Studies on the Systematics and Biogeography of Terrestrial Flatworms (Platyhelminthes: Tricladida: Terricola) of the Australian Region.

Thesis submitted by
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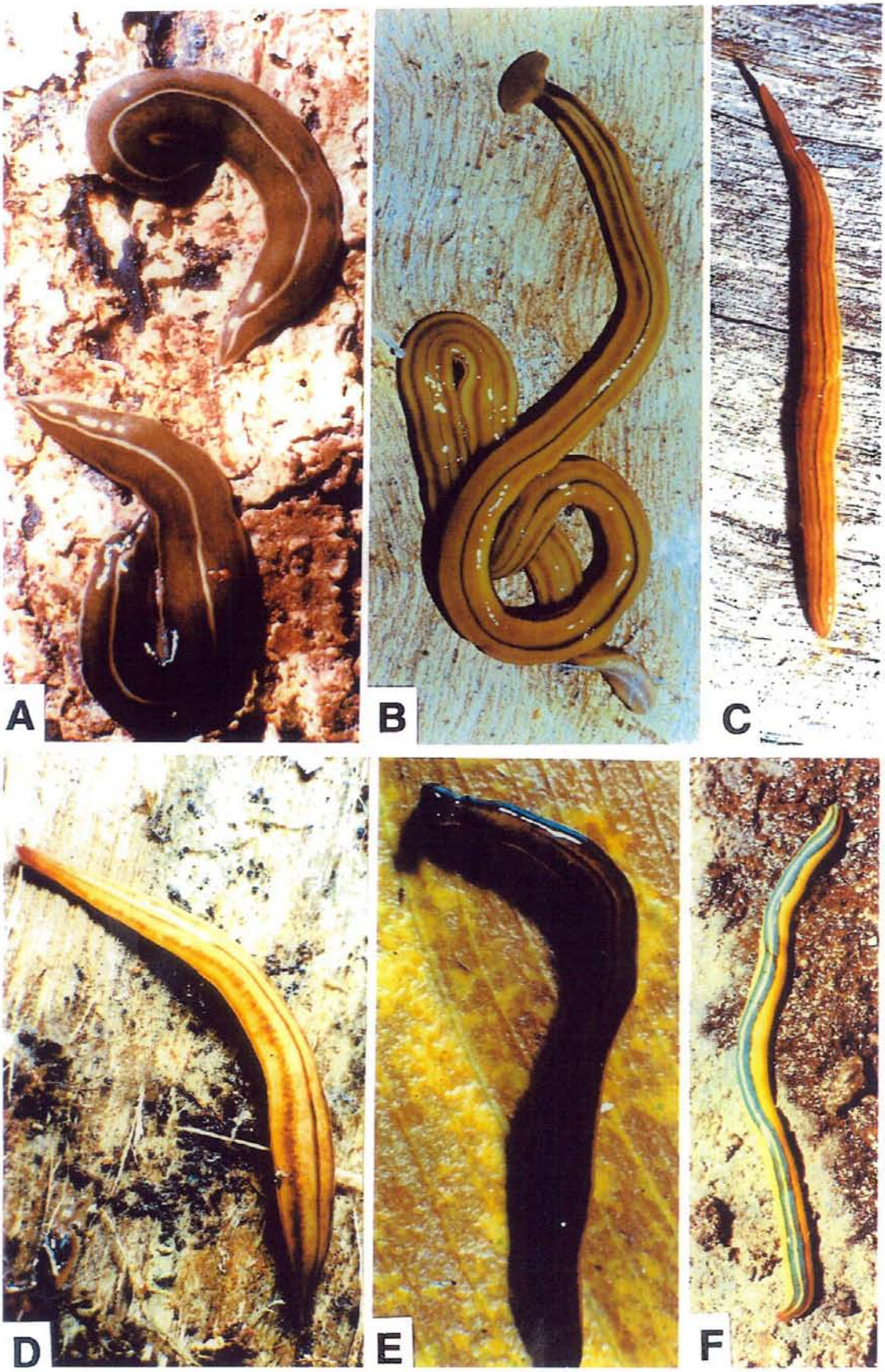
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Frontispiece

A. *Platydemus manokwari* Beauchamp, 1962 (Rhynchodemidae: Rhynchodeminae), 40 mm long, urban habitat, Townsville, north Queensland dry tropics, Australia. A molluscivorous species originally from Papua New Guinea which has been introduced to several countries in the Pacific region. Common. (photo L. Winsor).

B. *Bipalium kewense* Moseley,1878 (Bipaliidae), 140mm long, Lissner Park, Charters Towers, north Queensland dry tropics, Australia. A cosmopolitan vermivorous species originally from Vietnam. Common. (photo L. Winsor).

C. *Fletchamia quinquelineata* (Fletcher & Hamilton, 1888) (Geoplanidae: Caenoplaninae), 60 mm long, dry Ironbark forest, Maryborough, Victoria. Common. (photo L. Winsor).

D. *Tasmanoplana tasmaniana* (Darwin, 1844) (Geoplanidae: Caenoplaninae), 35 mm long, tall open sclerophyll forest, Kamona, north eastern Tasmania, Australia. This was the first described Australian species, collected by Darwin during the voyage of the Beagle. Common. (photo L. Winsor).

E. *Cotyloplana sp.* (Rhynchodemidae: Rhynchodeminae), 25 mm long, tropical rainforest, near Millaa Millaa, north Queensland wet tropics, Australia. Uncommon. (photo L. Winsor).

F. *Caenoplana dubia* (Dendy, 1892a) (Geoplanidae: Caenoplaninae), 50 mm long, tall open sclerophyll forest, Gembrook, Victoria, Australia. Uncommon. (photo L. Winsor).

STATEMENT ON ACCESS TO THIS THESIS

Nomenclature in this thesis complies with the *International Code of Zoological Nomenclature* 4th edition, effective from 1 January 2000. However the new taxa described in this thesis are *nomina nuda* as the provisions of Article 11 of the *International Code of Zoological Nomenclature* (ICZN 1999) are not met. For this reason an embargo is placed on access to this thesis for a period of two years. This should allow sufficient time to formally publish the descriptions of new taxa.

After the embargo period, I, the undersigned, the author of this thesis, understand that James Cook University will make it available for use within the University Library and, by microfilm or other photographic means, allow access to users in other approved libraries. All users consulting this thesis will have to sign the following statement:

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Beyond this I do not wish to place any restriction on access to this thesis.

29.03.2003

L. Winsor Date

2/4/03

Professor R. G. Pearson Date
Head
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Abstract

This study contributes to knowledge of the systematics and biogeography of terrestrial flatworms (Platyhelminthes: Tricladida: Terricola) of the Australian region. Terrestrial flatworms are carnivorous soil animals some of which are important commercially as biological control agents for the Giant African snail, or as introduced pest species preying upon earthworms in Europe.

The total Australian terrestrial flatworm fauna is estimated to be in excess of 300 species. At present only 137 species are named of which three-quarters have been described solely from external features. Taxonomy of the Terricola is based on a combination of external features and internal anatomical characters and remains in a state of flux. Recent molecular studies of the Tricladida have cast doubt on the monophyly of the Terricola. The austral fauna is poorly known anatomically, and taxonomy of the group further hampered by the existence of numerous species complexes which are poorly understood.

The objectives of this study are to locate and examine type and supplementary specimens, review the functional anatomy of austral terrestrial flatworms, identify reliable taxonomic characters and states, revise certain taxa, and develop identification keys. Furthermore, efforts have been made to determine the distribution of terricolan taxa of the region, identify the biogeographical components of the austral terricolan fauna and to identify the occurrence of introduced, threatening and vagrant terrestrial flatworms. Cladistic and molecular analyses of the taxa have not been undertaken.

Fixation and parasite-induced artifacts can cause mis-interpretation of anatomical characters. A suite of taxonomic characters and states is used to provide standardized diagnoses for genera. Included in the characters assessed for their application in taxonomy are colour and pattern of markings, pharyngeal musculature, configuration of the nephridial ducts, dorsoventral distribution of testes, penis type, resorptive organs, and musculoglandular organs (adenodactyls). Seven types of the hitherto enigmatic adenodactyls are identified, some of which function to secrete

sclerotins which form the cocoon wall. The mechanism of cocoon formation in the Terricola involves the deposition of sclerotins, derived from antral secretions or adenodactyls, on the outer pre-cocoon membrane. This mechanism differs from the generally accepted Triclad model based upon the Paludicola, in which the cocoon is formed from within the pre-cocoon membrane by shell-globule components of the vitellocytes.

Representatives of all three terricolan families are present in the Australian region. A new subfamily is erected in the Geoplanidae, and of the twenty-seven genera considered in the study, ten are new. The problematic *Australoplana* complex is resolved into five genera and two sub-genera. Field keys are provided for the Terricola genera of the Australian region. This study supports the view that the Terricola are polyphyletic. Anatomical data suggest a possible phylogenetic relationship between some austral caenoplaninid and maricolan taxa.

The Australian flatworms mostly occur within hyper-humid to sub-humid moisture regions, and are assigned to two principal families. In the Rhynchodemidae: Rhynchodeminae 45 species are accommodated within *Cotyloplana, Digonopyla, Dolichoplana, Platydemus*, *Rhynchodemus* and in new genera not considered in this study. In the Geoplanidae: Caenoplaninae, 80 species are assigned to *Artioposthia, Australoplana, Caenoplana, Fletchamia, Lenkunya, Parakontikia, Reomkago, Tasmanoplana* and additional new genera considered here. Four species are assigned to two new genera in a new subfamily of the Geoplanidae. Eight introduced species are identified, none of which at present poses an ecological or commercial threat in the Australian region.

Two major flatworm faunal units are recognized in Australia. A northern element dominated by rhynchodemid genera including taxa which also occur in Papua-New Guinea – Irian Jaya and Indonesia. The southern element is dominated by geoplanid genera including some with currently poorly-defined Gondwanan affinities. These flatworm faunal units broadly accord with the Torresian (northern) and with the Tasmanian, South-western, and Bassian or Kosciuskan (southern) zoogeographic subregions.

STATEMENT ON SOURCES

DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references given.

28.03.2003

L. Winsor Date

Preface and Acknowledgments

My fascination with flatworms began when I was a young boy interested in all manner of invertebrate animals. My father Keith (1911-1950) a research engineer, died when I was not quite four years old. Sadly I have few recollections of him. By all accounts a clever and likable man, his library contained many books encompassing a wide variety of subjects including books on zoology and collecting methods for invertebrates. My favourite book was the excellently illustrated *Animals without backbones* by Ralph Buchsbaum, 1938, the hard covered copy of which has a large and engaging line drawing of a planarian on the cover. Early access to these books, and also to my father's hand lenses and stereo microscope, made knowledge readily accessible to a growing and curious lad, as they still do for me now. The completion of this thesis is in some small way a tribute to my mother Lesley (1920-1998), for the sacrifices she made, opportunities she presented, and for her love, encouragement and support over fifty two years. The thesis is dedicated to the memory of my late parents.

My earliest recollection of flatworms was as a child of five to six years old. A long thin lemon yellow, and black mono-striped species, probably *Fletchamia mediolineata*, lived along with centipedes and other interesting beasties behind the wooden border of my sandpit in semi-rural Watsonia, in the outer eastern suburbs of Melbourne, Victoria. These worms were difficult to handle, stuck to my fingers, and fragmented, the separate pieces crawling off into cover. They made a lasting impression on me.

My next memorable encounter with flatworms was in 1970 in the Field Survey Group (FSG), Field Naturalists' Club of Victoria. Having completed seven years of study at night school, I finally had time to renew my long-standing interest in natural history; in particular spiders and the odds and sods, such as flatworms and nemerteans in which nobody else was particularly interested. I became rapidly disenchanted with taxonomy of spiders. However the land planarians and nemerteans fascinated me. My life long love affaire with the flatworms began with the discovery of a paper on *The Victorian land planarians* by Arthur Dendy (1891) that had colour illustrations of the species I had fortuitously collected some fourteen kilometres from

the Type locality. My subsequent collections of specimens 1970-74 were made with the able assistance and wonderful companionship of FSG members, especially Arthur Brook and Ros St Clair.

Members of the FSG were fortunate in having as their mentor Dr Brian Smith, at the time Curator of Molluscs, Museum of Victoria. Brian's enthusiasm, encouragement, and support of natural history groups are well known. It was Brian who remarked to me that as far as he was aware, little had been done on the histology of Australian Terricola, and suggested that as a histologist interested in these flatworms I was well placed to rectify this deficiency. Little did I realize just what I was letting myself in for. To Brian I am deeply grateful for setting me on this path, for his practical support, encouragement over many years, and especially for successfully arguing on my behalf the case for sectioning Holotypes of Terricola held by the Natural History Museum – a major policy shift for the NHM.

My journey of discovery of the Terricola is life-long. Companionship and cooperation with colleagues overseas, especially Eudoxia Froehlich, and Ana-Maria Leal Zanchet and her team, have made for a challenging and stimulating journey. The good advice of Laurence Richardson (1913-1989), and empathy and support of my taxonomic endeavours by Marion Fyfe (1894–1986), have been most helpful. Both taxonomists had successfully grappled with the tyranny of distance working on unfashionable, relatively obscure and poorly known groups in the Australian region.

Support for equipment, consumables and facilities from the Australian Biological Resources Study, CSIRO Science and Industry Endowment Fund, and from Rhondda Jones, Howard Choat, and Richard Pearson, Heads of the Schools within Biological Sciences, is gratefully acknowledged. Special thanks to Ted Dews, and recently Peter Hill, Directors, Central Services, for their tolerance of a zoologist in their midst, and for facilitating my studies after my moving to Central Services. For access to collections, information, and for facilitating and extending specimen loans, I am most grateful to museum curatorial staff, in particular Carden Wallace, Peter Arnold, Lester Cannon, Pat Hutchings, Penny Berents, Brian Smith, Tim Stranks,

Tammy Scarborough, Rod Bray, and Ricardo Palma. My thanks to the numerous people who kindly forwarded to me specimens of flatworms for identification.

My part-time PhD has taken some nine years to complete. My heartfelt thanks to Rhondda Jones for her initial encouragement and backing to undertake a PhD. Without the support and encouragement of many friends and colleagues over the nine years, particularly during the very difficult times of personal problems and change of vocation, this thesis would never have been completed. It is in this sense very much a collaborative effort. Your odd comment, joke, shared experience, practical help, IT support, technical and other advice, and empathy, have all helped get me through: my heartfelt gratitude to all these friends, especially to Chris Alexander, Orpha & David Bellwood, Gillian Brodie, John Collins, Jim, Margaret and Martin Darley, Rachel Groves, Zoli Florian, Savita Francis, Ray Gibson, Betsy & Mick Jackes, Michelle Keeler, Helene Marsh, Di McNamara, Bob Mesibov, Laurie & Sue Reilly, Peter & Ann Renton, Jason Symonds, and all my workmates in the Central Services team.

To my supervisor David Blair I owe a special debt of gratitude. Despite an impossibly crowded schedule of teaching, administration, and research, David always made time for me to discuss progress with my project, and promptly returned drafts with constructive comments. For these, his sound advice, and long association as a colleague and enthusiastic fellow taxonomist of the Platyhelminthes, my deep appreciation.

Completing this thesis is but one small way in which I can express my deepest gratitude to my family Heather, Keith and Lara who over many years provided me with practical help, support and encouragement with my private madness. I am especially appreciative of their long suffering and forbearance with the fieldwork… *we'll just stop here for ten minutes to quickly check these logs* ... in reality usually half an hour or more ..... and our camping holidays and trips to places which just happened to be to type localities. I am particularly grateful to my extended family in Melbourne, especially Meg, Hilary, and Michele for their emotional support. Last but definitely not least, a very special thanks to Kay Cameron for her love, understanding, support, and faith in me that this task would eventually be completed.

Contents

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Publications arising from this thesis

Publications in refereed journals and book:

Winsor, L. 1997. The biodiversity of terrestrial flatworms (Tricladida: Terricola) in Queensland - a preliminary report. *Mem. Mus. Vict.* **56**: 575-579.

Winsor, L., Johns, P.M., and Yeates, G.W. 1998. Introduction, and ecological and systematic background, to the Terricola (Tricladida). *Pedobiologia* **42:** 457-463.

Winsor, L. 1998. Collection, handling, fixation, histological and storage procedures for taxonomic studies of terrestrial flatworms (Tricladida: Terricola). *Pedobiologia* **42:** 405-411.

Winsor, L. 1998. Aspects of taxonomy and functional anatomy in terrestrial flatworms (Tricladida: Terricola). *Pedobiologia* **42:** 412-432.

Winsor, L. 1998. The Australian terrestrial flatworm fauna (Tricladida: Terricola). *Pedobiologia* **42:** 457-463.

Winsor, L. 1998. Flatworm infestation of commercial earthworm farms in Australia (abstract). *Pedobiologia* **42**: 573

Jones, H.D., Johns, P.M., and Winsor, L. 1998. The proposed synonymy of *Parakontikia ventrolineata* (Dendy, 1892) and *Kontikia mexicana* (Hyman, 1939): what is a penis papilla. *Hydrobiologia* **383**: 91-96.

Cannon, L (Ed). 2000 *Wildlife of Tropical North Queensland.* Worms - text and illustrations for terrestrial and freshwater triclads by L. Winsor. Brisbane: Queensland Museum.

Information Sheets:

Winsor, L. 1997. Terrestrial flatworms INFOSHEETS No.1. The collection, handling and preservation of specimens for general identification.

Winsor, L. 1997. Terrestrial flatworms INFOSHEETS No.2. The collection, handling and preservation of specimens in the field for taxonomic purposes.

Winsor, L. 1998. Terrestrial flatworms INFOSHEETS No.3. Prevention and control of flatworm infestation of earthworm beds. Revised edition.

Winsor, L. 1997. Terrestrial flatworms INFOSHEETS No.4. The Long Wanderers – *Dolichoplana* species: earthworm predators.

Winsor, L. 1998. Terrestrial flatworms INFOSHEETS No.5. Predators in earthworm beds – flatworms or leeches?

Winsor, L. 1999. Terrestrial flatworms INFOSHEETS No.6. The New Guinea flatworm – *Platydemus manokwari*: predator of land snails.

Winsor, L. 2003. Terrestrial Flatworms – Facts Sheet. James Cook University: Townsville.

Author's note:

New genera are described in Chapter 5, and new taxa are described in Appendix 8.

In order to improve the readability of the thesis, the decriptors *gen. nov, sub. gen. nov,* and *sp. nov.,* apart from the formal descriptions, are not used with the new names throughout the text.

The nomenclature of new taxa will be treated in the recognized formal manner in any publications arising from this thesis.