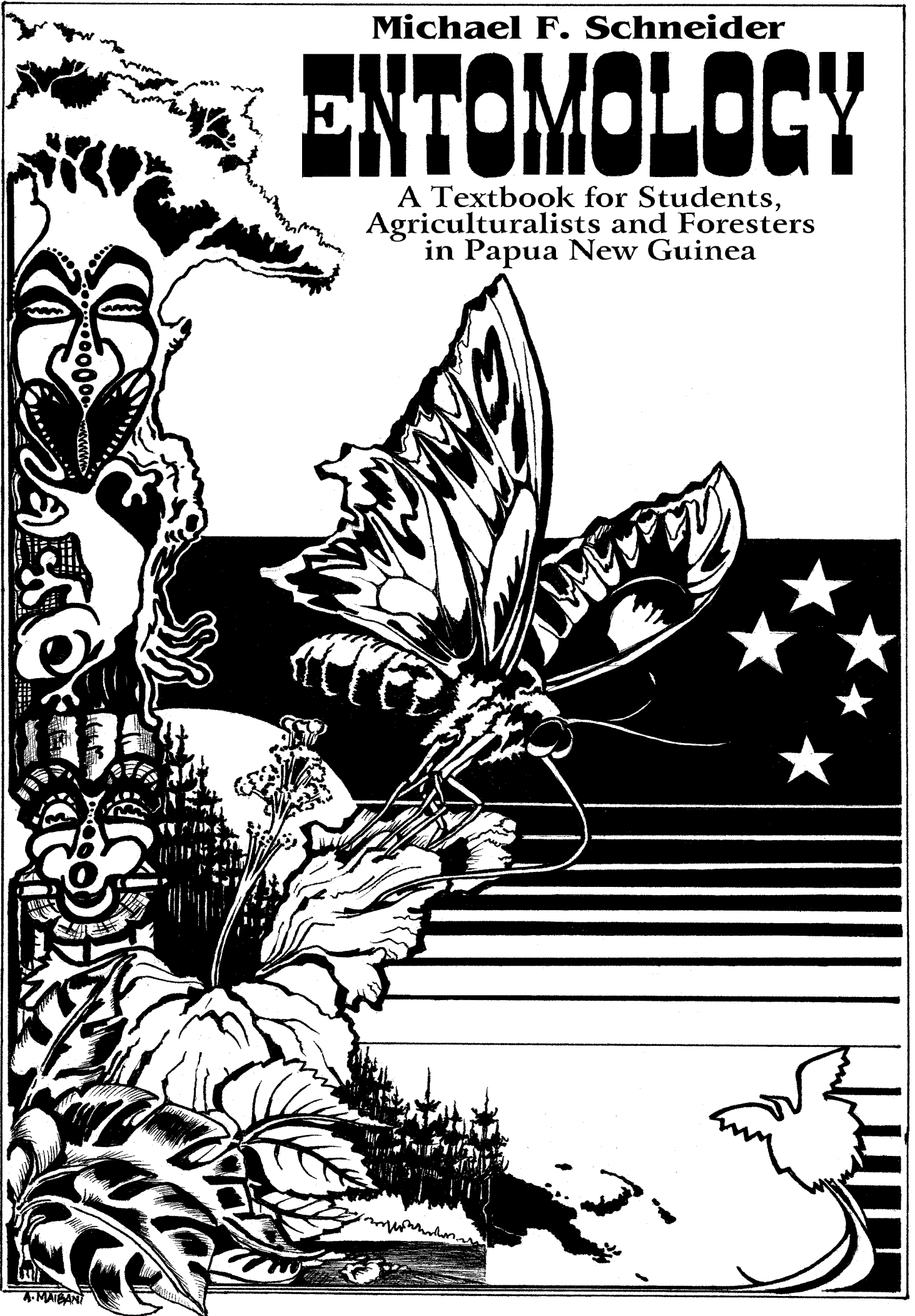


Michael F. Schneider

ENTOMOLOGY

A Textbook for Students,
Agriculturalists and Foresters
in Papua New Guinea



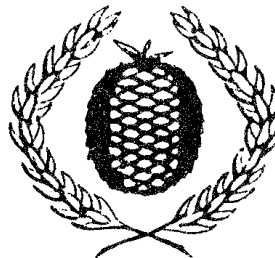
ENTOMOLOGY

**A Textbook for Students, Agriculturalists and Foresters in
Papua New Guinea**

Michael F. Schneider

with illustrations by Anthony Maibani

Bulolo University College
Bulolo, Morobe Province
Papua New Guinea



Training Manual

No. 19

ded

The production of this publication was
subsidised by the Australian Agency for
International Development and German
Development Service


AusAID

Published by **Bulolo University College**
P.O. Box 92; Bulolo/Morobe Province; Papua New Guinea
Training Manual No 19

First edition 1999

© Michael F. Schneider, 1999
mfschneider@hotmail.com

All rights reserved

Design and Lay-out: Michael F. Schneider

Printed by PNG Printing, Port Moresby

National Library of Papua New Guinea
Cataloguing-in-Publication entry:

Schneider, Michael F., 1962-
Entomology - A Textbook for Students, Agriculturalists and Foresters in Papua New Guinea
312 pages and 11 colour plates
Includes bibliographical references, glossary and index
ISBN 9980-85-259-3

Apart from any fair dealing for the purposes of research or private study, or criticism or review, as permitted by copyright laws, this publication may not be reproduced, stored or transmitted, in any form or by any means, without the prior permission in writing of the author, or in the case of reprographic reproduction only in accordance with the terms of licences issued by the appropriate Reproduction Rights Organisation. Enquiries concerning the reproduction outside the terms stated there should be addressed to the author.

The publisher and the author make no representation, express or implied, with regard to the accuracy of the information contained in this book and cannot accept any legal responsibility or liability for any errors or omissions that may be made.

About the Author

Dr. Michael Schneider was born in 1962, studied Biology and was awarded an MSc in 1990 and a PhD in 1993. From 1989 to 1993 he worked as a Scientific Officer at University of Mainz, Germany, involved in a research project on biological control of migrating locusts in Madagascar/East Africa. Since 1994 he has been a volunteer with German Development Service at Bulolo University College, teaching amongst others Forest Entomology.

About the Illustrator

Anthony Maibani is a young promising artist from Wamira, Rabaraba District in Milne Bay Province. He was born in 1972, finished high school in 1990 and wants to broaden his skills at the School of Arts in Port Moresby. He has already illustrated several books and currently makes his living by arts and design work.

100% Made in Papua New Guinea

**Dedicated to
my mentor, lecturer and supervisor**

Professor Dr. August Dorn

**Department of Zoology
Johannes-Gutenberg-University
Mainz, Germany**

Table of Contents

PREFACE	IV
ACKNOWLEDGEMENTS	VI
REMARKS ON SCIENTIFIC NAMES AND TERMS	VIII
1. INTRODUCTION	
1.1 INSECT DIVERSITY	2
1.2 INSECTS AND HUMANS	3
1.3 INSECT TRADE AND CONSERVATION	5
1.4 BIOGEOGRAPHY OF INSECTS	7
2. STRUCTURE AND FUNCTION	
2.1 EXTERNAL ANATOMY	10
2.1.1 Integument and Exoskeleton	11
2.1.2 Head	11
2.1.2.1 Antennae	12
2.1.2.2 Mouthparts	12
2.1.3 Thorax	16
2.1.3.1 Legs	17
2.1.3.2 Wings	18
2.1.4 Abdomen	18
2.2 INTERNAL ANATOMY AND LIFE PROCESSES	19
2.2.1 Digestion and Excretion	19
2.2.2 Circulatory System	20
2.2.3 Gas Exchange	20
2.2.4 Nervous System	21
2.2.5 Endo- and Exocrine System	22
2.2.6 Sense Organs	23
2.2.7 Locomotion	24
2.2.8 Reproduction	25
2.2.9 Development	27
3. RESPONSE AND BEHAVIOUR	
3.1 COMMUNICATION	36
3.1.1 Auditory Communication	36
3.1.2 Visual Communication	38
3.1.3 Chemical Communication	38
3.1.4 Tactile Communication	39
3.2 INSECT SOCIETIES	40
3.2.1 Termites	41
3.2.2 Bees	44
3.2.3 Ants	47
4. INSECTS AND ECOLOGY	
4.1 FOOD CHAIN AND MATERIALS TRIANGLE	52
4.2 INSECT-PLANT INTERACTIONS	53
4.2.1 Herbivory	53
4.2.2 Pollination by Insects	54
4.2.3 Seed Dispersal by Insects	55
4.2.4 Other Symbiotic Interactions	56
4.3 INTERACTIONS BETWEEN INSECTS AND OTHER ANIMALS	57
4.3.1 Predation	58
4.3.2 Parasitism	59
4.4 INSECT DEFENCE	60
4.4.1 Protective Colour Patterns	61
4.4.2 Morphological Defence	61
4.4.3 Behavioural Defence	62
4.4.4 Chemical Defence	62
4.4.5 Mimicry	64
4.5 INTERACTIONS BETWEEN INSECTS AND MICROORGANISMS	65
4.6 INSECTS AS DECOMPOSERS	65
4.7 POPULATION ECOLOGY	68

4.7.1 Population Dynamics	68
4.7.2 Age Grading	70
4.7.3 Spatial Distribution	70
4.7.4 Regulation of Population Growth	71
4.7.5 Insect Outbreaks	75
5. EVOLUTION AND CLASSIFICATION	
5.1 PHYLOGENY OF INSECTS	78
5.2 FOSSIL HISTORY	79
5.3 TAXONOMY AND CLASSIFICATION	79
5.4 IDENTIFICATION OF SPECIMENS	81
5.5 SYNOPSIS OF THE ANIMAL PHYLUM ARTHROPODA	81
5.5.1 Subphylum Chelicerata	82
5.5.1.1 Order Araneae (True Spiders)	82
5.5.1.2 Order Acari (Acarina: Mites, Ticks)	83
5.5.1.3 Order Opiliones (Harvestmen)	86
5.5.1.4 Order Scorpiones (Scorpions)	86
5.5.1.5 Order Pseudoscorpiones (Pseudoscorpions)	87
5.5.1.6 Order Pedipalpi	87
5.5.2 Subphylum Mandibulata	87
5.5.2.1 Class Chilopoda (Centipedes)	87
5.5.2.2 Class Progoneata (Millipedes)	87
5.5.2.3 Class Entognatha	88
5.5.2.4 Class Insecta (Insects)	89
5.6 The Insect Orders	90
5.6.1 Simple Key to Insect Orders	90
5.6.2 Synopsis of Insect Orders	92
5.6.3 Outline of Insect Orders	92
5.6.3.1 Archaeognatha (Bristletails)	92
5.6.3.2 Thysanura (Silverfish, Firebrats)	93
5.6.3.3 Ephemeroptera (Mayflies)	93
5.6.3.4 Odonata (Damselflies and Dragonflies)	94
5.6.3.5 Plecoptera (Stoneflies)	94
5.6.3.6 Blattodea (Cockroaches)	95
5.6.3.7 Isoptera (Termites)	96
5.6.3.8 Mantodea (Praying Mantids)	97
5.6.3.9 Grylloblattodea (Ice Crawlers)	97
5.6.3.10 Dermaptera (Earwigs)	98
5.6.3.11 Orthoptera (Crickets, Katydid, Grasshoppers and Locusts)	98
5.6.3.12 Phasmatodea (Stick and Leaf Insects)	100
5.6.3.13 Embioptera (Web- or Footspinners)	101
5.6.3.14 Psocoptera (Booklice, Barklice; Psocids)	101
5.6.3.15 Zoraptera	102
5.6.3.16 Phthiraptera (Lice)	102
5.6.3.17 Hemiptera (Aphids, Leafhoppers, Scale Insects, Lerps, Cicadas, True Bugs, etc.)	103
5.6.3.18 Thysanoptera (Thrips)	109
5.6.3.19 Megaloptera (Alderflies and Dobsonflies)	110
5.6.3.20 Raphidioptera (Snake-Flies, Camelneck-Flies)	110
5.6.3.21 Neuroptera (Lacewings and Antlions)	111
5.6.3.22 Lenticulgeroptera	112
5.6.3.23 Coleoptera (Beetles)	112
5.6.3.24 Strepsiptera (Stylops)	122
5.6.3.25 Mecoptera (Scorpion Flies, Hanging Flies)	123
5.6.3.25 Siphonaptera (Fleas)	123
5.6.3.26 Diptera (True Flies, Midges, Mosquitoes, Crane Flies, Sandflies, Gnats, Punkies)	124
5.6.3.27 Trichoptera (Caddis Flies)	132
5.6.3.28 Lepidoptera (Butterflies and Moths)	133
5.6.3.29 Hymenoptera (Sawflies, Wasps, Bees and Ants)	147
5.6.4 Literature on the Identification of Insects	154

6. FOREST INSECT PESTS AND THEIR SIGNS	
6.1 INSECT DAMAGE AND SIGN CATEGORIES	159
6.1.1 Leaf Damage	159
6.1.2 Seed and Cone Damage	160
6.1.3 Shoot, Twig, Trunk and Root Damage	161
6.1.4 Insect Signs	162
6.2 COMMON FOREST INSECT PESTS OF PAPUA NEW GUINEA	162
6.2.1 Termite Pests	174
6.2.2 Orthopteran Pests	182
6.2.3 Hemipteran Pests	182
6.2.4 Dipteran Pests	184
6.2.5 Coleopteran Pests	184
6.2.6 Lepidopteran Pests	192
6.2.7 Hymenopteran Pests	197
6.3 FOREST INSECT PESTS OF OTHER SOUTH PACIFIC COUNTRIES	198
7. ASSESSMENT OF INSECT POPULATIONS	
7.1 MONITORING STRATEGIES	202
7.1.1 Sampling Techniques	203
7.1.2 Absolute Methods	203
7.1.3 Relative Methods	204
7.1.4 Direct and Indirect Assessment	204
7.1.5 Damage Assessment	205
7.2 COLLECTION AND TRAPPING METHODS	206
7.3 COLLECTION AND PRESERVATION OF INSECT SPECIMENS FOR IDENTIFICATION	211
7.3.1 Collection of Insect Specimens	211
7.3.2 Rearing of Immature Insects	212
7.3.3 Killing Methods	212
7.3.4 Labelling of Specimens	213
7.3.5 Wet Preservation of Specimens	213
7.3.6 Dry Preservation of Specimens	214
7.3.7 Transport of Insect Specimens	216
7.3.8 Storage of Dried Insect Specimens	216
8. INSECT PEST MANAGEMENT	
8.1 INSECTS AS PESTS	220
8.2 PREVENTION OR CURE?	222
8.2.1 Preventive Measures in Forestry	222
8.2.2 Available Curative Measures	224
8.3 QUARANTINE	224
8.4 PLANT RESISTANCE	225
8.5 CULTURAL METHODS	226
8.6 MECHANICAL AND PHYSICAL METHODS	226
8.7 BIOLOGICAL METHODS	227
8.7.1 Entomopathogens	230
8.7.2 Predators and Parasites	232
8.7.3 Plant-derived Insecticides	236
8.8 CHEMICAL METHODS	239
8.8.1 Insecticide Classes	239
8.8.2 Some Important Facts about Chemical Insecticides	241
8.8.3 Safe Use of Insecticides	244
8.8.4 Calculation of Concentration	245
8.8.5 Pesticide Legislation	245
8.8.6 Application of Insecticides	248
8.9 INTEGRATED PEST MANAGEMENT (IPM)	252
REFERENCES	255
GLOSSARY	265
ADDRESSES	290
ABBREVIATIONS	291
QUESTIONS FOR SELF-ASSESSMENT	292
INDEX	294

Preface

Entomology is the study of insects and their allies like spiders and mites. It includes their external and internal structure (morphology and anatomy), the interaction between cells, tissues and organs as well as the biochemical processes involved (physiology), their behaviour (ethology), their fossil history (palaeontology), their diversity, classification and evolutionary history (taxonomy and systematics), their relationships to other organisms and to the environment as well as their population dynamics (ecology), their relation to legal matters (forensic entomology) and finally beneficial insects, detrimental insects (pests), their control and their use as control agents (applied entomology).

Entomology is a wide field offering vast employment and research opportunities for a large number of scientists and applied entomologists in agriculture, forestry, horticulture and human and veterinary medicine. In PNG's expanding large-scale plantations of coffee, sugar cane, tree crops, etc., pest insects can cause substantial damage and the economic loss can be minimised by means of proper pest management. Although there are noxious pests that interfere with man's property, most insects are utterly beneficial and important for the ecological balance of animal and plant communities. Insects are the most diverse and bizarre animals outnumbering any other group of organisms. There is hardly anything that they cannot do and there is hardly any place where they cannot be found.

People might believe that an entomologist has to love insects. As far as I am concerned, this is not 100% true. Actually, I like most insects, but there are some that I really dislike. The worst ones are fleas (Siphonaptera). They love my blood and therefore I hate them. The fleas are followed by cockroaches (Blattodea). These are disgusting creatures. I enjoy to chase cockroaches with a broom and to kill them finally. The last kind of insect that I cannot stand are mosquitoes (Diptera), because these blood-suckers make us sick.



Moth Collection on Mount Kolorong, Kuper Range, Morobe Province (photo Dobunaba, J.)

I have been working with these creatures and studying them for almost ten years now, but still, they are incredibly alien to me. During my time in Papua New Guinea I have learned a lot more about insects, because PNG probably has one of the world's most outstanding insect fauna. I have been collecting insects for five years, mostly moths that were attracted to the light on the veranda of our residence. There were always insect specimens piling up in our deep freezer and you might find it disgusting to have these little creatures in the fridge, but why? People also store other dead animals such as chicken, beef mince and fish in deep freezers. One of the highlights of collecting insects occurred during the months when nature woke up after the prolonged drought in 1997. I was able to collect about 100 moth species, that I had never come across before, increasing the

number of moth species collected only from our veranda to about 400. This fact impressively demonstrates the biological diversity of Papua New Guinea's insect fauna when compared with the approximately 500 moth species occurring all over Europe. Another highlight showing the tremendous insect diversity of this country was a field trip to Mount Kolorong on the Kuper Range, south of Wau: as soon as the light of the trap was turned on, innumerable moths came like rain from the forest and densely covered not only the screen of the light trap but also the students, as shown below. In less than one hour we were able to collect the breath-taking number of about 1,200 specimens belonging to almost 300 species.

There are many excellent textbooks on Entomology. My favourite ones are 'The Insects: An Outline of Entomology' (Gullan, P.J. and Cranston, P.S., 1994), and 'The Insects of Australia' (CSIRO, 1991²), but unfortunately these books are very expensive (approx. K 100 and K 400 respectively) so that particularly students quite likely cannot afford to purchase these books. Many textbooks as well as lecture notes often have the disadvantage that their examples are not taken from PNG's fauna but mostly from overseas. Therefore, there was an urgent need for a textbook focusing on examples of the rich PNG insect fauna, as well as examples of general importance from other countries.

I knew that writing a book about insects would be a hard nut to crack and a very time-consuming task as well, and only the strong encouragement of Dr. Adrian Schuhbeck and Dr. Larry Orsak eventually made me tackle this task. My intention was to create a picture book, that would be eye-catching and inviting to read rather than a book containing text only.

The book introduces various aspects of entomology necessary for the basic understanding of insect pests, their biology, their identification and possible control measures. The first chapter introduces the diversity of insects, and briefly discusses conservation aspects related to insects and the insect trade in Papua New

Guinea. The second chapter outlines external and internal structure in relation to function as well as the development of insects. Communication and social insects like termites, bees, wasps and ants are the topic of chapter three. Ecological considerations such as herbivory, pollination, insect defence, population dynamics and the reasons for insect outbreaks are explained in chapter four. This is followed by a chapter outlining the 28 insect orders and describing families and species that are of importance for Papua New Guinea. The colour plates illustrate some of the amazing insects and forest pests found in PNG. The chapter on forest insect pests of Papua New Guinea is based on the pioneer work of the entomologists B. Gray and H. Roberts and includes a key to common and less common forest insect pests, their identification and the symptoms of the respective infestations, their host plants, their economic importance and possible remedies. The topics of the following chapter are the sampling of insect populations, and the collection of insect specimens for biodiversity and pest insect assessment. The last chapter elucidates various control measures suitable to combat insect pests in plantations and nurseries. An attempt was made to gather information on forest insect pests, registered pesticides and pesticide legislation in other South Pacific countries, however most of the inquiries have not been answered by the respective government bodies. Therefore, some of the facts provided might be either obsolete or rudimentary. The references included are available at the libraries of UPNG, Unitech or FRI. Finally, a glossary and an index have been included for the reader's convenience so that scientific terms related to entomology can be quickly looked up and located in the text.

I hope the book will help students of Forestry, Agriculture and Science to discover the wonderful world of insects and to provide the basic knowledge for successful pest management. Additionally, the book might be helpful for the daily activities of professional foresters and agriculturalists in Papua New Guinea.

January, 1999

Michael F. Schneider

Acknowledgements

First of all I would like to thank my wife Phyllis and our son Bellamy for the patience they had with Daddy when he was typing the manuscript. My deep appreciation to Chris Skelton for having done the unpleasant job of proof reading the manuscript, especially chapter 5 which is like the Beijing phone directory. I wish to thank the artist Anthony Maibani for creating the cover page as well as the impressive vignettes for each chapter. Furthermore, I would like to express many thanks to Dr. Larry Orsak, Alan Landford, Dr. Bryant Richards, Dr. Adrian Schuhbeck, John Dobunaba and Dr. Heino Hertel for their precious comments on the first draft of the manuscript and their encouragement to get the manuscript published; Andrew Binie and Dr. Heino Hertel for their professional advice on the lay-out of the manuscript and printing procedures; my students Alois S. Jenkihau, Vanessa B. Kumo, Snoky T. Bowin, Conrad Kilalang, Jack Keas, Lekos Helide, George S. Rifi, Hermann H. Winch and Douglas G. Nawe for their cooperation during their final year projects; Lawong Balun and Papa Aubeta Kairo for their botanical assistance; Gerd Unger for providing the addresses of various publishers and Mr. Richard Kuhau, Morobe Pharmacy, Lae for photographic work. I also want to acknowledge the continuous cooperation with staff of National Forest Service, Bulolo, in particular 'Snow' R. H. Kimpton, Kof Zavetave, Arinaso Pilisi and Derek Bosimbi as well as John Dobunaba and Tommy Kosi from Forest Research Institute, Lae. The advice and assistance of these experienced foresters and entomologists contributed considerably towards the chapter on forest insect pests. My appreciation also includes staff of Insect Farming and Trading Agency (IFTA) at Bulolo, especially Alan Landford for his professional advice on various aspects of entomology, and Mrs. Catherine Aisi for her always uncomplicated, instant and friendly assistance. Many thanks to Prof. Dr. August Dorn, to whom this book is dedicated, for his professional guidance during my time at

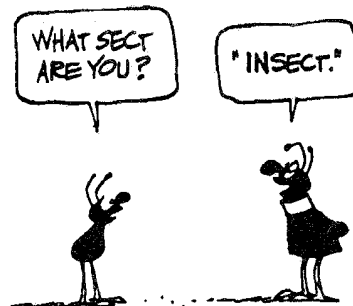
the Johannes-Gutenberg University Mainz, Germany, and his encouragement that made me finally start this assignment in Papua New Guinea. Lastly, I sincerely appreciate the financial support from the German Development Service (GDS) and PNG Forestry Human Resource Development Project (HRD)/AusAID that made it possible to get this book produced and printed.

Permission was kindly granted for the reproduction of the following drawings and photos by Dr. Heino Hertel (fig. 5-32); Dr. Matthias Holtmann (figs. 3-7, 7-6 A); Prof. Dr. Dietrich Mebs (figs. 5-53 A-C); G. & R. McKie (fig. 1-3); Dr. Larry Orsak (fig. 1-5); Derek Bosimbi (fig. 6-20); Queensland Museum (figs. 2-34, 2-45, 7-14 and the figure on page 312); Anthony Maibani (drawings on the cover page, page 264 and the vignettes of the chapters 1 to 8); AGROMISA/FAO (fig. 8-18); John Dobunaba (photo on page IV); Harvest/PNG Department of Agriculture and Livestock/John Dobunaba (figs. 6-3 Q, R, Y, 6-5, 6-9, 6-10, 6-11 D-G, 6-12 D-F, 6-17, 8-17, 8-19 C); Queensland Forestry Research Institute (fig. 6-14 A); Gustav Fischer Verlag (fig. 5-5); Domino Books (fig. 6-2 C); CRC for Tropical Pest Management, Artist Gaynor Cardew (figs. 8-2, 8-4, 8-12, 8-13, 8-14); CAB International (box 6-1 D); Thieme Verlag (figs. 2-9, 2-11, 2-15, 2-17); J.D. Sauerländer's Verlag (fig. in box 6-1 I); Addison Wesley Longman (figs. 5-7; 5-8 C; 5-46 M-O); Wau Ecology Institute (figs. 5-34 B, D-J; 5-37 A-D, F, H, J; 5-53 H-J; 6-3 S, Z, Z2); Principal, Bulolo University College/Bruno Denfop (fig. 7-2); Grassroots Comic Company (fig. on page 267); Wiley VCH/Prof. Dr. H. Schmutterer (fig. 8-10). The figures 3-1, 6-3 K, L, 6-8 and box 6-1 Q were reproduced by permission of CSIRO Australia. The figures 2-44 B, 3-9, 3-10, 3-11, 3-12, 3-13 and 3-14 were reproduced with permission of UNSW Press. The figures 5-43 and 5-44 were reproduced with permission from Jacaranda Wiley from Ewers, W.H.: *Parasites of Man in Niugini*; Jacaranda Wiley (1971). The figures 8-19 A, B, D - F on page 250 have been provided by the Department of Primary Indus-

tries, Queensland, from their book *Pesticide Application Manual* published by the DPI Queensland. Fig. 4-11 D was reproduced by courtesy of The Natural History Museum London. Fig. 8-1 B was reproduced with permission of the copyright owner, The German Hunting and Fishing Museum, Neuhauser Straße 3, 80331 Munich/Bavaria, Germany. The copyright of figure 1-4 and the figure on page 263 belongs to Cordon Art B.V. - Baarn - Holland. All rights reserved. The figures 1-1; 2-3; 2-5 J, K; 2-7; 2-8 A, B; 2-13; 2-16; 2-18; 2-19; 2-21; 2-22; 2-23; 2-25; 2-28; 2-32; 2-38; 2-39; 2-40; 3-16; 3-17; 4-11 B; 4-18; 4-23; 5-1; 5-2 A, B; 5-8 D; 5-9 A - F; 5-16 A and 8-19 G were reprinted from Ross, H.H. et al. (1982) 'A Textbook of Entomology' by permission of Wiley-Lyss, Inc., a subsidiary of John Wiley & Sons Inc., New York, USA. The figures 7-6 C, F, G, I, L-O and Q were reprinted from Metcalf, R.L. & Luckmann, W.H. (1975) 'Introduction to Insect Pest Management' by permission of John Wiley & Sons Inc., New York, USA. The figures 7-4; 7-6 B, E, H and 8-19 J were reprinted from Coulson, R.N. and Witter, J.A. (1984) 'Forest Entomology, Ecology and Management' by permission of John Wiley & Sons Inc., New York, USA. The permission for the reproduction of figures has been sought from the following publishers, however, no response has been received after more than five months: Forest Department, Zambia (fig. 3-15); ICI Plant Protection Division (fig. 8-19 L); AVI Publishing (figs. 5-8 A, B; 5-35 F); Corbis-Bettmann (fig. 8-15

and text); Chapman & Hall (figs. 2-2; 2-5 A-I; 2-6; 2-10; 2-12; 2-14; 2-20; 2-27; 2-41 [right]; 2-42; 2-43; 3-5; 3-8 A, B; 3-19; 3-20; 3-21; 3-22; 4-2; 4-3; 4-4; 4-7; 4-8; 4-9; 4-14; 4-15; 4-17; 5-11; 5-26 M, N; 5-36; 5-45; 5-57 C; 6-2); Melbourne University Press (figs. 2-1; 2-4; 2-24; 2-29; 2-30 A, B; 2-31; 2-33; 2-36; 2-37; 2-41 [top]; 2-44 A; 3-2; 3-3; 3-4; 4-10 A, B; 4-13 B; 4-16; 5-10 A, B, C; 5-12 A, B; 5-13 A, B; 5-14 A, B; 5-15 A, B; 5-16 B; 5-17 A-F; 5-18 A, B; 5-19 A, B; 5-20 A-G; 5-21 A-D; 5-22; 5-23; 5-24 A, B; 5-25 A, B, F-K; 5-26 A-L, O-T; 5-27 A-C; 5-28 A, B; 5-29 A, B; 5-30 A, B; 5-33 A-D; 5-34 A, C; 5-35 A, D-E; G-J; 5-37 E, G, I, K, L; 5-39 A-C; 5-40 A, B; 5-41 A; 5-42 A-C; 5-46 A-I, P, Q; 5-47 A-G; 5-49 A, B; 5-50 A-K; 5-51 A, B; 5-53 E, F; 5-55 A, B; 5-56; 5-59; 6-3 A-J, M-O, T; 6-7; 6-19; 8-5 A, B; 8-6); Australian Entomological Society (box 6-1 R; figs. 7-6 K, P; 7-10); CRC Lewis Publ. (fig. 8-9); Entomology Department, Bernice B. Bishop Museum (box 6-1 S, T, figs. 6-3 U, V, X, Z1, Z3; 6-4 T; 6-13 A-C; 6-14 B; 6-15 A-D); Australasian Biological Control Inc. (figs. 5-57 B; 8-7 A-G); Quelle & Meyer (figs. 5-41 B; 7-1 A, B) and Academic Press (figs. 5-38; 8-3; 8-19 I; 8-20). The author regrets that he is unable to trace the copyright holders (or their addresses) of the following figures and apologises for any infringement of the copyright caused: P. Samson (fig. 5-53 G); B.J.W. Heath (fig. 4-6); W.F. Tweedie (fig. 4-11 C); T. Denham (fig. 8-19 H); the two comics on the pages VII and 217 and the figs. 5-57 A; 6-3 P; 7-3 and 7-7.

B.C.



12-25

By Johnny Hart



Remarks on Scientific Names and Terms

Those studying insects have to deal with a great variety of scientific names and terms. Most of these words are of Greek or Latin origin. Some out of this variety have already been adopted by English, for instance **thorax**, and **abdomen**, whereas other very specific terms are borrowed from their respective original language. One of the problems with the use of scientific terms is that forming the plural differs from how this is done in English. In most cases in English the plural is formed by simply adding an 's' to the singular form. In Latin - to make it worse - the formation of the plural depends on the gender of the term. To avoid constructions as odd as 'the dog eat', the examples listed below should be followed.

The generic and species names are commonly printed in *italics* and are only underlined in hand-written manuscripts. The names of other taxonomic categories like the family or order are not printed in italics. All scientific names start with a capital letter, except the species name. After a species name the respective order and family can be indicated in brackets, separated by a colon, for instance *Ornithoptera priamus* (Lepidoptera: Papilionidae).

Reference:

General Assembly of the International Union of Biological Sciences (1985³): International Code of Zoological Nomenclature; International Trust for Zoological Nomenclature in association with British Museum (Natural History) and University of California Press; London, Los Angeles, Berkeley; UK, USA

GENDER	RULE TO FORM PLURAL	SINGULAR (one only)	PLURAL (several)
Feminine	add e to words ending with -a	larva pupa antenna trachea tibia	larvae pupae antennae tracheae tibiae
Masculine	replace -us with i	cercus tarsus clypeus anus radius	cerci tarsi clypei ani radii
Neuter	replace -um with a	notum ovarium sternum mentum labium	nota ovaria sterna menta labia
Irregular formation of the plural		elytron femur genus imago kinesis tagma taxon tegmen	elytra femora genera imagines kineses tagmata taxa tegmina