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**Characterisation of the Australian Nacophorini using adult morphology,
and phylogeny of the Geometridae based on morphological characters**

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Abstract

The Australian Nacophorini and related taxa are described using a matrix of 116 adult morphological characters. Adults of 72 species are illustrated using photographs and electron micrographs. Subsets of the characters are used to conduct a phylogenetic analysis based on cladistic principles. The adult morphological character set was augmented with 17 characters from eggs and 27 from larvae. The resulting phylogeny is poorly resolved but provides support for many of the relationships recovered by previous molecular analyses of the group, including basal derivations for characters of Larentiinae and Sterrhinae relative to those of the rest of Geometridae, and the monophyly of the Geometrinae + Oenochrominae *s. str.* Combining 28S D2 data

with morphological data produced a matrix of 60 taxa and 590 characters. The majority rule consensus tree produced by the combined morphological and 28S D2 data is almost identical to the majority rule consensus tree produced by the 28S D2 data alone, except that bootstrap support is lower for most nodes. Common clades obtained from the molecular and morphological trees are described in terms of morphological data. On this basis a concept of the Australian Nacophorini includes Lithinini and Australian Archiearinae. Two robust groups within the tribe also are delimited using characters from all data sources. Comparisons are made between the Nearctic and Neotropical Nacophorini on the basis of shared morphological characters. Australian Boarmiini are defined by synapomorphies.

Key words: Archiearinae, Australia, Ennomimae, Geometridae, morphological phylogeny, morphology, Nacophorini

Introduction

Ennominae comprise the largest of the six subfamilies of Geometridae with 9,700 described species in approximately 1,100 genera that represent just under half of all geometrids (Minet & Scoble, 1999). Their distribution is worldwide, but they are particularly well represented in the New World, especially in tropical areas (e.g. Rindge, 1983; Krüger & Scoble, 1992; Scoble, 1995a; Pitkin, 2002, 2005). Nacophorini (*sensu* Rindge, 1983) are the largest ennomine tribe in southern Australia; they also are widely distributed in the Americas from southern Canada to Chile and southern Argentina. The tribe is poorly represented in Asia and the temperate regions of the Palaearctic (McQuillan, 1986). This pattern suggests that fragmentation of Gondwana may have contributed to the dispersal and present day distribution of the tribe.

Duponchel (1845) first proposed the “Ennomites” as a family-group name. However, Pierce (1918) was the first to synthesise a suprageneric classification of Geometridae based on male genitalia. He distinguished eight tribes in the Palaearctic Ennominae: Ennomini, Macariini, Ourapterygini, Bistonini, Boarmiini, Eranini, Gnophini, and Abraxini. Concurrently, Prout (1915–1920) grouped genera now known as ennomines as the Geometrinae [Leach], a title subsequently discarded for the subfamily in favour of Ennominae. Prout used the absence or degeneration of M_2 in the hindwing as the defining apomorphy for the group, a character still used as the single distinguishing feature for the subfamily. On at least this basis Ennominae most likely are not monophyletic (Minet & Scoble, 1999).

Forbes (1948) was the first to attempt a tribal classification of Nearctic ennomine genera and separated tribes on the basis of male antennal, genitalic, and pupal characteristics. McGuffin (1972, 1977, 1981, 1987), in his synopses of Nearctic ennomines, largely followed the tribal classification of Forbes. Holloway (1994) subsequently rationalised the tribal classification and provided a comprehensive listing of tribal names encompassing all family-group names used by various authors up to that time.

Several recent major revisions of ennomine tribes have contributed substantially to the understanding of the taxonomy of the group. Rindge comprehensively reviewed American Bistonini, Melanophiini (both included in the Boarmiini by Holloway (1994)), Nacophorini, and Lithinini (Rindge 1975, 1983, 1986); Scoble (1995b) reviewed Palyadini (treated as Caberini/Baptini by Pitkin (2002)); and Krüger (2001) and Scoble and Krüger (2002) reviewed the genera of Macariini. The Neotropical ennomines, encompassing 267 genera, were reviewed extensively and tribal classifications relevant to this group reassessed by Pitkin (2002, 2005).

Despite extensive generic revisions, few recent authors have attempted to propose phylogenetic relationships within the Geometridae at the subfamily or tribal levels. McGuffin (1987) deduced phylogenetic relationships within the Ennominae from inferences on the evolutionary status of various characters of adults and immature stages and also drew on observations by Rindge (1964, 1966, 1967, 1973, 1975) on geometrid characters. He proposed that Macariini and Abraxini should hold a ‘basal’ position, and Ourapterygini was the