



*Zootaxa* 3653 (1): 001–162  
www.mapress.com/zootaxa/

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# Monograph

ISSN 1175-5326 (print edition)

**ZOOTAXA**

ISSN 1175-5334 (online edition)

<http://dx.doi.org/10.11646/zootaxa.3653.1.1>

<http://zoobank.org/urn:lsid:zoobank.org:pub:72A07BC6-AEB0-4EBC-AFA8-F5871065680F>

# ZOOTAXA

3653

## **Systematics and Phylogenetics of Indo-Pacific Luciolinae Fireflies (Coleoptera: Lampyridae) and the Description of new Genera**

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Magnolia Press  
Auckland, New Zealand

*Accepted by C. Majka: 28 Feb. 2013; published: 22 May 2013*

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(*Zootaxa* 3653)

162 pp.; 30 cm.

22 May 2013

ISBN 978-1-77557-160-5 (paperback)

ISBN 978-1-77557-161-2 (Online edition)

FIRST PUBLISHED IN 2013 BY

Magnolia Press

P.O. Box 41-383

Auckland 1346

New Zealand

e-mail: [zootaxa@mapress.com](mailto:zootaxa@mapress.com)

<http://www.mapress.com/zootaxa/>

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ISSN 1175-5326 (Print edition)

ISSN 1175-5334 (Online edition)

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## Abstract

This revision completes a taxonomic survey of fireflies (Coleoptera: Lampyridae) in the area encompassed by Australia, the Republic of Palau, Federated States of Micronesia, Papua New Guinea, Indonesia (West Irian/Papua), Solomon Islands, New Caledonia, Vanuatu and Fiji. It finalises the taxonomic issues arising from the 1969–70 voyage of the scientific vessel *Alpha Helix* to New Guinea. The firefly fauna of this area is exclusively Luciolinae. The scope of the revision was extended to include all known Luciolinae genera and certain species from SE Asia, and a phylogenetic analysis of 436 morphological characters of males, females, and associated larvae includes 142 Luciolinae species (Ballantyne & Lambkin 2009, and Fu *et al.* 2012a). The phylogenetic analyses infer four major groups within the Luciolinae. The monotypic *Missimia* Ballantyne is sister to all remaining Luciolinae and forms a grade to *Aquatica* Fu *et al.* Ballantyne. The large clade of *Curtos* Motschulsky, *Photuro luciola* Pic, *Colophotia* Motschulsky, *Poluninius* **gen. nov.**, *Pyrophanes* Olivier, *Pteroptyx* **s. str.** Olivier, *Medeopteryx* **gen. nov.**, *Trisinuata* **gen. nov.**, and *Australoluciola* **gen. nov.** forms a grade to the clade of *Luciola* **s. str.** Laporte (including *Bourgeoisia* Olivier). The monotypic *Emeia* Fu *et al.* forms a grade with a clade of *Luciola* and *Pygoluciola* Wittmer, sister to a large clade of *Convexa* Ballantyne, *Pacifica* **gen. nov.**, *Magnalata* Ballantyne, *Lloydielli* Ballantyne, *Asymmetricata* Ballantyne, *Pygatyphella* **s. str.** Ballantyne, *Atyphella* Olliff, *Aquilonia* Ballantyne, and *Gilvainsula* Ballantyne. *Luciola* is paraphyletic, found in up to six clades across the tree. Together with *Luciola*, *Magnalata*, *Aquilonia*, and *Gilvainsula* render *Atyphella* paraphyletic. The new genera described here are all monophyletic and supported in the phylogenetic analyses that also provide evidence for the inclusion of taxa within them. Twenty-three genera including five new ones, and ten new species, are recognised and keys are presented for the males and females. Certain females are characterised by the nature of their bursa plates.

*Australoluciola* **gen. nov.** is proposed for ten species from Australia and New Guinea, seven transferred from *Luciola* and three new, with species keyed from males, all of which have an entire light organ in ventrite 7. *Aus. anthracina* (Olivier), *Aus. aspera* (Olivier), *Aus. australis* (F.), *Aus. flavicollis* (MacLeay), *Aus. foveicollis* (Olivier), *Aus. nigra* (Olivier) and *Aus. orapallida* (Ballantyne) are transferred from *Luciola* with males assigned to *Aus. aspera* (Olivier), and a lectotype designated for *Luciola foveicollis* Olivier; *Aus. baduria* **sp. nov.**, *Aus. fuscamagna* **sp. nov.**, *Aus. fuscaparva* **sp. nov.**, *Aus. japenensis* **sp. nov.** and *Aus. pharusaura* **sp. nov.** are described. Females of *Aus. australis* and *Aus. flavicollis* have two pairs of wide bursa plates.

The bent-winged fireflies of New Guinea and Australia are removed from *Pteroptyx* Olivier and assigned to *Medeopteryx* **gen. nov.** and *Trisinuata* **gen. nov.** *Medeopteryx* **gen. nov.** is erected for 17 species including two new; all have ventrite 7 with an entire light organ, trisinuate posterior margin and short posterolateral projections; the following 14 species in which males have deflexed elytral apices are transferred from *Pteroptyx* Olivier: *M. amilae* (Satô), *M. antennata* (Olivier), *M. corusca* (Ballantyne), *M. cribellata* (Olivier), *M. effulgens* (Ballantyne), *M. elucens* (Ballantyne), *M. flagrans* (Ballantyne), *M. fulminea* (Ballantyne), *M. hanedai* (Ballantyne), *M. platygaster* (Lea), *M. similisantennata* (Ballantyne), *M. sublustris* (Ballantyne), *M. tarsalis* (Olivier), and *M. torricelliensis* (Ballantyne). *M. clipeata* **sp. nov.** is described. Two species without deflexed elytral apices include *M. pupilla* (Olivier) which is transferred from *Luciola*, and *M. similispupillae* **sp. nov.** A Lectotype is designated for *Luciola pupilla* (Olivier). Females of *M. corusca* (Ballantyne), *M. cribellata* (Olivier), *M. effulgens* (Ballantyne), and *M. similispupillae* **sp. nov.** have two pairs of wide bursa plates. The second genus including species in which the males have deflexed elytral apices is *Trisinuata* **gen. nov.**, where all males have light organ in ventrite 7 bipartite and posterolateral projections expanded; it is proposed for eight New Guinean species: *T. microthorax* (Olivier), *T. minor* (Ballantyne), *T. papuae* (McDermott) and *T. similispapuae* (Ballantyne) are transferred from *Pteroptyx* Olivier; *T. papuana* (Olivier) previously known only from a female, has males associated and is transferred from *Luciola*, and *T. caudabifurca* **sp. nov.**, *T. dimidiata* **sp. nov.** and *T. apicula* **sp. nov.** are described. Females of *T. similispapuae* (Ballantyne) have two pairs of wide bursa plates.

*Luciola* **s. str.** is defined by scoring the type species *L. italica* (L), *Bourgeoisia* Olivier and *Lampyroidea* (based on its type species *syriaca* Costa) both of which are submerged into *Luciola*; *Luciola* **s. str.** is addressed here from four Pacific Island species: *L. hypocrita* Olivier, *L. antipodum* Bourgeois both transferred from *Bourgeoisia*; *L. aquilaclara* **sp. nov.** and *L. oculoifissa* **sp. nov.** are described. *L. oculoifissa* **sp. nov.** is the only Luciolinae male known to lack light organs. Females of *L. italica* and *L. hypocrita* lack bursa plates.

*Pacifica* **gen. nov.** is proposed for five species from the Solomon Islands transferred from *Pygatyphella* (Ballantyne), and which the phylogenetic analysis shows to be distinctive viz. *P. limbatifusca* (Ballantyne), *P. limbatipennis* (Pic), *P. plagiata* (Blanchard), *P. russellia* (Ballantyne), and *P. salomonis* (Olivier).

A monotypic genus *Poluninius* **gen. nov.** is proposed for *Pol. selangoriensis* **sp. nov.** from Selangor, Malaysia. The genera *Colophotia*, *Pteroptyx*, *Pyrophanes*, and *Pygoluciola* are treated in an abbreviated fashion with generic diagnoses, lists of, and keys to, species. *Pteroptyx bearni* Olivier and *P. tener* Olivier are characterised from type specimens and female bursae and *P. similis* Ballantyne is synonymised with *P. bearni*. *Luciola semilimbata* Olivier is transferred to *Pyrophanes*, and *Luciola cowleyi* Blackburn to *Pygoluciola*. The following species are treated as *species incertae sedis*: *L. melancholica* Olivier, *L. ruficollis* Guérin-Ménéville. The New Guinean records of *Luciola tenuicornis* Olivier, *L. timida* Olivier and *Photinus cinctellus* Motschulsky are suspect. Fifteen of the species treated here are recognised by flashing patterns. The functions of the terminal abdominal modifications, origins of the Australopacific firefly fauna, and use of female and larval characters in interpretations of relationships are considered.

**Key words:** *Australoluciola* **gen. nov.**, *Medeopteryx* **gen. nov.**, *Pacifica* **gen. nov.**, *Poluninius* **gen. nov.**, *Trisinuata* **gen. nov.**, Australia, Republic of Palau, Federated States of Micronesia, Papua New Guinea, Indonesia, Solomon Islands, New Caledonia, Vanuatu, Fiji, taxonomy, new species, identification keys, morphological phylogenetic analysis, female bursa plates

## Introduction

Ballantyne and Lambkin's (2009) major taxonomic review of the Luciolinae established seven new genera and 19 new species and concentrated primarily on the genera related to *Atyphella* Olliff. With two exceptions, these genera and species occur in the area encompassed by Australia, the Republic of Palau, Federated States of Micronesia, Papua New Guinea, Indonesia (West Irian), Solomon Islands, New Caledonia, Vanuatu and Fiji. Six of the species placed in this *Atyphella* "complex" had been collected during the 1969–70 voyage of the scientific vessel Alpha Helix to New Guinea and were characterised by flashing patterns (Lloyd 1973a).

The first aim of this study was to resolve the outstanding taxonomic issues posed by the Alpha Helix voyage. It includes species first characterised by their flashing patterns, and that were initially placed within the genus *Luciola* Laporte (Table 1; Lloyd, 1973a; Ballantyne in Lloyd 1973b). The scope of our revision was subsequently extended to encompass all known Luciolinae genera, including certain species from SE Asia, while concentrating primarily on species presently included within the genus *Luciola*. Genera from outside the study area, as defined above, are treated in an abbreviated fashion with diagnoses, and keys to species.

To date the Luciolinae have been subject to six phylogenetic analyses, with each successive one based on increasing numbers of species and characters. Therefore, due this improved level of accumulated evidence, further