

**Phylogenetic relationships of the geometroid lepidopterans
(Lepidoptera: Cimeliidae, Epicopeiidae, Sematuridae, Drepanidae, Uraniidae, Geometridae)**

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Advancement in the taxonomy of geometrid moths at subfamily and tribal levels seems set on a path of comparison between morphological and molecular phylogenetic analysis. This study investigates the morphological phylogeny of families and subfamilies of geometroid lepidopterans (consisting of Geometridae, Uraniidae s.l., Drepanidae s.l., Epicopeiidae and Sematuridae), with the Cimeliidae as probable sister family to this group. Main efforts were given on the determination of probable ancestral apomorphies of the families and subfamilies, and on the establishment of monophyletic groups.

A combination of the results of independent morphological analyses of basal abdominal segments and male genitalia (including musculature), confirms the sister relationship between Geometridae and Uraniidae and the more remote relationship with Drepanidae. Phylogenetic relationships of Drepaninae, Thyatirinae and Cyclidiinae remain unresolved. The assumed branching of subfamilies in Uraniidae (Uraniinae (Auzeinae (Epipleminae + Microniinae))) does not support current theories on their relationships. Epicopeiidae and Sematuridae, probably, form a sister pair branching earlier than the radiation of tympanote geometroid families. The family Cimeliidae is proposed as phylogenetically closest to the complex of geometroid families.

A new phylogeny of geometrid subfamilies is hypothesized, based on the examination of structures of the proximal segments of the abdomen, tibial androconial apparatus of males and genitalia. The basic division of geometrid subfamilies into two large monophyletic lineages – the geometrine and larentiine lineages – is confirmed. In the geometrine lineage, the branching of subfamilies in the sequence (Archiearinae (Ennominae (Desmobathrinae (Oenochrominae s.str. + Geometrinae))) is postulated. The larentiine lineage includes the sister subfamilies Larentiinae and Sterrhinae. The taxa 'Alsophilinae', 'Orthostixinae' and 'Cheimoptenini' are included into the core group of Desmobathrinae (genera centrales, g.c.). The genera *Abraxaphantes* Warr., *Dichromodes* Gn., *Epidesmia* D. & Westw. and *Heteralex*

Warr. are also transferred into the Desmobathrinae as a basally derived (possibly paraphyletic) group (genera marginales, g.m.). The tribe Eumeleini and, tentatively, the genus *Celerena* Wlk. are included in the subfamily Geometrinae. The tribe Ametridini is associated with the subfamily Sterrhinae.

The proposed relationships of the families and subfamilies of geometroid lepidopterans coincide with or, at least, do not contradict the modern molecular phylogeny of these taxa in most nodes, including the proposed sister relationship of the Sematuridae and Epicopeiidae. The most marked differences concern the grouping of the Uraniidae subfamilies and the position of the 'Alsophilinae'. A detailed substantiation of the phylogeny is given in Beljaev (2008). Selected apomorphies for most debatable nodes are shown in Fig. 1.

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Apomorphies*

1. Muscles m_2 arising from tegumen dorsolaterally and remotely from median ridge of tegumen.
2. Labides joined by their ventral margin with dorso-medial margin of the base of valvella.
3. Labides with ventromedial process articulated with lateral margins of the juxta dorsomedial of base of valvella.
4. Valvella separated dorsally from lateral margins of the juxta.
5. Muscles m_3 attached basally to the sclerotized fold between vinculum and sacculi.
6. Valvella placed almost ventrad of juxta and flattened dorsoventrally.
7. Aedeagus basally ankylosed with caulis.
8. Anterolateral processes of second sternite modified into tympanal organs.
9. Labides arising from basal part of the ventral margin of costula.

* For Sematuridae and Epicopeiidae, apomorphies are defined relative to the basally derived position of *Deuveia* in the latter family (Minet, 2002).

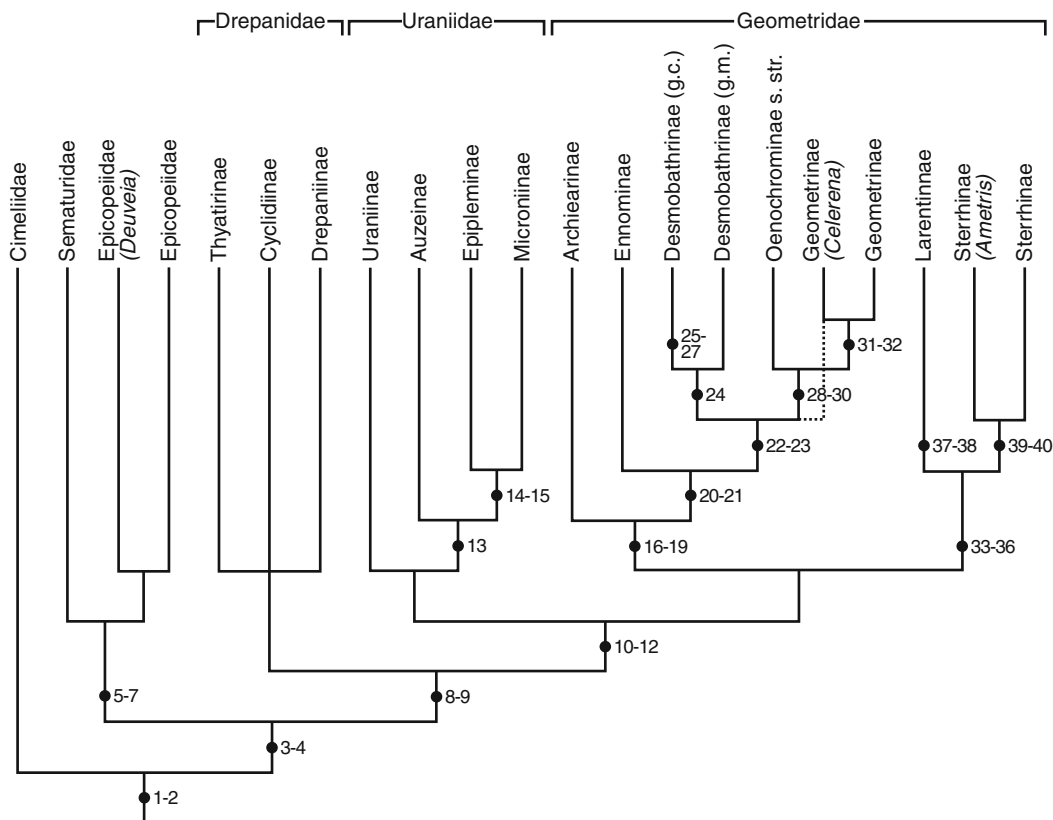


Fig. 1. Phylogenetic cladogram of the families and subfamilies of geometroid lepidopterans.

10. Tympanal case joined with anterior margin of the second abdominal sternite; wall of anterior apodeme of the sternite lying opposite tympanum is formed by wall of tympanal case.
11. Labides as lobe-like process placed between the dorsobasal angle of valva and juxta, dorsally separated from subcostal fold of valvula and have flexible connection with costula.
12. Valvella reduced to small setaceous plates (cristae), widely fused with juxta and sacculi.
13. Dorsal wall of tympanal case fused with sternite; air channel into the cavity of anterior apodeme of the sternite located between basal plate of the case and wall of corpus of the case.
14. Labides shaped as membranous setaceous lobes.
15. Saccus absent.
16. Male third abdominal sternite with a pair of lateral patches of long setae protruding over scales covering abdomen.
17. Base of the gnathos arms deeply wedged between uncus and tegumen so that lateral sides of the uncus base widely contact the base of gnathos.
18. Costula is in form of bilobate hemitransstilla; muscle m_4 attached to the dorsal lobe of hemitransstilla, mediad of muscle m_2 and both muscles crossed.
19. Signum on the corpus bursae as entire, well-sclerotized, rounded, dentate and moderately concave plate.
20. In males setal patches on third abdominal sternite consist of strong needle-like setae.
21. Apical part of the air canal of ansa possesses rather long thinned portion, with almost parallel sided, apex of canal capitate.
22. Uncus medially free of connection with tegumen and articulated with bases of the gnathos arms only.
23. Valva with large, prominent medial lobe of valvula.
24. Tympanal organs without lobe-like cardolacina.
25. In males third abdominal sternite with pair of longitudinally elongated setal patches.
26. Tegumen wide, muscles m_4 attached to tegumen.
27. Costa separated from valva at apex.
28. Uncus at base with wide median "window" intersected by longitudinal band of sclerotization.
29. Juxta is short and wide, concave at the base, more or less semilunar.
30. Muscles m_3 basally attached to the sacculi.
31. Scales with large content of green pigment geoverdian.
32. Male hind tibiae with distal process.

33. Male hind tibia with hairpencil, directed towards medial secretory zone on the second abdominal sternite.
34. Scoloparial dilatation of ansa is formed by dilation of the ansa air canal.
35. Gnathos basally fused with tegumen and uncus.
36. Subanal plate fused with median part of gnathos.
37. In males, tibial hairpencil composed of thickened springy hairs, medial groove on hind tibia and marginosternal processes on second abdominal sternite absent.
38. Labides separated distally from costula by narrow membranous fold.
39. On forewing, vein M_1 relatively very long and section between point of branching from R_s stem and discal vein is longitudinally orientated.
40. Discal spots on the wings have light nucleus, different in colour from groundcolour of wings.

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Evolutionary Relationships within the Australian Geometrinae – Research Update

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This ongoing study examines the relationships between Australian geometrine genera and the relationships between these groups and other geometrid subfamilies. Geometrinae are strongly represented in Australia and this includes many genera of the Pseudoterpnini, the so called robust or grey Geometrinae. Very little has been published on the systematics of this group apart from the important and comprehensive work by Pitkin et al. (2007) on the Pseudoterpnini. Previous research into the higher order relationships within geometrid subfamilies has shown that they may be a sister group relationship between the Geometrinae and the Oenochrominae s. str. based on both morphological and molecular data (Young 2006, Yamamoto & Sota 2007). The Pseudoterpnini are also interesting in an evolutionary context because they have been postulated as being basally derived. In this study, data from two genes, 28S D2 and LW Rhodopsin were used to construct phylogenies for geometrine species and representatives of other geometrid subfamilies. Preliminary results show that:

- The Pseudoterpnini most likely do not form a separate clade within the Geometrinae;
- The Pseudoterpnini are most likely not basally derived;
- A sister relationship between Oenochrominae

and Geometrinae is uncertain, but is evident from Rhodopsin data;

- Dysphanini is a separate tribe from the Geometrinae on Rhodopsin data only;
- *Chlorocoma* is not monophyletic as '*Prasinocyma semicrocea*' most likely belongs to *Chlorocoma*, whereas *Chlorocoma cadmaria* does not;
- *Anomogenes* is possibly an ennomine and not a geometrine.

To further clarify these relationships, molecular data will be analysed using Bayesian inference. Morphological data, based mainly on adult characters, but also some immature characters, will be analysed to further understand relationships.

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