

THE CURRENT STATUS OF EPHEMEROPTERA BIOLOGY IN AUSTRALIA

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ABSTRACT

Since the most recent comprehensive review of the biology of Australian Ephemeroptera by Peters and Campbell in 1991, knowledge has been rapidly increasing. In formal taxonomy there have been new genera and/or species described within the Caenidae, Leptophlebiidae and Prosopistomatidae, but there has also been substantial progress in informal taxonomy with the publication of several keys for identification. In ecology there have been studies published on egg development and effects of river regulation and there are papers in preparation on mayfly production. Some of the ecological studies have shed light on some apparent conundrums relating to the distribution of some southeastern Australian taxa such as *Coloburiscoides*, and there have been additional useful biogeographical studies on previously little known taxa such as *Ephemerellina*.

INTRODUCTION

There have been several comprehensive reviews of the biology of Australian Ephemeroptera, the earliest being that of Tillyard (1926) and the most recent being those prepared for the two editions of the CSIRO book "The Insects of Australia" (Riek 1970, Peters and Campbell 1991). Two catalogues of Australian Ephemeroptera have also been published (Campbell 1988, Hubbard and Campbell 1996). This paper reviews progress in research on Australian ephemeropteran biology since Peters and Campbell (1991).

TAXONOMIC STUDIES

There has been considerable progress in Australian mayfly taxonomy since 1991. Table 1 documents new taxa described since that time. Within the Leptophlebiidae, which is the largest Australian family, two new genera *Kalbaybaria* and *Tillyardophlebia*, have been described together with 9 new species from those two genera, *Atalomicria* and *Austrophlebioides*.

There have also been significant taxonomic additions to the Australian Caenidae with two new genera and 6 new species described (Suter 1993, 1999), and the only Australian prosopistomatid has been described as a new species (Campbell and Hubbard 1998). In addition there has been an informal key to the genera published by Dean and Suter (1996). Within the Baetidae Lugo-Ortiz and McCafferty (1998a, b, 1999) have described two new genera and two new species, and the first record of the genus *Cloeodes* from Australia. Dean and Suter also noted the presence of *Platybaetis* in northern Australia and suggest that neither true *Baetis* nor *Pseudocloeon* actually occur in Australia.

The most bizarre taxonomic addition has been the record by Lugo-Ortiz and McCafferty (1998c) of a species of *Siphlaenigma* (Siphlaenigmatidae) from Australia, a record almost certainly based on an erroneous data label.

Taxonomic piracy is a continuing problem for Australia as it is also for many developing countries. There continue to be frequent cases of foreign taxonomists obtaining small collections of Australian Ephemeroptera and using these to describe new genera and species with types lodged in foreign museums where they are inaccessible to Australian taxonomists. Frequently the published descriptions are poor and incomplete, and usually they are made without reference to the remainder of the Australian fauna. The motivation is apparently solely the acquisition of publications, certainly they make little contribution to the progress of Australian taxonomy since the material requires later redescription by Australian taxonomists before it can be used. Frequently the poor quality of the work requires more than the usual taxonomic work to correct the errors.

ECOLOGICAL STUDIES

It is not possible in the context of this paper to review all the ecological data which has been produced since 1991, because much of that data resides in references to Ephemeroptera in studies of stream invertebrates, often only available as unpublished theses. For the purposes of this paper I have restricted consideration to studies of which Ephemeroptera are the principal subject of the study.

Hearnden and Pearson (1991) investigated habitat partitioning among 13 mayfly species in Yuccabine Creek, a tropical semi-permanent stream in tropical north Queensland. Regrettably the taxonomy used in the paper is poor, they referred to two *Atalophlebioides* species, presumably in error for *Austrophlebioides*, and *Atalonella* presumably in error for either *Nousia*, *Koormonga* or *Neboissophlebia*. The study was carried out using multiple regression of field data consisting of mayfly numbers and a series of environmental variables measured at the sampling site including current velocity, leaf litter dry mass and rock size. They also carried out an experiment using replicate trays with four different substrate types with and without added leaf litter placed in riffles and pools. They found no one controlling factor, but only 2 of the 13 species preferred riffles to pools, and two of the pool species showed a preference for leaf litter presence. Two species, a *Tasmanocoenis* species and an "*Atalonella*" had rather narrow niches as measured by the Simpson-Yule index but the others all demonstrated broad niche preferences. One difficulty with the study was the rather coarse methods used to assess environmental factors. In particular the scale of current measurements was fairly large particularly in the context of the extensive discussions in the literature on possible invertebrate responses to hydrodynamics (e.g. see Davis 1986, Davis and Barmuta 1989).

A further study of tropical Australian mayflies was a description of the life cycles of three *Jappa* species from two streams in far north Queensland (Campbell 1991). Not surprisingly, in view of the high water temperatures, the life cycles were all quite rapid and very aseasonal with emergence, egg hatching and growth throughout the year.

Pardo et al. (1998) investigated the influence of an irrigation reservoir on mayfly assemblages and life histories in two southeastern Australian streams. They found a richer assemblage of 17 species in the unregulated stream, compared with only 11 in the regulated

Table 1. A list of the genera and species of Australian Ephemeroptera described since 1991.

Taxon	Reference
Leptophlebiidae	
<i>Kalbaybaria</i>	Campbell 1993
<i>Kalbaybaria doantrangae</i>	Campbell 1993
<i>Atalomicria banjdzalama</i>	Campbell and Peters 1993
<i>Atalomicria bifasciata</i>	Campbell and Peters 1993
<i>Atalomicria chessmani</i>	Campbell and Peters 1993
<i>Atalomicria dalagara</i>	Campbell and Peters 1993
<i>Austrophlebioides booloumbi</i>	Parnrong and Campbell 1997
<i>Austrophlebioides marchanti</i>	Parnrong and Campbell 1997
<i>Tillyardophlebia</i>	Dean 1997
<i>Tillyardophlebia rufosa</i>	Dean 1997
<i>Tillyardophlebia alpina</i>	Dean 1997
Caenidae	
<i>Wundacaenis</i>	Suter 1993
<i>Wundacaenis angulata</i>	Suter 1993
<i>Wundacaenis dostini</i>	Suter 1993
<i>Wundacaenis flabellum</i>	Suter 1993
<i>Irpacaenis</i>	Suter 1999
<i>Irpacaenis deani</i>	Suter 1999
<i>Irpacaenis kaapi</i>	Suter 1999
<i>Irpacaenis coolooli</i>	Suter 1999
Prosopistomatidae	
<i>Prosopistoma pearsonorum</i>	Campbell and Hubbard 1998
Baetidae	
<i>Offadens</i>	Lugo-Ortiz and McCafferty (1998a).
<i>Offadens sobrinus</i>	Lugo-Ortiz and McCafferty (1998a).
<i>Cloeodes fustipalpus</i>	Lugo-Ortiz and McCafferty (1998b).
<i>Cloeodes illiesi</i>	Lugo-Ortiz and McCafferty (1998b).
<i>Edmundsiops</i>	Lugo-Ortiz and McCafferty (1999).
<i>Edmundsiops instigatus</i>	Lugo-Ortiz and McCafferty (1999).
Siphlaenigmatidae	
<i>Siphlaenigma edmundsi</i>	Lugo-Ortiz and McCafferty (1998c).

Mitta Mitta River. The pattern of flow in the regulated stream included a summer release of cold water which resulted in the highest water levels of the year occurring during a normally low water period, and temperatures 5–10°C lower than would normally be expected at that time of year. The two most abundant mayflies – a species they identified as belonging to *Baetis* and a species of *Coloburiscoides*, both declined numerically during the summer water release, and the period of cold water appeared to delay nymphal hatching of *Coloburiscoides*.

An earlier study of egg development of *Coloburiscoides* by Brittain and Campbell (1991) found that egg hatching rates were related to water temperature between 10° and 25°C but that no eggs hatched at temperatures of 5°C or 30°. Some of the streams in which *Coloburiscoides* occurs have temperatures below 5° for a significant part of the year, so this data supported the earlier suggestion by Campbell (1986) that *Coloburiscoides* display an egg diapause in some streams near Mt Kosciusko.

The most substantial, although as yet incomplete, study of an Australian mayfly is that of *Austrophlebioides marchanti* being carried out by Parnrong (pers. comm). She has investigated the egg development time, life cycle and production of the species at four sites, two in forest streams and two in farmland streams. Life cycles of *Austrophlebioides* species had previously been described based purely on field samples (Marchant 1986, Campbell et al.

1990), but the growth is asynchronous making it very difficult to ascertain growth rates or to accurately determine voltinism. As part of her study Parnrong grew nymphs in cages in the field, allowing a much more accurate determination of nymphal growth rate. Previous authors had suggested that *Austrophlebioides* was univoltine (Campbell et al. 1990) or bivoltine (Marchant 1986). Parnrong has demonstrated that *Austrophlebioides marchanti* has 2.5 to 3 generations per year.

The final body of substantial work on Australian Ephemeroptera is the work on trichomycete fungi which occur in the guts of many aquatic insects, and have been collected from the guts of a number of Australian mayflies by Lichtwardt and Williams (1990, 1992a,b,c). The main hosts seem to be baetids, including *Centroptilum* nymphs (Lichtwardt and Williams 1990, 1992a) but some species have also been recorded from the guts of *Nousia* (*Australonousia*) (Leptophlebiidae) (Lichtwardt and Williams 1992b). The ecological significance of Trichomycetes either as parasites or as endosymbionts is unclear.

BIOGEOGRAPHICAL STUDIES

As yet there have been few biogeographic studies completed or published on Australian mayflies. As noted above Brittain and Campbell (1991) suggested that the requirement of *Coloburiscoides* eggs for water temperatures higher than 5°C for development may explain the absence of that genus from Tasmania, and it is likely that the same explanation will be true for *Mirawara* which extends into the tropics on the Australian mainland.

Dean and Cartwright (1992) published survey data from the Pelion Valley from Tasmania which included the first record of the genus *Austrophlebioides* from Tasmania. They collected two species from the genus, both of which had previously been recorded from the mainland of Australia. They also collected the species "*Jappa tristis*" and suggested that it does not in fact belong to *Jappa*, and that true *Jappa* do not appear to occur in Tasmania.

One of the most interesting biogeographical publications is that of Chessman and Boulton (in press), documenting new localities for the sole Australian ephemereiid, *Ephemereidina* (*Austremereidina*) *picta* (Riek). This species was previously known from a single locality in southeastern Queensland, and was definitely known not to occur in southeastern Australia, as might be expected for a Gondwanian relict, or in tropical northern Australia (as might be expected for a recent tropical arrival). One possibility was that it was an exotic species introduced by Europeans (Campbell 1990). Chessman and Boulton record the species from 18 new localities in northern New South Wales making it extremely unlikely that it is a recent exotic species, but its geographic restriction and its isolation from related species, which seem to occur in Africa (Allen 1965) still pose a biogeographic conundrum.

CURRENT RESEARCH

Taxonomic studies of Australian Ephemeroptera are continuing. Kyla Finlay, a PhD student at Monash University is working on the taxonomy and biogeography of selected southeastern Australian leptophlebiid genera, and Faye Christidis, a PhD. student at James Cook University in North Queensland is working on the taxonomy of tropical Leptophlebiidae. The National River Health initiative has provided funding to support some graduate student work on formal taxonomy and is also supporting the production of keys and voucher collections.

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REFERENCES

- Allen, R. K. 1965. A review of the subfamilies of the Epemerellidae (Ephemeroptera). *J. Kans. ent. Soc.* 38: 262-266.
- Brittain, J. E. and I. C. Campbell. 1991. The effect of temperature on egg development of the Australian mayfly genus *Coloburiscoides* (Ephemeroptera: Coloburiscidae) and its relationship to distribution and life history. *J. Biogeogr.* 18: 231-235.
- Campbell, I. C. 1986. Life histories of some Australian siphonurid and oligoneuriid mayflies (Insecta: Ephemeroptera). *Aust. J. Mar. Freshw. Res.*, 37: 261-288.
- Campbell, I. C. 1988. Ephemeroptera. In: *Zoological Catalogue of Australia. Volume 6.* ABRS, Canberra.
- Campbell, I. C. 1990. The Australian mayfly fauna: composition, distribution and convergence. In: I. C. Campbell (ed.), *Mayflies and Stoneflies, Life Histories and Biology.* Kluwer Academic Press, Dordrecht, Netherlands.
- Campbell, I. C. 1991. Size allometry in some Australian mayfly nymphs (Insecta: Ephemeroptera). *Aquat. Insects* 13: 79-86.
- Campbell, I. C. 1993. A new genus and species of leptophlebiid mayfly (Ephemeroptera: Leptophlebiidae: Atalophlebiinae) from tropical Australia. *Aquat. Insects* 15:159-167.
- Campbell, I. C. 1995. The life histories of three tropical species of *Jappa* Harker (Ephemeroptera: Leptophlebiidae) in the Mitchell River system, Queensland, Australia, pp. 197-206. In: J. Ciborowski and L. Corkum (eds.). *Current Directions in Research on Ephemeroptera.* Canadian Scholars Press, Toronto.
- Campbell, I. C., M. J. Duncan and K. M. Swadlin. 1990. Life histories of some Ephemeroptera from Victoria, Australia. In: I. C. Campbell (ed.). *Mayflies and Stoneflies, Life Histories and Biology.* Kluwer Academic, Dordrecht, Netherlands.
- Campbell, I. C. and M. D. Hubbard. 1998. A new species of *Prosopistoma* (Ephemeroptera: Prosopistomatidae) from Australia. *Aquat. Insects* 20: 141-8.
- Campbell, I. C. and W. L. Peters. 1993. A revision of the Australian Ephemeroptera genus *Atalomicria* Harker (Leptophlebiidae: Atalophlebiinae). *Aquat. Insects* 15: 89 -117.
- Campbell, I. C. and P. J. Suter. 1988. Three new genera, a new subgenus and a new species of Leptophlebiidae (Ephemeroptera) from Australia. *J. Aust. Ent. Soc.* 27: 259-273.
- Chessman, B. C. and A. J. Boulton. Occurrence of the mayfly family Epemerellidae in northern New South Wales. *Mar. Freshw. Res.* In press.
- Davis, J. A. 1986. Boundary layers, flow microenvironments and stream benthos. In: P. de Dekker and W. D. Williams (eds.). *Limnology in Australia.* Junk, Dordrecht. pp. 291,12.
- Davis, J. A. and L. A. Barmuta. 1989. An ecologically useful classification of mean and near-bed flows in streams and rivers. *Freshw. Biol.* 21: 271-82.
- Dean, J. C. 1997. Descriptions of new Leptophlebiidae (Insecta: Ephemeroptera) from Australia. 1. *Tillyardophlebia* Gen. Nov. *Mem. Mus. Vict.* 56: 83-89.
- Dean, J. C. and D. I. Cartwright. 1992. Plecoptera, Ephemeroptera and Trichoptera of the Pelion Valley, Tasmanian World Heritage Area. *Occ. Papers Mus. Vict.* 5: 73-79.
- Dean, J. C. and P. J. Suter. 1996. *Mayfly Nymphs of Australia. A guide to genera.* Cooperative Research Centre for Freshwater Ecology. Identification Guide Number 7. 76 pp.
- Hearnden, M. N. and Pearson, R. G. 1991. Habitat partitioning among the mayfly species (Ephemeroptera) of Yuccabine Creek, a tropical Australian stream. *Oecologia* 87:91-101.
- Hubbard, M. D. and I. C. Campbell. 1996. *A checklist of the Australian Ephemeroptera (Mayflies).* Australian Society for Limnology, Special Publication.
- Lichtwardt, R. W. and M. C. Williams, M. C. 1990. Trichomycete gut fungi in Australian aquatic insect larvae. *Can. J. Bot.* 68: 1057-1074.
- Lichtwardt, R. W. and M. C. Williams. 1992a. Western Australian species of *Smittium* and other trichomycetes in aquatic insect larvae. *Mycologia* 84: 392-398.
- Lichtwardt, R. W. and M. C. Williams. 1992b. Tasmanian trichomycete gut fungi in aquatic insect larvae. *Mycologia* 84: 384-391.
- Lichtwardt, R. W. and M. C. Williams. 1990c. Two new Australasian species of Amoebidiales associated with aquatic insect larvae, and comments on their biogeography. *Mycologia* 84: 376-383.
- Lugo-Ortiz, C. R. and W. P. McCafferty. 1998a. *Offadens*, a new genus of small minnow mayflies (Ephemeroptera: Baetidae) from Australia. *Proc. ent. Soc. Wash.* 100: 306-309.
- Lugo-Ortiz, C. R. and W. P. McCafferty. 1998b. First report and a new species of the genus *Cloeodes* (Ephemeroptera: Baetidae) from Australia. *Ent. News* 109: 122-128.
- Lugo-Ortiz, C. R. and W. P. McCafferty. 1998c. First report of the genus *Siphlaenigma* Penniket and the family Siphlaenigmatidae (Ephemeroptera) from Australia. *Proc. ent. Soc. Wash.* 100: 209-213.
- Lugo-Ortiz, C. R. and W. P. McCafferty. 1999. *Edmundsiops instigatus*: a new genus and species of small minnow mayflies (Ephemeroptera: Baetidae) from Australia. *Ent. News* 110: 65-69.

- Marchant, R. 1986. Estimates of annual production for some aquatic insects from the LaTrobe River, Victoria. *Aust. J. Mar. Freshw. Res.* 37: 113-120.
- Pardo, I., I. C. Campbell and J. E. Brittain. 1998. Influence of dam operation on mayfly assemblage structure and life histories in two southeastern Australian streams. *Regulated Rivers, Res Manag.* 14: 285-295.
- Parnrong, S. and I. C. Campbell. 1997. Two new species of *Austrophlebioides* Campbell and Suter (Ephemeroptera: Leptophlebiidae) with notes on the genus. *Aust. J. ent.* 36: 121-127.
- Peters, W. L. and I. C. Campbell. 1991. Ephemeroptera. In : CSIRO (ed.) *The Insects of Australia, A textbook for students and research workers.* 2nd Edition. Melbourne University Press, Carlton.
- Riek, E. F. 1970. Ephemeroptera. In CSIRO (eds). *The Insects of Australia.* CSIRO/ Melbourne University Press, Carlton.
- Suter, P. J. 1993. *Wundacaenis*, a new genus of Caenidae (Insecta: Ephemeroptera) from Australia. *Invert. Taxonomy* 7: 787-803.
- Suter, P. J. 1999. *Irpacaenis*, a new genus of Caenidae (Insecta: Ephemeroptera) from Australia. *Aust. J. ent.* 38: 159-167.
- Tillyard, R. J. 1926. Order Plectoptera (or Ephemeroptera) (May-flies). In: R. J. Tillyard (ed.). *The Insects of Australia and New Zealand.* Angus and Robertson, Sydney.