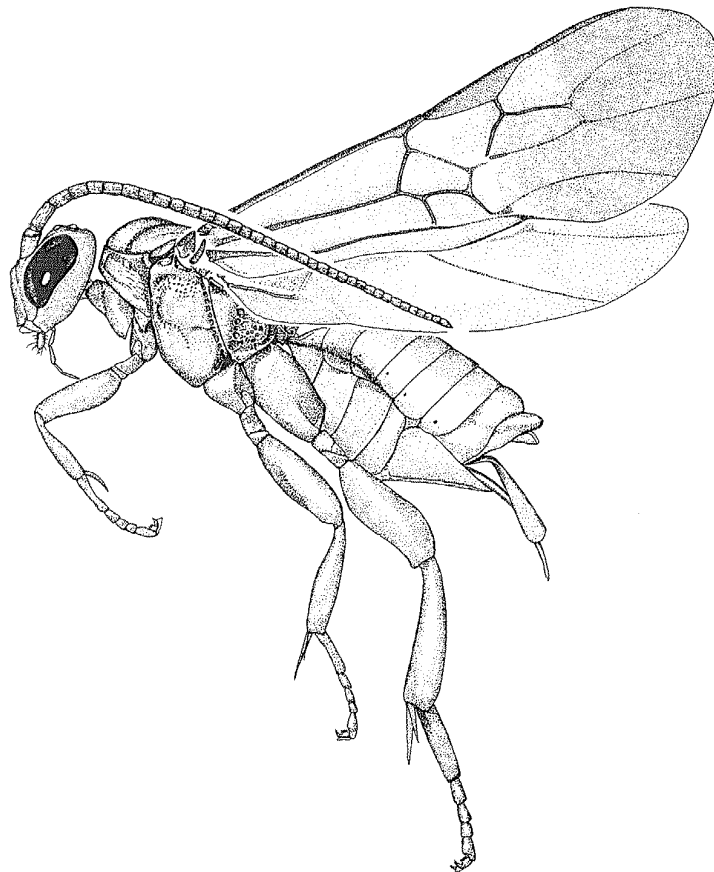




**THE SYSTEMATICS OF THE GENERA OF CARDIOCHILINAE
(HYMENOPTERA: BRACONIDAE) WITH A REVISION OF
AUSTRALASIAN SPECIES**



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SUMMARY

Members of the wasp subfamily Cardiochilinae (Hymenoptera: Braconidae) are endoparasitic in lepidopterous larvae and have proven and potential importance as biocontrol agents of agricultural pests. This project was initiated firstly to examine the taxonomy of species in the Australasian region, which was previously poorly studied, and secondly, to develop a phylogenetic framework for world genera based on cladistic methodology.

A brief literature review provides a background to the taxonomic, phylogenetic and biological knowledge of the subfamily and outlines the need for a revision based on the morphological diversity of the speciose genus *Cardiochiles* Nees ab Esenbeck, which contained 95% (170 described species) of the world fauna. A detailed treatment of the morphology of the Cardiochilinae provides a framework for the phylogenetic and taxonomic analyses conducted, and introduces new characters and terminology used in the revision.

The subfamily forms a monophyletic group based on the following combination of apomorphies: second submarginal cell of the fore wing broad, large and four-sided; first metasomal tergite with 'Y-shaped' groove; spiracle position on the first laterotergite of the metasoma; laterotergites only partially defined; axilla reduced to a vertical area of carinate lobe; and the form of larval mouthparts.

Prior to the cladistic analyses of genera and species, the higher phylogeny of the Hymenoptera is reviewed, specifically to select more distant outgroups to the sister group of the cardiochilines, the Microgastrinae. This section also reviews the choice of characters, the assignment of character states, and an assessment of polarity and order for the characters used. The program PAUP (Version 3.1.1) is employed to determine the most parsimonious solution to the data set, which was assembled using MacClade (Version 3.02). An assessment of the different parameters of the software is also presented. Statistical testing of the resultant phylogenies utilised both the PTP test to

analyse cladistic information and the T-PTP test to analyse cladistic structure of the trees obtained.

The types of Cardiochilinae from all previously recognised genera, exemplar species, and the new taxa identified in this study were used in the cladistic analyses. These analyses were undertaken using *Prasmadon* Nixon (Microgastrinae), *Epsilogaster* Whitfield (Mendesellinae) and a hypothetical ancestor as outgroups. In addition, the hypothetical ancestor was used with polarities and orders predetermined from a multiple outgroup comparison of characters. Results using these three outgroups yielded similar monophyletic groupings of species, however, the sister group relationships of these clades were not always well-defined, with basal clades changing position when different outgroups were employed. Tests for significance confirmed that the resultant trees contained significant cladistic information and structure, but the sister group relationships of some genera could not be elucidated due to the variation in the structure of the trees when different outgroups were used.

A generic classification from the Cardiochilinae is proposed based on the recognisable monophyletic groups from the analyses, representing eighteen genera. Eight of these genera are described as new, seven are redescribed, and three raised to generic level having previously been treated as junior synonyms of *Cardiochiles sensu lato*. The genera proposed are *Asiacardiochiles* Telenga, stat. rev. (1 species - Russian), *Austerocardiochiles* gen. nov. (6 species - Oriental, Australasian and African), *Bohayella* Belokobylskij (3 species - Oriental and Australasian), *Brevicardiochiles* gen. nov. (3 species - African and Philippine), *Cardiochiles* Nees *sensu stricto* (22 species - cosmopolitan), *Circocardiochiles* gen. nov. (1 species - Oriental and Australian), *Hartemita* Cameron (9 species - Oriental), *Heteropteron* Brullé (1 species - Neotropical), *Hymenicis* gen. nov. (3 species - Australian), *Latitergum* gen. nov. (3 species - Australian), *Leptocardiochiles* gen. nov. (1 species - Nearctic), *Neocardiochiles* Szépligeti (1 species - Neotropical), *Polycardiochiles* gen. nov. (10 species - cosmopolitan), *Pseudcardiochilus* Hedwig (3 species - Australian), *Psilommiscus* Enderlein, stat. rev. (1 species - Oriental), *Retusigaster* gen. nov. (6

species - Nearctic and northern Neotropical), *Toxoneuron* Say, stat. rev. (12 species - Nearctic and northern Neotropical) and *Wesmaelella* Spinola (2 species - Neotropical). Sixty-six previously described species and the 21 species newly described here are placed within the revised generic classification, an illustrated key to genera is presented, and the relationships and distributions of genera are discussed. A survey of available host data revealed information for only five genera: Uraniidae have been recorded as hosts for *Bohayella*, Pyralidae and Noctuidae for *Cardiochiles*, Gelechiidae and Cosmopterigidae for *Leptocardiochiles*, Gelechiidae, Noctuidae and Tortricidae for *Polycardiochiles*, and Noctuidae for *Toxoneuron*. One hundred and four species are listed as species *incertae sedis*, because insufficient information was available due to their descriptions being too superficial to place them into the generic classification, and their holotypes were not available prior to the completion of this study.

Following the reclassification of genera, the subfamily is revised for the Australasian region, here defined as Australia, New Guinea, the Bismark Archipelago, Fiji and New Zealand, although no species are known from the latter two areas. Twenty-six species from eight genera are recorded from Australasia. Twenty-one species are described as new and five are redescribed: *Austerocardiochiles callemondah* sp. nov., *Aus. deetoo* sp. nov., *Aus. exleyae* sp. nov., *Aus. morulus* sp. nov., *Aus. pollinator* sp. nov., *Bohayella toxopeusi* sp. nov., *Cardiochiles evelinae* sp. nov., *Car. goosei* sp. nov., *Car. iqbali* sp. nov., *Car. rasi* sp. nov., *Car. rufator* Roman, *Car. saeedi* sp. nov., *Car. scotti* sp. nov., *Car. uniformis* Turner, *Car. verticalis* Turner, *Circocardiochiles occidentalis* sp. nov., *Hymenicis bubbur* sp. nov., *Hym. nockatungensis* sp. nov., *Hym. noongarensis* sp. nov., *Latitergum areyongensis* sp. nov., *Lat. eremophilasturtiae* sp. nov., *Lat. turneri* sp. nov., *Polycardiochiles dissimulator* (Turner), *Pol. fuscipennis* (Szépligeti), *Pol. gwenae* sp. nov., and *Pseudcardiochilus naumanni* sp. nov. One species from the Oriental region, *Pol. philippensis* (Ashmead), is redescribed due to its strong similarity to, and parapatric distribution with, *Pol. fuscipennis*. *Boh. adina* (Wilkinson), also from the Oriental region, is described and transferred from *Cardiochiles sensu lato*. Previously

recognised species *Car. assimilator* Turner, *Car. fasciatus* Szépligeti, *Car. piliventris* Cameron, *Car. similis* Brues and *Car. trichiosomus* Cameron are synonymised with *Pol. fuscipennis*. An illustrated key to Australasian species based on females is presented, as are notes on their biology (where known), relationships and distribution.

Finally, the results of this study are discussed in the broad context of their influence on future research. They will hopefully serve as a base for further taxonomic revisions of specific zoogeographic regions. Clearly, many species are yet to be described given that the revision here of the Australasian fauna has resulted in a three-fold increase in known species, and other regions, particularly the Neotropical, Oriental and Ethiopian, are poorly studied. It is hoped that the resultant phylogenetic hypotheses will serve as a framework for future evolutionary studies on the host relationships and ecology of the subfamily, and also aid in ongoing phylogenetic work aimed at resolving the relationships among braconid subfamilies.