERM	Dermoptera;
ORTH	Orthoptera;
PHAS	Phasmatodea;
EMBI	Embiopoda;
ZORA	Zoraptera;
PSOC	Psocoptera;
PHTH	Phthiraptera;
HEMI	Hemiptera;
THPT	Thysanoptera;
MEGA	Megaloptera;
RAPH	Raphidioptera;
NEUR	Neuroptera;
COLE	Coleoptera;
STRP	Strepsiptera;
MECO	Mecoptera;
SIPH	Siphonaptera;
DIPT	Diptera;
TRIC	Trichoptera;
LEPI	Lepidoptera;
HYMN	Hymenoptera.

9. References have presented a particular problem. It is impossible to give extensive bibliographies in the space available, and reliance has been placed as much as possible on references to reviews and monographic works which provide a recent, readily available entry into the major literature. It must be stressed that this in no way implies any lack of appreciation of earlier classical papers. Direct study of these works is indispensable to any serious student, and some of them have been referred to in general terms when the full references are included in a publication that is cited. References in round brackets relate to the statements in which they occur, those in square brackets usually to the group as a whole. Papers on Australian insects up to 1930 have been listed in the bibliography by Musgrave (1932).